AEROSPACE MAGAZINE - 1976-1980

TABLE OF CONTENTS

Fall

"Air Transports: The New Generation"
"Viking: Mars Mission Accomplishments"
"Rotorcraft R&D: Tomorrow's Potential"
"Technology: Biting the Hand that Leads Us"

Winter

"Aerospace Review and Forecast 1978/79"
"Aerospace Highlights 1978"
"U.S. Innovation Declines"
"Pioneer Venus – Understanding Earth's Weather"

1979

Spring

"Space Policy and the International Economic Challenge," Senator Adlai E. Stevenson
"1979 Space Policy Act Testimony"
"Landsat – Earth Monitor"
"The 1980s: Greatest Test Yet?," Heath Larry, National Association of Manufacturers
"Igor Sikorsky: Aviation Pioneer"
"Basic Research Budget Up"

Summer

"Where Are They Now? The Moonwalkers"
"The Shape of Wings to Come"
"New Trade Agreement Promises U.S. Export Increase," Ambassador Robert S. Strauss
"Public Heliports: A National Need"

Fall

"U.S. Jetliners – 25th Anniversary"
"Government Paperwork – What's The Cost? Industry Spends Millions Yearly"
"Women in Aerospace"
"1979: Planet Year"
"Spinoff 1979"
"Aerospace and Energy"

1980

Winter

"Aerospace Review and Forecast 1979/80"
"Competitive Threat to U.S. Companies in Export Markets," Dr. Michael A. Samuels
"Ride a Comet's Tail on Wings of the Sun"
"Aerospace Highlights 1979"
"Kill Devil Hill: A Book Review"

Spring

"Future of the Manned Bomber," Lt. Gen. Kelly H. Burke, USAF
"The U.S. Tax Structure: Entry or Barrier to the Future?," Reginald H. Jones, General Electric Co.
"Tools of the Aerospace Trade"
"Space Manufacturing: A New Challenge"
"Hardhats in Space," Fred W. Haise, Jr., Grumman Aerospace Corp.

Fall

"Exports: Economic Cornerstone," Ambassador Reubin O'D. Askew
"Productivity: The Competitive Threat," T.J. Murrin, Westinghouse Electric Corp.
"What's Next in Aerospace"
"Navstar: Revolution in Navigation"

AEROSPACE MAGAZINE - 1976-1980

INDEX

National Air and Space Museum

"National Air and Space Museum – Historical Perspective," June 1976

Productivity

"U.S. Innovation Declines," William M. Agee, Bendix Corporation, Roy A. Anderson, Lockheed Corporation, Winter 1978

"Productivity: The Competitive Threat," T. J. Murrin, Westinghouse Electric Corp., Fall 1980

Research

"Aeronautical Research – Cleaner, Quieter Airplanes," Summer 1978

"Rotorcraft R&D: Tomorrow's Potential," Fall 1978

"Basic Research Budget Up," Spring 1979

Revitalization

"America's Goals," (Special Edition), Summer 1977

Solar Energy

"Solar Energy: Power for Tomorrow," Summer 1978

"Aerospace and Energy," Fall 1979

Space Science

"Space Science – Investment in Tomorrow," Fall 1977

"Pioneer Venus: Understanding Earth's Weather," Winter 1978

"Navstar: Revolution in Navigation," Fall 1980

"1979: Planet Year," Fall 1979

"Ride a Comet's Tail on Wings of the Sun," Winter 1980

Space Shuttle

"Space Shuttle: Next Giant Step for Mankind," December 1976

Space Programs

"Viking: Mars Mission Accomplishments," Fall 1978

"1979 Space Policy Act Testimony," Spring 1979

"Landsat – Earth Monitor," Spring 1979

"Space Policy and the International Economic Challenge," Senator Adlai E. Stevenson, Spring 1979

"Where Are They Now – The Moonwalkers," Summer 1979

"Space Manufacturing: A New Challenge," Spring 1980

"Hardhats in Space," Fred W. Haise, Jr., Grumman Aerospace Co., Fall 1980

Technology

"At Home with Technology," December 1976

"Technology: Biting the Hand that Leads Us," Fall 1978

"The Shape of Wings to Come," Summer 1979

"Tools of the Aerospace Trade," Spring 1980

"What's Next in Aerospace," Fall 1980

U.S. Government

"How Government Competes with Free Enterprise," Summer 1978

"Government Paperwork – What's the Cost?," Fall 1979

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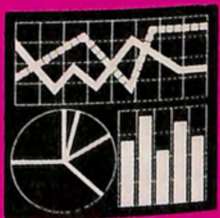
OFFICIAL PUBLICATION OF THE AEROSPACE INDUSTRIES ASSOCIATION • FEBRUARY 1976



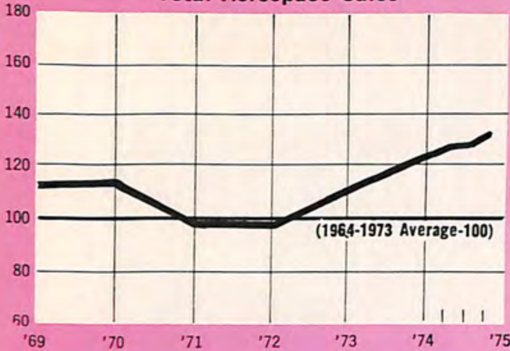
AEROSPACE REVIEW AND FORECAST 1975/76

1974
1973
1972
1971

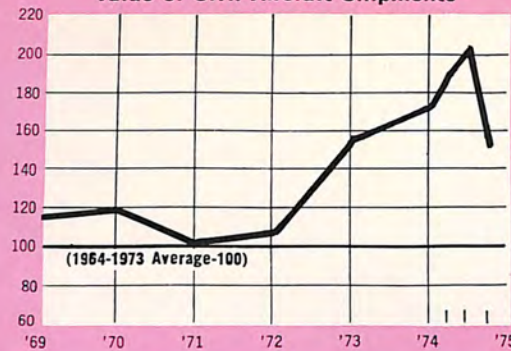
AEROSPACE ECONOMIC INDICATORS

CURRENT

Total Aerospace Sales

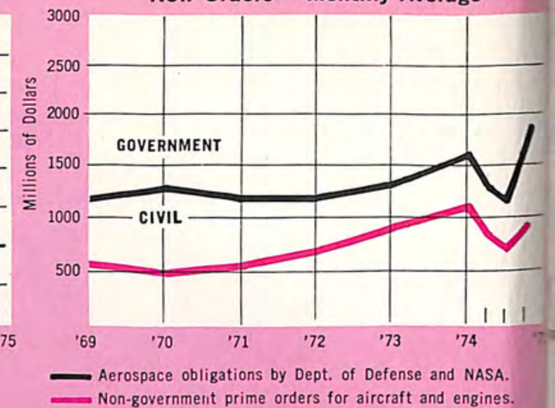


Value of Civil Aircraft Shipments



OUTLOOK

New Orders — Monthly Average



ITEM	UNIT	PERIOD	AVERAGE 1964-1973 *	LATEST PERIOD SHOWN	SAME PERIOD YEAR AGO	PRECEDING PERIOD †	LATEST PERIOD
AEROSPACE SALES: Total	Billion $ Billion $	Annual Rate Quarterly	24.1 6.1	3rd Quarter 1975	26.2 6.3	27.6 7.3	28.8 7.5
AEROSPACE SALES: Total (In Constant Dollars, 1958=100)	*Billion $* *Billion $*	*Annual Rate* *Quarterly*	*15.8* *4.0*	*3rd Quarter 1975*	*15.2* *3.7*	*15.0* *4.0*	*15.5* *4.0*
DEPARTMENT OF DEFENSE							
Aerospace obligations: Total	Million $	Monthly	1,194	Sept. 1975	1,638	2,270	1,235
Aircraft	Million $	Monthly	716	Sept. 1975	962	1,093	822
Missiles & Space	Million $	Monthly	478	Sept. 1975	676	1,177	413
Aerospace outlays: Total	Million $	Monthly	1,129	Sept. 1975	968	1,165	850
Aircraft	Million $	Monthly	669	Sept. 1975	502	699	638
Missiles & Space	Million $	Monthly	460	Sept. 1975	466	466	412
Aerospace Military Prime Contract Awards: TOTAL	Million $	Monthly	1,061	Sept. 1975	1,714	2,266	848
Aircraft	Million $	Monthly	667	Sept. 1975	866	1,196	469
Missiles & Space	Million $	Monthly	394	Sept. 1975	848	1,070	379
NASA RESEARCH AND DEVELOPMENT							
Obligations	Million $	Monthly	283	Sept. 1975	192	259	259
Expenditures	Million $	Monthly	287	Sept. 1975	206	243	238
BACKLOG (60 Aerospace Mfrs.): Total	Billion $	Quarterly	25.5	3rd Quarter 1975	33.8	33.5	34.4
U.S. Government	Billion $	Quarterly	14.5		19.5	20.3	21.1
Nongovernment	Billion $	Quarterly	11.0		14.3	13.2	13.3
EXPORTS							
Total (Including military)	Million $	Monthly	249	Sept. 1975	505	586	576
New Commercial Transports	Million $	Monthly	77	Sept. 1975	163	133	114
PROFITS				3rd Quarter 1975			
Aerospace — Based on Sales	Percent	Quarterly	2.7		2.8	3.1	3.2
All Manufacturing — Based on Sales	Percent	Quarterly	4.9		5.7	4.7	4.9
EMPLOYMENT: Total	Thousands	Monthly	1,213	Sept. 1975	976	932	938
Aircraft	Thousands	Monthly	669	Sept. 1975	539	508	512
Missiles & Space	Thousands	Monthly	128	Sept. 1975	93	89	90
AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS	Dollars	Monthly	3.86	Sept. 1975	5.48	6.05	6.12

* 1964-1973 average is computed by dividing total year data by 12 or 4 to yield monthly or quarterly averages.
† Preceding period refers to month or quarter preceding latest period shown.

Source: Aerospace Industries Association

Where Does Our Money Go?

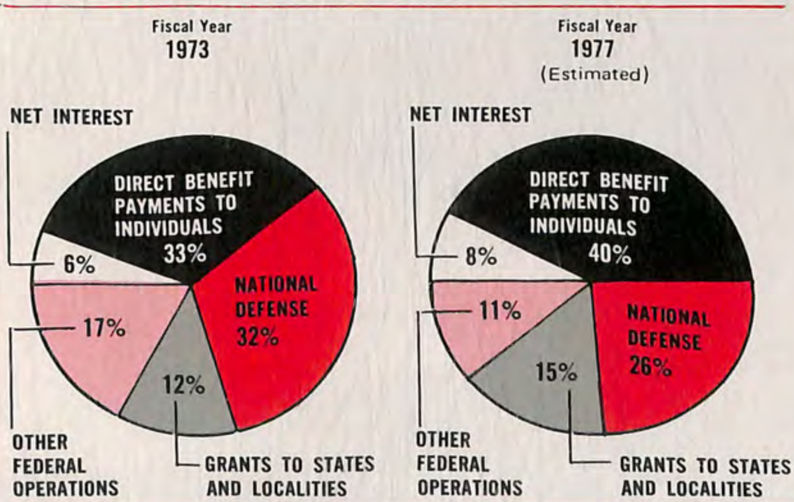
By KARL G. HARR, JR.
President, Aerospace Industries Association

Karl G. Harr, Jr.

For many years, public opinion pollsters have been documenting the substantial lack of understanding that exists among our citizens about economic matters. Given the critical importance of economics, this lack of knowledge should be of concern to all of us.

Each year about this time we are reminded of a specific area where widespread ignorance of the facts is apparent yet an abundance of facts is available for public scrutiny. We refer to the question of where does our money go in terms of expenditures by the federal government? The answers are to be found in one of the most informative and educational documents available—the annual Federal Budget. Here we can find not only to which major programs the money goes but, if we follow budgets year to year, we can determine the trends of federal spending.

Inasmuch as recent trends are not generally appreciated, especially as they relate to spending for human resources as opposed to meeting needs in national defense, we herewith publish this informative graphic comparing Fiscal Year 1973 with Fiscal Year 1977:



The President's recent budget message noted the significant shift in the distribution of federal resources. It stated: "Non-defense spending on payments to individuals and grants to State and local governments rose on an average of about 9.5 percent per year, and a total of about 500 percent, *even when adjusted for inflation,* over the 20-year period ending in 1975. Before adjustment for inflation, the increase was over 13 percent per year, or over 1,000 percent. During the same period, spending for defense with a comparable adjustment for inflation, declined a total of 10 percent, although it increased 117 percent before adjustment for inflation."

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Official Publication of the Aerospace Industries Association of America, Inc.

PRESIDENT • Karl G. Harr, Jr.
VICE PRESIDENT FOR PUBLIC AFFAIRS • Carlyle H. Jones

VOL. 14, NO. 1 *FEBRUARY 1976*

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CONTENTS

The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems;

Foster understanding of the aerospace industry's responsibilities in the space exploration program;

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade;

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

AEROSPACE is published by the Aerospace Industries Association of America, Inc., the national trade association of the designers, developers and manufacturers of aircraft, missiles, spacecraft, their propulsion, navigation and guidance systems and other aeronautical systems and their components.

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AEROSPACE REVIEW AND FORECAST

1975/76

Best estimates of the economic performance of the U.S. aerospace industry in 1975, released in December, indicated that sales would closely approximate the record $29 billion figure achieved in 1968. The estimate of $28.4 billion of sales in 1975 represents a $2 billion gain over 1974.

However, Karl G. Harr, Jr., president of the Aerospace Industries Association, in a year-end review and forecast of the industry, warned that inflation continued to erode the apparent gains made by the industry during 1975.

"In constant 1968 dollars," Harr stated, "total sales for the aerospace industry are $10 billion less than seven years ago."

Highlights of 1975, in addition to total sales, include the following:

- Aerospace exports attained a new high of $7.8 billion, up from the previous record of $7.1 billion in 1974. Civil equipment accounted for $5.6 billion of the total. In connection with military sales, it was pointed out that *orders* are often confused with *sales* or deliveries. Military orders usually exceed *sales* by a 2 to 1 ratio since deliveries are made over a period of several years.
- Backlog of orders on hand by major aerospace companies was up nearly $1 billion from $35.5 billion in 1974 to an estimated $36.4 billion at the end of 1975.
- Net profits (after taxes) slipped in 1975 to 2.9 percent compared with 3.0 percent in 1974. That is considerably less than the estimated net profit of 4.5 percent reported by the Federal Trade Commission for all manufacturing corporations in 1975.
- Aerospace employment has been on a declining trend since 1968. Based on statistics compiled by the Bureau of Labor Statistics and AIA, employment in 1974 was 973,000 (483,000 production workers); the figure dropped in 1975 to an estimated 921,000 (447,000 production) and is predicted to decline to 900,000 (435,000 production) in 1976.
- Department of Defense outlays for aerospace products and services increased by $700 million but, more importantly, the aerospace share of the DOD total outlay (14.7 percent) continued a seven-year downturn.
- By major categories, the $28.4 billion in 1975 sales amounted to $15.8 billion for aircraft and related equipment, $5 billion for missiles, $3.2 billion for space equipment, and $4.4 billion for non-aerospace products produced in aerospace facilities.
- In 1976, sales (deliveries) are expected to increase to $29.2 billion. All major categories are expected to show an increase with the exception of civil aircraft which may decline as much as $2.0 billion.

"These figures are by no means the whole story," Mr. Harr commented to a conference sponsored by the Aviation/Space Writers Association. "The economic and regulatory climate in which the aerospace industry operates has a profound effect on the statistics of its performance. There are many elements that form this operating climate."

One is a problem common to all industry, he said, i.e. the erosion of capital. Although being experienced by industry as a whole, it is an especially critical problem for aerospace because of our large and particular capital demands.

The second factor focuses more directly on aerospace itself. That is the whole compliment of constraints that fall upon us as suppliers to the government. Capital shortages, inflation and government-imposed constraints taken together, tend to limit near-term optimism.

Mr. Harr pointed out that aerospace traditionally requires large capital investments. Unfortunately, it is also characteristic of the industry to realize low levels of profits while taking exceptionally high risks. These factors make it difficult either to attract outside capital or to generate capital internally. The latter is made the more difficult by the lack of sufficient governmental incentives to invest coupled with inadequate depreciation allowances to replace plant facilities and equipment as they become obsolete. Aerospace companies commonly face cash flow problems, often of substantial proportions.

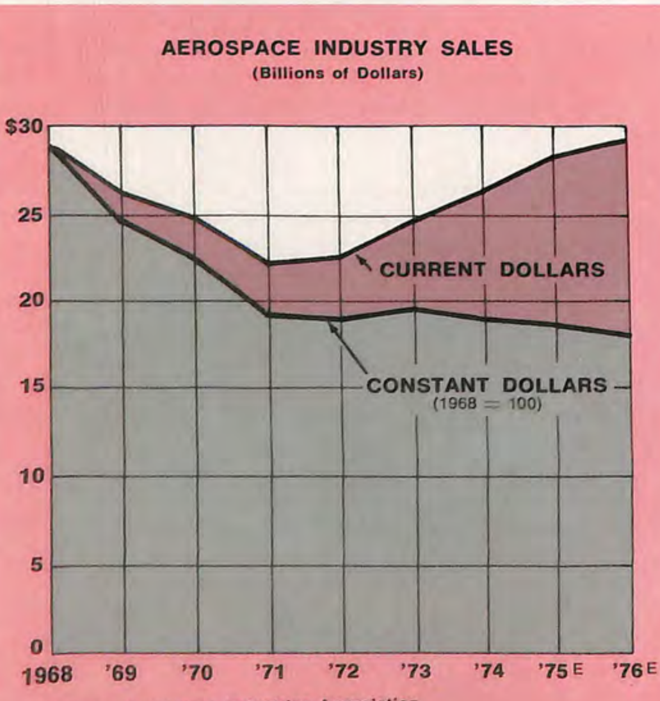
Further, because of the aerospace industry's role as the leading supplier of sophisticated products and services to the government, it is subject to infinitely detailed regulations, directives, bulletins, audits and reviews. Some are necessary and proper. Others seem to serve no cost-effective purpose.

Mr. Harr also cited the attacks upon the Independent Research and Development (IR&D) activities of government contractors, and the special cost accounting methods and procedures being imposed upon suppliers to the government.

Regarding IR&D, there is perhaps no issue in government procurement around which so few have been able to raise so much unfounded havoc. The future technical and competitive capability of outstanding high-technology companies is at stake. Such companies—as with companies in most industries—initiate and carry out their own technical effort. Whether or not they have government customers, each expects to recover as a normal cost of doing business all or an equitable portion of its research and development costs in the prices charged to customers. That is not only simple and logical but a necessary and recognized business practice. When a person buys a car, the price of that car includes some automotive research and development costs the manufacturer has incurred working toward that and future models. The only issue is whether sellers to the government should be equally treated.

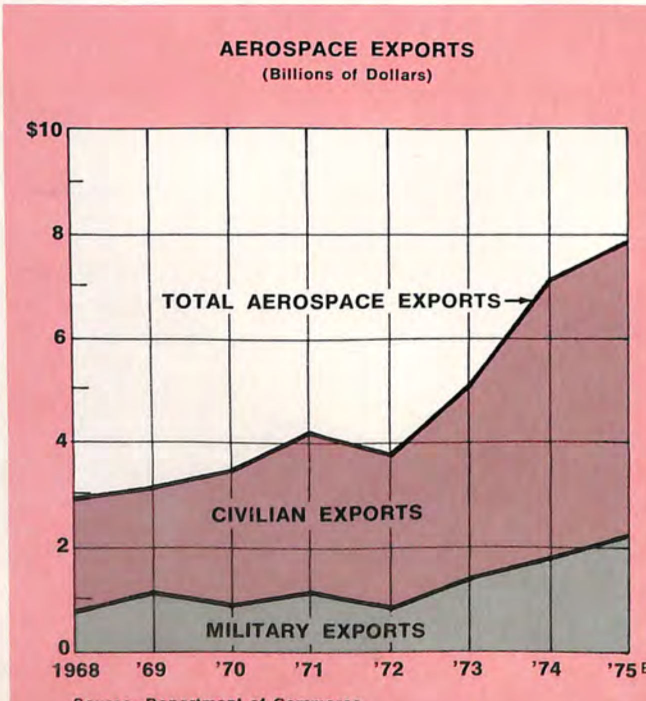
"Industry believes that Congress should study the facts on this IR&D issue and establish a policy so that government agencies and their contractors can get on with their prime responsibilities," Mr. Harr stated.

Notwithstanding all the above, he concluded, the aerospace industry solidly retained its position in 1975 as the well-spring of U.S. high technology, a national asset extending far beyond mere statistical measurement.



Source: Aerospace Industries Association

E: Estimate



Source: Department of Commerce

E: Estimate

CIVIL AIRCRAFT SHIPMENTS
Calendar Years 1968 - 1976

Year	TOTAL	Commercial Transport Aircraft	Helicopters	General Aviation
Number of Aircraft Shipped				
1968	14,922	702	522	13,698
1969	13,505	514	534	12,457
1970	8,076	311	482	7,283
1971	8,158	223	469	7,466
1972	10,576	227	575	9,774
1973	14,709	294	770	13,645
1974	15,327 r	332	828	14,167 R
1975 E	15,352	282	870	14,200
1976 E	16,215	215	1,000	15,000
Value (Millions of Dollars)				
1968	$ 4,267	$3,789	$ 57	$ 421
1969	3,598	2,939	75	584
1970	3,546	3,158	49	339
1971	2,984	2,594	69	321
1972	3,308	2,660	90	558
1973	4,665	3,718	121	826
1974	5,090	3,993	189	908
1975 E	5,511	4,227	284	1,000
1976 E	4,155	2,700	330	1,125

Source: Commercial Transport Aircraft & Helicopters: AIA Company Reports. General Aviation: AIA & GAMA.

E: Estimate.

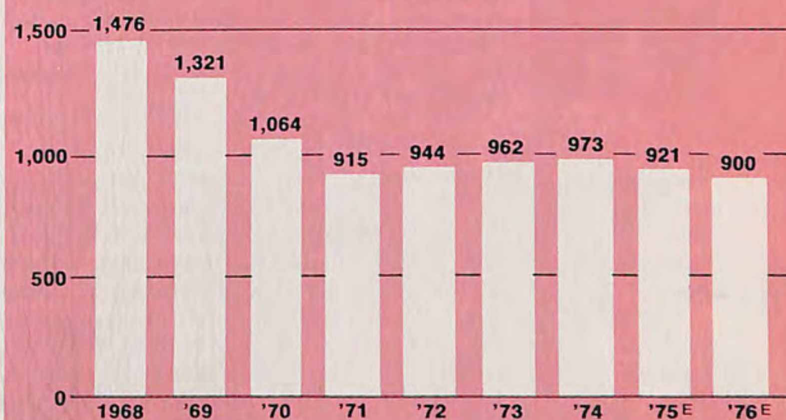
R: Revised.

NET PROFIT AFTER TAXES AS A PERCENT OF SALES
Calendar Years 1968 - 1975

Year	All Manufacturing Corporations	Aerospace
1968	5.1%	3.2%
1969	4.6	2.5
1970	4.0	2.0
1971	4.1	1.8
1972	4.4	2.4
1973	4.7	2.9
1974	5.4	3.0
1975 E	4.5	2.9

Source: Federal Trade Commission.

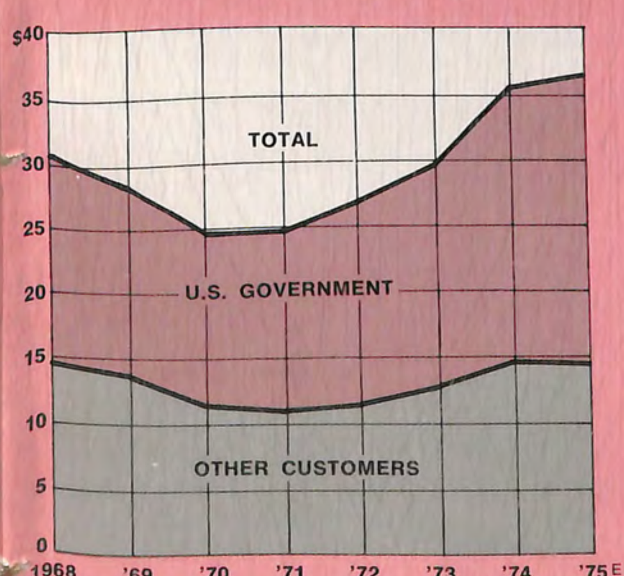
AEROSPACE EMPLOYMENT
(In Thousands)



Source: Employment — Aerospace Industries Association

E: Estimate

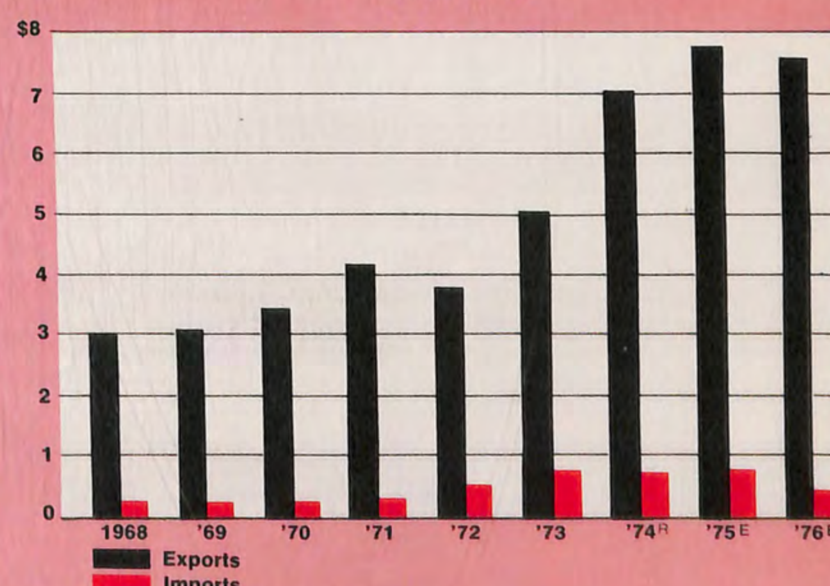
BACKLOG OF MAJOR AEROSPACE COMPANIES
(Millions of Dollars)



Source: Bureau of the Census, Current Industrial Reports, MQ-37D.

E: Estimate

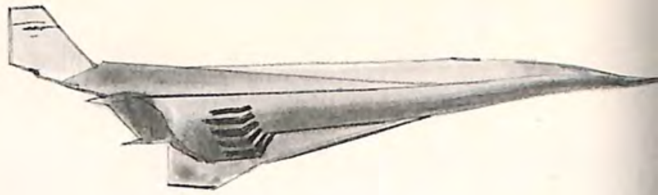
AEROSPACE EXPORTS AND IMPORTS
(Millions of Dollars)



Source: Bureau of the Census

E: Estimate

R: Revised



BY GERALD G. KAYTEN
Director of Study, Analysis and Planning
Office of Aeronautics and Space Technology
National Aeronautics and Space Administration

Gerald G. Kayten is Director of the OAST Study, Analysis and Planning Office in NASA Headquarters. Prior to this assignment he directed the Transport Experimental Programs Office. He joined NASA in 1968 after 13 years with the Martin Marietta Corporation in Baltimore, where he served as Chief Aerodynamics Engineer, Chief of Preliminary Design, and Advanced Design program manager. Mr. Kayten is a graduate of New York University's College of Engineering, and an Associate Fellow of the American Institute of Aeronautics and Astronautics.

The Bicentennial year 1976 also marks the 50th anniversary of U.S. scheduled air transportation, the dominant mode of U.S. public passenger travel and the finest system in the world.

This anniversary is an appropriate occasion to consider the future directions of the aeronautics industry which not only supports the civil air transport system, but also provides superior aircraft for national defense needs and contributes billions of dollars to U.S. trade balances from overseas aircraft sales.

The National Aeronautics and Space Administration has just completed an Outlook for Aeronautics study, with Federal Aviation Administration and Department of Defense participation, which considers the probable and possible directions of civil and military aeronautical development through the year 2000, the technology required to support the projected progress, and the role NASA should play in this period.

Since NASA's aeronautical technology serves a broad user community, we began by obtaining the views of industry and government leaders. We then incorporated our own point of view, based on NASA's responsibility to provide technical leadership for the future as well as support to current and planned programs.

As of this writing the study report is still in preparation. Some of the findings, however, have been summarized for Congressional briefings.

Yesterday and Today

Air transportation has grown tremendously in national importance during its relatively brief history. With business trips constituting approximately 50 percent of the public air travel, it is apparent that air transportation has also become a vital element of the country's commerce and economy.

In addition to the 200 million passengers boarded annually by commercial aviation, general aviation car-

2001
AN AERONAUTICS ODYSSEY

ries an additional 90 million. Again, of all general aviation operations, 72 percent are for business or commercial purposes. General aviation serves a network of 12,200 airports in addition to the 500 major commercial facilities.

At present, air cargo lags considerably behind passenger travel. Cargo movement by air currently accounts for less than 1 percent of total intercity cargo movement. However, air cargo is growing at a considerably faster rate than passenger travel and is expected to be an increasingly important factor in the nation's commerce in the future.

The U.S. is the principal supplier of aircraft to the world. Approximately 80 percent of the free world's civilian transports are of U.S. manufacture. In addition to the large positive impact on the U.S. trade balance, this strong position in world aviation contributes significantly to national prestige and international stature.

Technology Provides The Basis

The importance of aircraft in national defense has been demonstrated both in war-time and during "cold war" tension periods. Additionally, aeronautical technology has provided the basis for the equally vital missiles, antimissiles, and anti-aircraft defense systems of ever-increasing sophistication.

Clearly, aviation occupies a prominent position in our present national picture. Judging from current business reports, it also warrants concern for the future. The study suggests that —inflation, fuel cost, capital availability, international competition, and environmental concerns notwithstanding—the next quarter-century will be one of increasing opportunity. It further suggests that new technology can and must be generated if we are to meet the challenge and overcome the obstacles.

Tomorrow

The study projects a growth in air transportation demand over the next several decades at an average annual rate in excess of 5 percent. This expected growth is less than half the rate experienced during the 1950's and 60's. Nevertheless, it means a two-fold increase during the 1980's and perhaps a four-fold increase by the end of the century. Growth rates higher than the average appear likely in the cargo, supplemental carrier, and regional short-haul segments of the transportation systems, and in the use of business and utility aircraft in the general aviation and rotorcraft sectors.

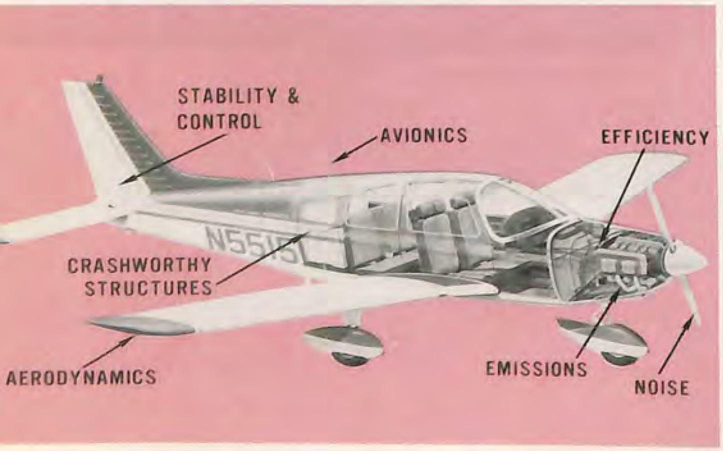
For perhaps the next decade, these needs probably will be met largely by current fleets, product improvements, and derivative models, rather than by new aircraft developments. It is expected, however, that economic factors, environmental considerations, market characteristics, international competition, and other pressures will lead to the development of new, advanced aircraft systems. The first of these—based on technology generated or available in the 1970's—could become operational beginning in the mid-1980s. The need for reduced operating cost and improved efficiency, aggravated by the high cost of fuel and the uncertainty as to future fuel cost and availability, will probably result in the application of energy efficient technology as the first major introduction of advanced technology in new aircraft.

Changing Composition

Another factor which will influence new aircraft selection later in the century is the changing composition of the market. The long-term transportation growth projections are based in part on an expected increase in international trade and tourism, with

Major civil aircraft developments predicted for the 1985-2000 period include short-range and medium-range transports, leading to V/STOL versions.

General aviation programs developed by the National Aeronautics and Space Administration are aimed at improving efficiency and safety and minimizing noise and emissions.



new intercontinental routes involving, for example, the Pacific Basin and equally remote areas. For such long-range routes, the importance of high-speed capability would significantly alter the requirements and economics of advanced supersonic transportation.

Additional examples of advanced specialized vehicle requirements would be those associated with a large growth of the air cargo market or with the advent of large-scale remote-area resource exploration and extraction.

Military aeronautical projections are influenced by an apparent trend toward reduction in overseas bases, leading to increased emphasis on long-range land- and sea-based reconnaissance, logistics, and airmobile tactical forces. The long-range capability would permit force deployment and logistic support without dependence on intermediate staging areas or refueling at the destination.

In the face of rising costs and constrained budgets, new military developments will occur less frequently than in the past and for those undertaken, reduction in both acquisition and life-cycle costs will be primary requirements.

Basis For Planning

As in the civil case, it is expected that near-future military needs will be satisfied wherever possible by derivatives and improvements. But new-generation systems will be required for the post-1985 period, with considerable emphasis on range extension and vertical or short takeoff and landing capability.

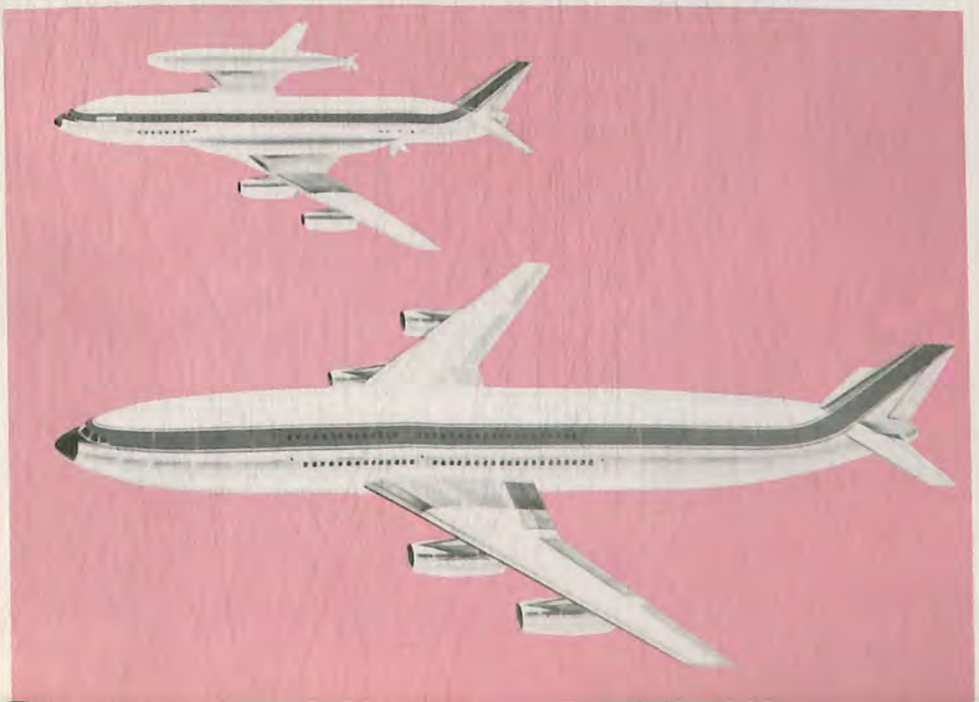
In the framework of these general considerations and more specific technical and planning information obtained in the survey, the NASA study team projected civil and military developments believed probable through the year 2000, together with likely dates of introduction. These projections are not intended as firm predictions or recommendations, but rather as typical representatives of the anticipated development directions and therefore, a realistic basis for technology planning.

For the subsonic development, it was found that the projected civil and military aircraft involve essentially similar technology. In the higher speed regimes, a divergence in technology requirements is expected between the developments directed toward long-range civil transportation and those directed toward tactical military weapon systems.

The major new civil aircraft developments foreseen for the 1985-2000 period include efficient short-range and medium-range subsonic transports, leading later to V/STOL versions; highly energy-efficient subsonic transports; ultra-large cargo aircraft; and an economical, environmentally-acceptable supersonic transport.

In regard to the supersonic transport, it is generally believed that the introduction of Concorde service on international routes will inevitably lead to a reassessment of the U.S. position by both industry and government. NASA's research, although maintained at a modest level since the abandonment of the U.S. SST prototype, has produced encouraging results. It now appears that—at least with respect to technology—we can postulate a second-generation SST with a 4,000 nautical miles range, fuel consumption approaching that of the narrow-body jets, and operating costs permitting profitable operation with little if any fare surcharge. The noise of this aircraft would be comfortably within present Federal Air Regulation levels, and reduced engine emissions would satisfy the environmental concerns.

The National Aeronautics and Space Administration is exploring the use of liquid hydrogen as an alternate fuel for both subsonic and supersonic aircraft. The liquified gas could be a means of reducing dependence on petroleum and other fossil fuel sources.



One of the goals of NASA's aeronautical program is to prove the capabilities of ultra-large cargo aircraft. An artist's conception of one design approach is shown here.

Environment Compatibility

Anticipated new military developments foreseen are conventional and unconventional systems compatible with a potential international environment in which considerably less dependence is placed on overseas bases and fuel stops. These systems include very long-range reconnaissance, patrol, and logistic support aircraft; multi-mission rotorcraft and V/STOL aircraft both for forward-area land applications and for small-ship and other naval air operations; and improved tactical systems emphasizing optimum combinations of advanced aircraft, new weapons, maneuvering missiles, and remotely piloted vehicles.

In estimating likely operational dates for these potential developments, the study indicated an appreciable spread over the next decades, but weighted heavily in the 1985-95 period. Such projections necessarily reflect the current conservatism of industry and military planners concerned with recent business setbacks, reductions in transportation demand, high costs, and constrained budgets. These are valid concerns, and the study team did not consider it advisable to project more ambitious or accelerated developments merely because technical feasibility appeared reasonable. It did, however, conclude that NASA's responsibility is to accelerate the associated technology readiness so that earlier development can be facilitated.

Creation of New Options

The team also felt strongly that NASA has the responsibility not only to satisfy known technology requirements, but also to lead in the creation of additional options and new opportunities beyond the present planning horizons of the developers and the operators. To this end, the team identified areas of applied research in which advances in the technical disciplines are essential to provide the foundations for more ambitious and promising aeronautical capabilities which could be technically feasible by the year 2000 or shortly thereafter.

These areas include, for example, the research which could lead eventually to the practical use of fuel alternatives such as liquified hydrogen, to intercontinental flight at hypersonic speeds, and to quiet VTOL operation directly into existing or new industrial centers. Depending on the outcome of current feasibility studies for specialized military and civil applications, lighter-than-air vehicles could conceivably be added to this category.

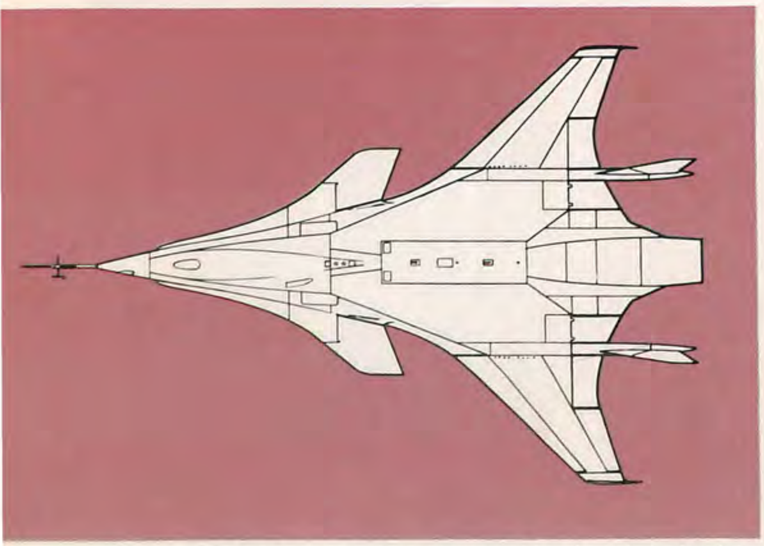
NASA Role

In addressing the question of NASA's role, the study team considered the importance of research and technology in assuring successful progress toward the future projections and the capabilities, limitations, and responsibilities of the various industrial and government organizations involved. It was recommended that NASA's primary role should be to conduct applied research, extending the understanding and confidence in the aeronautical disciplines, and to assure the timely readiness of those technology advances critical to classes of aircraft whose development is considered to be of national importance.

It was further recommended that the NASA programs include the aircraft-related research required to assure proper integration of future aircraft into the airways and air traffic control system, and that the agency continue to work closely with the universities, industry, DOD, and DOT/FAA.

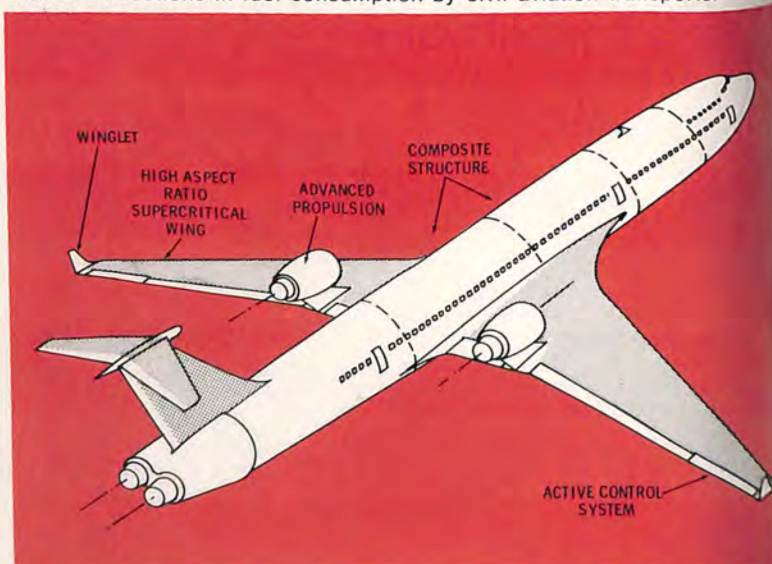
The possibility of potential NASA involvement in development through prototypes was recognized. It was felt that NASA could undertake this role if necessary, but that it should be regarded as secondary to the applied research and technology role.

We all appreciate the limitations of any attempt to project 25 years or



Scale models of the highly maneuverable aircraft technology program, incorporating advanced technology, will be flown in a joint NASA/U. S. Air Force program. The flight testing will utilize remotely piloted research vehicle techniques in which the aircraft are air-launched and then flown by a pilot located in a ground cockpit.

NASA programs include several technological developments to achieve reductions in fuel consumption by civil aviation transports.



more into the future of a high-technology field in a changing world. Such projections and the related research and technology (R&T) planning must be re-examined constantly. NASA has recently modified its long range planning process so that goals, objectives, and technology requirements, status, and opportunities are updated each year.

These updates do not involve studies of the magnitude of the Outlook project, but generally address similar questions as to likely civil and military development directions, problem areas and constraints restricting the growth or quality of civil and military aeronautics, and attractive opportunities based on promising advances in the technical disciplines.

Current and proposed R&T programs are then assessed critically in terms of how well they address the identified research and technology needs and opportunities. The assessment provides the basis for an annual review and restatement of long-term goals, 5-year objectives, priorities, resource allocations, and guidelines for preparation of the following year's budget request.

At this time, the following have been identified as areas of technical advancement and major thrusts appropriate for NASA aeronautical R&T emphasis in the next decade:

• Energy efficient vehicle technology, with the goal of providing the technical capability to develop transport aircraft which consume 40-50 percent less fuel than today's fleet. These efforts include aerodynamic design procedures, active controls, laminar flow control, engine and engine component efficiency, and demonstration of technology readiness for large-scale incorporation of composite materials.

• Reduction of undesirable engine emissions, with particular emphasis on stratospheric pollution.

• Propulsion cycles permitting efficient operation over a wider range of flight speeds and altitudes.

• Acceleration and expansion of the supersonic cruise aircraft research program toward timely technology readiness, emphasizing increased range and payload capability, sonic boom reduction, noise and exhaust emissions reduction, and operating economy.

• Advancement of computational analysis in aerodynamics, propulsion, and structures toward the achievement of major savings in vehicle design and development.

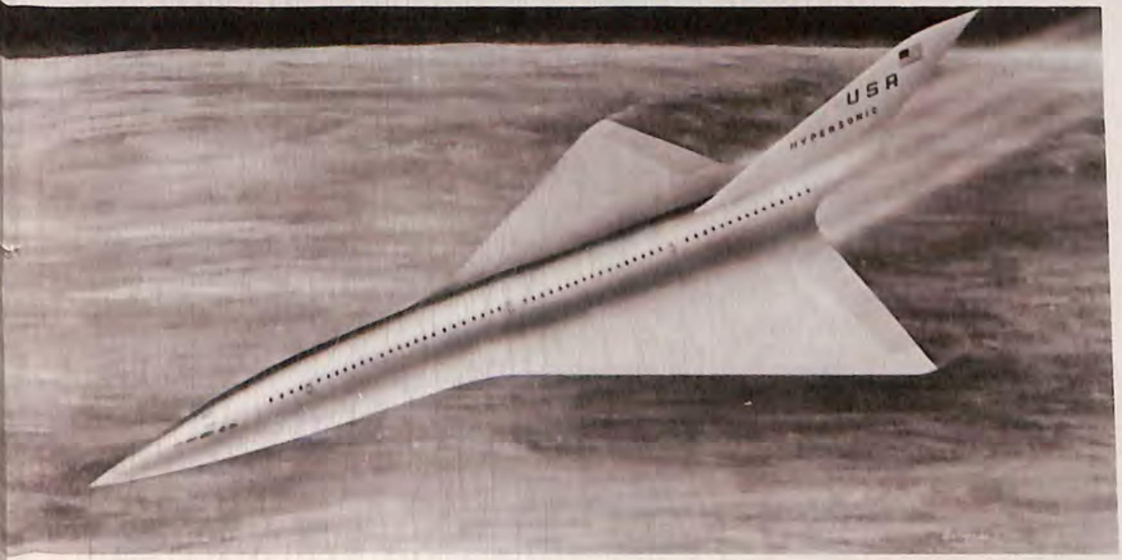
• Advanced avionics system technology for improved capability, safety, and reliability in Instrument Flight Rules operations, automatic or semi-automatic traffic control, reduced aircraft spacing, and active control systems.

• Minimization of wake vortex upset moments.

• Reduction in aircraft noise and community impact through optimal flight path control as well as acoustic suppression.

• Improved maneuverability for specialized combat aircraft applications, through advanced configurations and devices to reduce buffet and flow separation at high angles of attack.

These and other NASA R&T efforts are addressing technology development in areas of high technical risk but of potential near-term applicability. NASA is also supporting the development of longer-range technology that will eventually provide dramatically greater gains in performance, productivity, and commercial service. Current pessimism notwithstanding, the industry may very shortly be designing new military and commercial aircraft. It is NASA's objective to assure that when the expected major steps forward are attempted, the results of accelerated research and technology accomplishments will permit these steps to be made at significantly lower technical and financial risk.



Hypersonic aircraft studies by NASA are concerned with propulsion, structures and aerodynamics. Model shown here would use liquid hydrogen fuel.

In July 1975, the United States and the Soviet Union accomplished an historic feat: the orbital rendezvous and docking of Apollo and Soyuz spacecraft.

The success of the mission was due in great part to the cooperation of the two countries and of individual participants in solving problems that obstructed or hindered compatibility. An example of this cooperation was the study and use by each flight crew of its counterpart's native language, thereby greatly facilitating communication and joint experimental efforts.

Before the news media made us aware of how this communication barrier was dealt with, however, another kind of language problem — this due to the different measurement systems used by the two countries — was solved, unnoticed by the public. Rockwell International engineers designed a "bilingual" interface to allow the Soyuz, a metric system product, to dock with the Apollo, a customary system product. The first international manned space mission provided a most appropriate setting for a demonstration of the ability of U.S. industry and technology to adapt to *the metric system, the international language of measurement.*

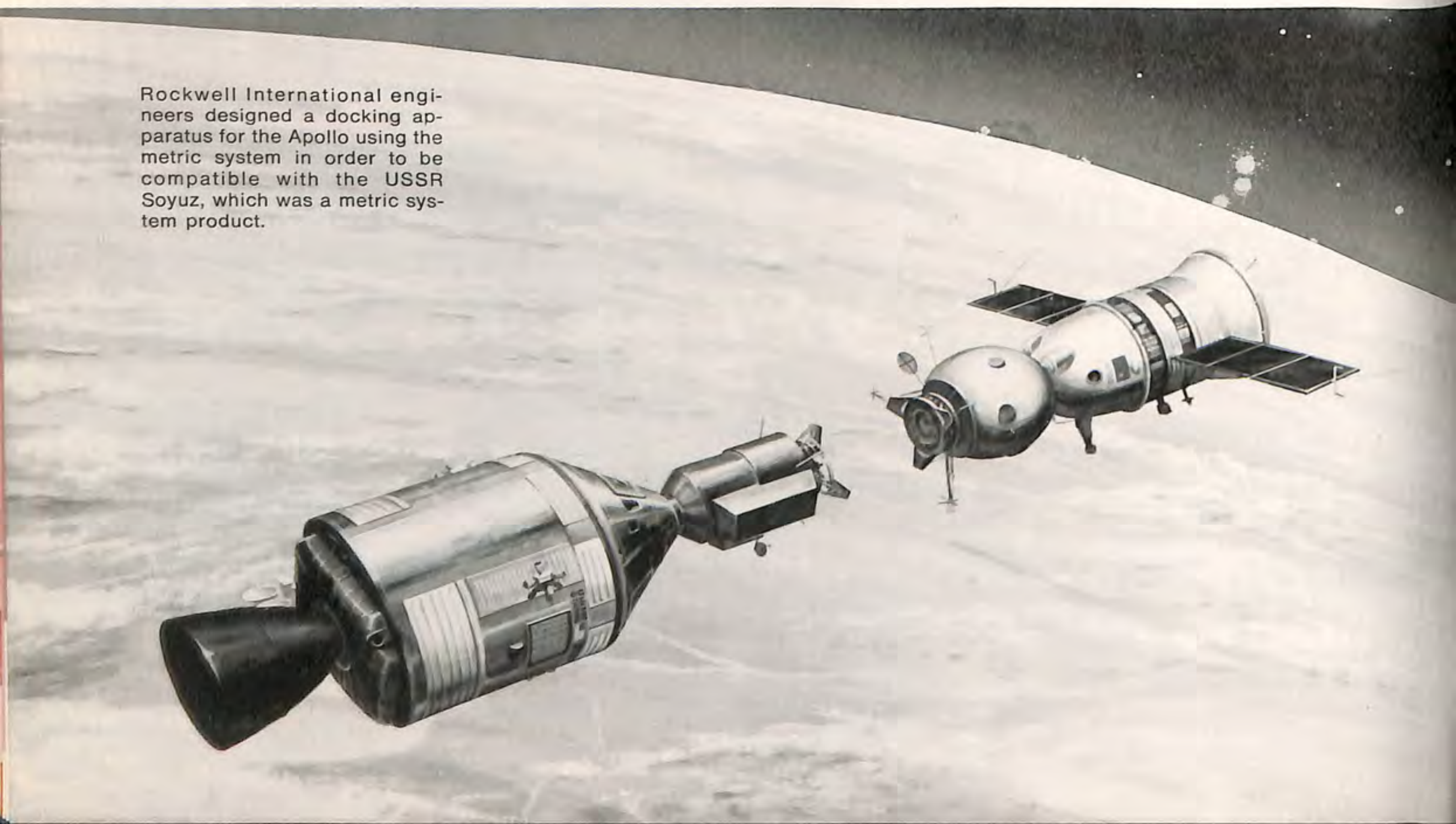
MEASUREMENT AND THE METRIC SYSTEM

A measurement system is a language, and measurement units are the words that allow us to relate to, and communicate with others about, the physical world. With interchange of products, technology, and ideas among all nations increasing, the need for a common language of measurement has become crucial.

The metric system originated with the Paris Academy of Sciences in the 1790's. Until recently, the United States has been an island in a metric world — a world where all other industrialized nations and nearly 95 percent of all people were using or adopting the metric system. On December 23, 1975, President Ford signed the Metric Conversion Act of 1975, officially announcing to the world the intention of the United States to join in making the metric system truly the international language of measurement.

The federal legislation provides official notice of intent and will result in invaluable assistance to the U.S. conversion effort, but the transition from customary to metric measurement actually began some time ago. Led by large multinational corporations, many companies have already begun planning and implementation of various conversion activities. For the multinationals, the prospects of expanded international markets, improved coordination and efficiency of worldwide operations, and improved competitive positions in foreign trade have provided ample economic incentive for conversion to the metric system. For the smaller domestic companies, the incentive is either anticipation of future demand or the necessity of customer requirements.

The U.S. Metric Association, educators, and other groups have long supported metric conversion, but industry support and conversion are recent developments. It is primarily this increasing involvement of industry over the past decade that has prompted substantial studies of the desirability and effects of metric conversion in the United States. In 1968, Congress directed the Department of Commerce to examine the benefits and costs of increasing use of the metric system in the U.S. After a three year study by the National



Rockwell International engineers designed a docking apparatus for the Apollo using the metric system in order to be compatible with the USSR Soyuz, which was a metric system product.

Bureau of Standards, a report was issued recommending that the U.S. undertake, as soon as feasible, a coordinated, voluntary program for transition of the country from predominant use of the customary system to predominant use of the metric system.

AEROSPACE INDUSTRY CONVERSION

The U.S. aerospace industry is in a somewhat unique position with respect to metric conversion. Superiority of its technology and productive capability give the industry strong dominance of world aerospace product markets. Approximately 80 percent of all transport aircraft in operation on world civil airlines in 1973 were manufactured in the United States. In 1974, the value of U.S. aerospace exports exceeded the value of imports by $6.4 billion.

What competition does exist for U.S. industry comes primarily from European aerospace manufacturers. But, despite the predominant use of the metric system throughout Europe, its aerospace industry still depends heavily on U.S. technology and standards. In the 1960's the French manufactured the *Caravelle*, a "hybrid" jet transport designed in metric units but incorporating a substantial amount of non-metric hardware. The aircraft could not be entirely metric because suitable metric parts and standards were not available for many applications.

A decade later, the new supersonic transport, *Concorde*, is being manufactured as a joint French/British venture. The *Concorde*, too, is a hybrid aircraft, designed in metric units but employing even less metric hardware (on a percentage basis) than the *Caravelle*. Not only are appropriate metric standards and parts still unavailable for many applications but the French discovered, with the *Caravelle*, that the use of metric hardware does not hold great appeal for product users. Airlines throughout the world continue to rely on and prefer the proven customary system standards, parts, and products that dominate the market.

Although the incentives of foreign competition and expansion of trade now prompting conversion in other industries are nearly nonexistent for aerospace, it is generally acknowledged that the U.S. aerospace industry will convert to predominant use of the metric system.

Representative of industry sentiment is the statement of Karl G. Harr, Jr., President of AIA, before a House Subcommittee in May 1973: "[AIA] fully supports a voluntary, planned program for the substitution of international metric units of measurement for the customary units now in general use, in order to make the metric system the predominant but not the exclusive system of measurement in the United States."

In the absence of competitive factors to provide incentive, what will prompt metric conversion in the aerospace sector? At least three sources of influence will induce the changeover:

• **Conversion in other sectors of the economy.** Suppliers of aerospace contractors are often predominantly dependent on aerospace business and therefore would follow the industry lead. But some aerospace suppliers that deal extensively with customers in other industries may convert in conjunction with those industries, perhaps inducing aerospace conversion activity.

metric
a language change for aerospace

BY LAWRENCE S. WENBERG
Assistant Director
University of Minnesota Metric Center

Lawrence S. Wenberg, Assistant Director of the University of Minnesota Metric Center, is an aeronautical engineer currently doing graduate study in business administration and industrial relations. The Metric Center was established in early 1974 by a group of interested Institute of Technology faculty members. One of the primary tasks of the Center was to research and report on the aerospace sector for a National Science Foundation study on metric transition. The study surveyed the source of metric transition, identified major impacts and issues, and examined alternative conversion models over a broad cross-section of the economy.

Many existing aerospace standards, however, must be totally rewritten, using metric units directly, i.e., conversion must be accomplished by "rethinking" the standards in metric language (hard conversion). This is much more costly than soft conversion but will be necessary to give the industry true metric capability.

This important difference in conversion methods can be clarified by analogy: Literal translation of a foreign phrase into one's own language may be adequate to achieve understanding and allow use of the phrase. Often, however, the phrase might be better understood and of greater value if the translation were a complete rewriting of the original phrase according to the idioms, words, and other elements that make up one's own language.

Hard conversion will yield aerospace standards that are "native" to the new measurement language of the industry. The sooner this can be accomplished the greater will be the U.S. input to development of international aerospace standards. The Society of Automotive Engineers, the National Aerospace Standards Committee, and DOD have undertaken a joint project to convert a group of the most critical standards. It is imperative that metric standards writing efforts receive high priority in metric conversion planning, not just in aerospace but all U.S. industry.

CONVERSION EFFECTS

Standards writing is one of the first and most important requirements facing the aerospace industry, but it is just one of the many effects of conversion. Planning for metric transition should begin with identification of all conceivable effects, no matter how remote they may at first seem. From that point, it will be possible to identify those things that do *not* need to be given attention and those that can be just passively monitored. Throughout the planning process, full advantage should be taken of the experiences — failures as well as successes — of others who have converted or who have undertaken metric projects.

The specific effects of metric transition will vary considerably, but the general impact areas for aerospace (with examples of potential effects) include:

- **Electronic data processing.** Software adaptation could be a major task for firms with extensive measurement-sensitive data bases.
- **Engineering.** Since the industry will be converting on a piecemeal basis, it will be many years before required metric standards and hardware are fully available. Until such time, aeropace systems will be hybrid (part metric, part customary); design and other engineering and technical personnel will have to think in both systems of measurement throughout the transition period. Adherence to standard metric system usage (unit spellings, symbols, etc.) will greatly aid communication and understanding but may be difficult to bring about.
- **Standards and hardware.** Standardization of metric fasteners (nuts, bolts, screws, rivets, etc.) is an important and controversial issue that must be resolved as soon as possible (without sacrificing technological quality) if metric transition is to proceed smoothly and efficiently.
- **Procurement.** Coordination of conversion activities with supplier capabilities is essential to avoidance of shortages and cost penalties (for metric parts and materials in the early stages of transition and, just as importantly, for customaıy parts and materials in the later stages).
- **Manufacturing.** Conversion of machine tools should present no significant problems; many will require no conversion at all and others just recalibration. Production to metric specifications on customary-calibrated machines is possible by means of soft conversion of the specs; however, the resulting rounding of numerical values may require a tradeoff between decreased precision and decreased tolerance limits (increased cost), making this method suitable only for limited applications. The extended period of dual production and dual inventory will necessitate some positive means of avoiding substitution errors; physical differentiation of metric and customary parts and tools and segregation of activities might solve this problem.
- **Test.** Laboratory equipment, instruments, and measuring devices may all require some degree of conversion. Flight testing will be affected by changes in regulatory standards to incorporate metric units.
- **Safety.** Confusion of units, misreading of dual calibrated instruments, and substitution of parts are all potentially hazardous. For example, misreading of a dual calibrated pressure gauge would cause the reading to be in error.
- **Personnel.** Considerations include training (how? how much? when?), compensation for employees purchasing own metric hand tools for use on the job, psychological effects of change, collective bargaining issues (differential pay, promotions, etc.).
- **Customers.** Manufacturers will need to assure customers that conversion will not affect product performance. Customers should become involved in planning since conversion of products will affect maintenance and conversion of regulations will affect operations.
- **Legal issues.** Standardization, coordination of conversion activities, and other cooperative efforts must steer a careful course to avoid any anti-trust implications. Measurement-sensitive regulations, legal standards and laws that affect the industry (including product users) will all eventually be converted.

The list could go on and on; obviously, the potential effects of conversion are many. While it may be impossible to predict exactly what will occur, planning and coordination are probably the best means of minimizing uncertainty.

COORDINATION

Efficient coordination of metric transition in the aerospace sector can significantly benefit both the industry and individual companies. For example, a cooperative metric training program for aerospace would probably carry a price tag little above the cost of an equivalent-content individual program for a typical airframe company. The cost to participating firms could be a pro rata share (based on number of employees, annual sales, or other appropriate criterion) of total program costs.

The cooperative program would have four advantages over uncoordinated individual programs: 1) the industry and the whole economy would benefit from more efficient allocation of resources, primarily, personnel time; 2) participating companies would realize significant cost savings; 3) suppliers and customers could participate, helping to unify the conversion effort; and 4) the program would effect standardization of metric practices throughout the aerospace community.

Consideration of cooperative activities will, it is hoped, be one of the endeavors of the Aerospace Sector Committee (ASC) of the American National Metric Council (ANMC). The mission of ANMC is to provide a means of exchange of ideas and information and voluntary coordination of metric conversion among all sectors of American business, government, and society. It is expected that ANMC and the newly legislated United State Metric Board will work together in planning and coordinating to minimize costs and maximize benefits of the transition. The ASC will help coordinate aerospace conversion with that in other sectors and will provide a forum for discussion of the issues, identification of the impacts, and planning and coordination of activities. The roles of some ASC participants may seem to them quite obscure this early in the transition. It is important, though, that all groups in and associated with the aerospace industry provide input to the changes coming with metric transition — changes that will have long-lasting effects.

A CHALLENGE

Conversion to predominant use of the metric system is not a future possibility, it is a certainty, already in progress. With the Department of Defense (and the U.S./NATO interchangeability requirement) in the forefront, customers are leading the aerospace industry into the transition.

The changeover will not be accomplished cheaply (but customers will share the costs) or quickly — the transition will continue into the twenty-first century. Aerospace industry and personnel will have to develop a bilingual measurement capability for use throughout the transition.

The industry cannot afford to sit back and wait for changes to be forced upon it; it must anticipate and control the changes. Careful planning of conversion activities is essential to predictability and minimization of problems and costs. Since standards are vital to efficiency and cost control, metric standards writing should receive high priority. Coordination of aerospace conversion, internally and with other sectors, is also of great importance. The Aerospace Sector Committee of ANMC should continue to receive the attention and support of all groups potentially affecting or affected by metric transition in the aerospace sector.

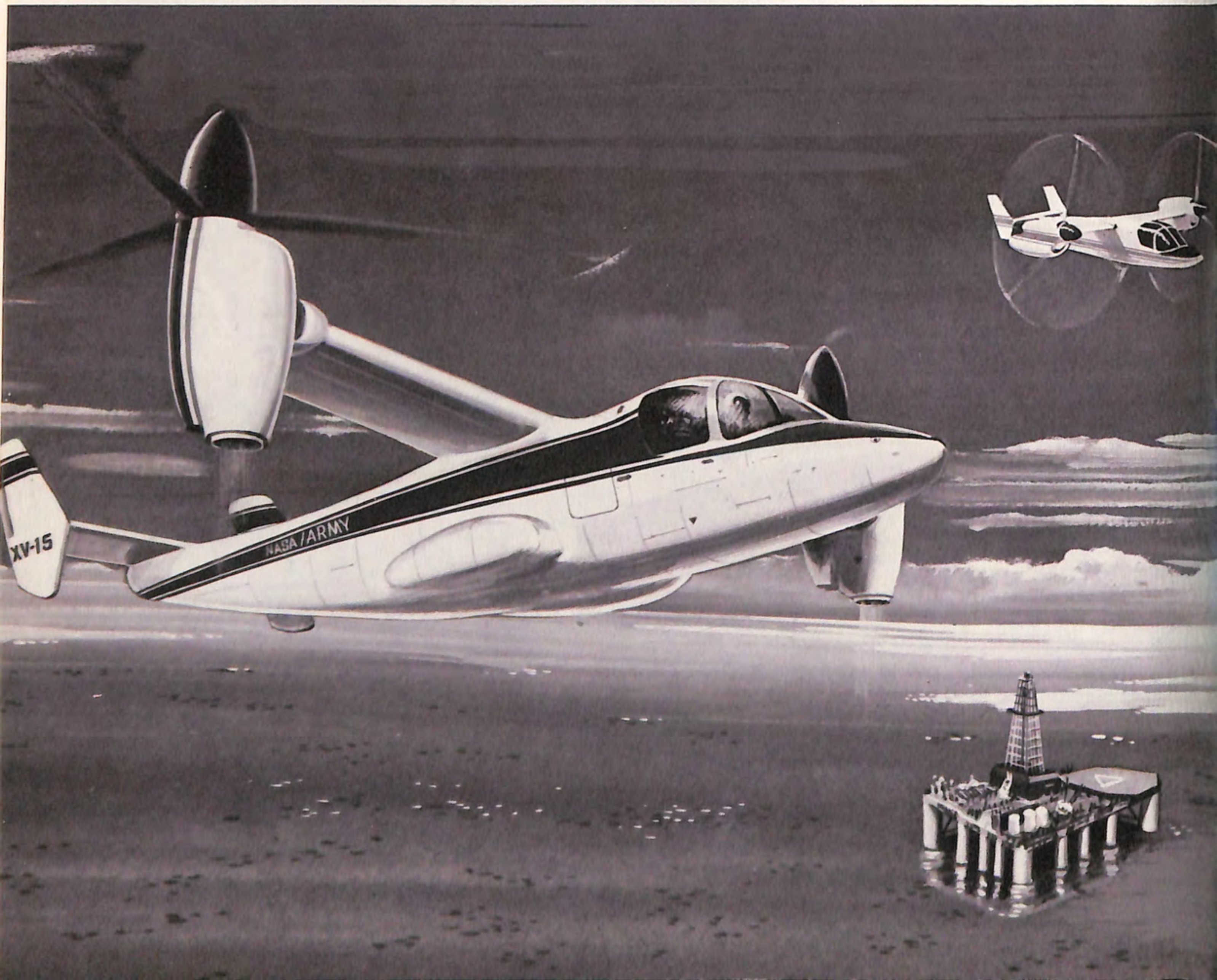
Metric conversion will present the U.S. aerospace industry with no significant technical problems. This is an industry that, in a remarkably short time, developed and integrated the ultra-sophisticated technologies capable of taking mankind from Kitty Hawk to the moon. The challenge, then, is not one of capability — the impacts of conversion will be treated as any other tasks facing the industry. Rather, the challenge is: will the U.S. aerospace industry use metric transition as an opportunity to improve standardization procedures; to increase U.S. input in ISO; to rationalize standards, hardware, and operations; and to improve communication, exchange, and interchangeability of aerospace technology, hardware, and systems among all nations?

I believe it will.

AEROSPACE INDUSTRIES ASSOCIATION
1725 De Sales St., N.W., Washington, D. C. 20036

RETURN REQUESTED

The tilt-rotor research aircraft is being developed for a joint NASA/U. S. Army "proof-of-concept" program. The tilt-rotor uses large motors mounted on the wing tips for vertical takeoff and landing like a helicopter. The rotors tilt forward once the aircraft is airborne to provide cruise propulsion. (See *2001—An Aeronautics Odyssey*, page 6).



aerospace

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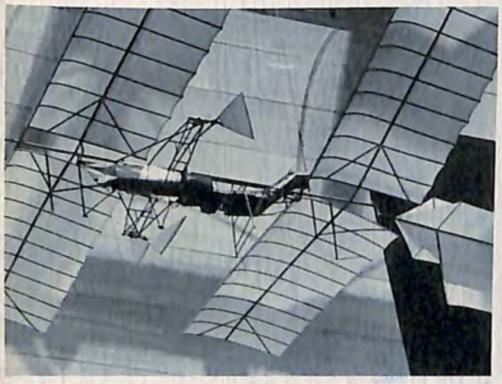
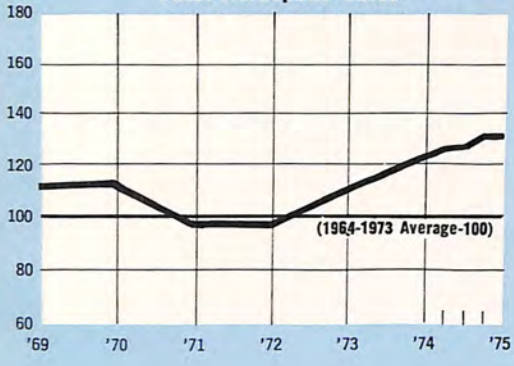


NATIONAL AIR AND SPACE MUSEUM
Heritage of Aerospace

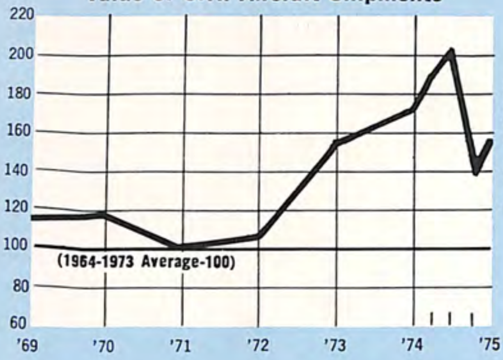
AEROSPACE ECONOMIC INDICATORS

CURRENT

Total Aerospace Sales

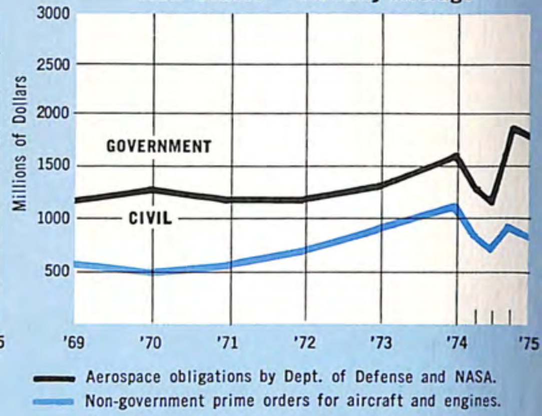


Value of Civil Aircraft Shipments



OUTLOOK

New Orders — Monthly Average



ITEM	UNIT	PERIOD	AVERAGE 1964-1973 *	SAME PERIOD YEAR AGO	PRECEDING PERIOD†	LATEST PERIOD 4th QTR. 1975
AEROSPACE SALES: TOTAL	Billion $	Annually	24.1	26.8	28.8	29.1
	Billion $	Quarterly	6.1	7.1	7.5	7.5
AEROSPACE SALES: TOTAL (In Constant Dollars, 1972=100)	*Billion $*	*Annually*	*27.9*	*22.1*	*22.6*	*22.6*
	Billion $	*Quarterly*	*7.1*	*5.8*	*5.9*	*5.8*
DEPARTMENT OF DEFENSE						
Aerospace obligations: TOTAL	Million $	Quarterly	3,582	3,947	5,088	3,353
Aircraft	Million $	Quarterly	2,148	2,691	2,763	1,922
Missiles & Space	Million $	Quarterly	1,434	1,256	2,325	1,431
Aerospace outlays: TOTAL	Million $	Quarterly	3,387	3,231	3,306	3,146
Aircraft	Million $	Quarterly	2,007	1,899	2,015	1,904
Missiles & Space	Million $	Quarterly	1,380	1,332	1,291	1,242
Aerospace Military Prime Contract Awards: TOTAL	Million $	Quarterly	3,183	3,786	4,585	2,060
Aircraft	Million $	Quarterly	2,001	2,581	2,475	1,673
Missiles & Space	Million $	Quarterly	1,182	1,205	2,110	1,387
NASA RESEARCH AND DEVELOPMENT						
Obligations	Million $	Quarterly	849	889	1,035	994
Expenditures	Million $	Quarterly	861	864	991	962
BACKLOG (60 Aerospace Mfrs.): TOTAL	Billion $	Quarterly	25.5	35.5	34.5	35.1
U.S. Government	Billion $	Quarterly	14.5	20.9	21.2	22.3
Nongovernment	Billion $	Quarterly	11.0	14.6	13.3	18.4
EXPORTS						
Total (Including military)	Million $	Quarterly	747	2,104	1,750	2,019
New Commercial Transports	Million $	Quarterly	231	848	384	502
PROFITS						
Aerospace — Based on Sales	Percent	Quarterly	2.7	2.2	3.2	2.9
All Manufacturing — Based on Sales	Percent	Quarterly	4.9	4.8	4.9	5.0
EMPLOYMENT: TOTAL	Thousands	End of Quarter	1,213	973	938	925
Aircraft	Thousands	End of Quarter	669	537	512	503
Missiles & Space	Thousands	End of Quarter	128	92	90	89
AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS	Dollars	End of Quarter	3.86	5.67	6.12	6.30

* 1964-1973 average is computed by dividing total year data by 12 or 4 to yield monthly or quarterly averages.
† Preceding period refers to month or quarter preceding latest period shown.

Source: Aerospace Industries Association

'America's Birthday Gift to Itself'

Karl G. Harr, Jr.

By KARL G. HARR, JR.
President, Aerospace Industries Association

Practical flight originated in the United States, and in the 73 years that have passed since the Wright brothers made the first powered flights at Kitty Hawk, the U. S. has spearheaded development of the airplane. Similarly, the nation has led the world in exploration of space, and its achievement of landing men on the moon ranks, along with the Wrights' accomplishment, among man's greatest technological feats.

Thus it is appropriate that America's birthday gift to itself is a magnificent new home for the Smithsonian Institution's National Air and Space Museum, which houses the Wright Flyer, the Apollo spacecraft and several hundred other exhibits evidential of American technological prowess.

The July opening of the new museum commemorates not only the nation's bicentennial but also a number of Smithsonian anniversaries. It was just 150 years ago, in 1826, that Englishman James Smithson signed a will which left his fortune to the United States to establish an institution for "the increase and diffusion of knowledge among men." Exactly one hundred years ago, the Smithsonian Institution acquired its first aeronautical objects. Thirty years ago the National Air Museum was established by law as a separate bureau of the Smithsonian and 10 years ago an amendment to the legislation made it the National Air and Space Museum.

The new building serves a long-standing need. Ever since World War I, the priceless collection of aviation and space artifacts has resided in a "temporary" Quonset hut a few blocks from the current site, a building so small that only a few of the treasures could be displayed at one time.

Hundreds of people played important parts in the development of the National Air and Space Museum. Two of them merit special mention: former head curator and now historian emeritus Paul Garber, and NASM director Michael Collins.

To Paul Garber the July opening represents the culmination of 56 years of dedicated service to the preservation of aviation memorabilia. Garber was instrumental in acquiring many of the most important exhibits and he worked tirelessly to elevate the status of the museum.

The museum's inaugural is also a high point in the career of Michael Collins, one of the trio of astronauts who flew Apollo 11 on the initial lunar landing mission of July, 1969. It was Collins, Command Module pilot on that memorable flight, who orbited the moon while companions Neil Armstrong and Edwin Aldrin took man's first steps on the lunar surface. Director of the NASM since 1972, Collins supervised the construction and installation phases of the new museum, which were accomplished exactly on schedule and within original cost targets. It is particularly fitting that the NASM is directed, at this milestone stage of its existence, by a man who ranks with the greatest names in the annals of flight.

AIA

aerospace

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PRESIDENT • Karl G. Harr, Jr.
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ART DIRECTOR • James J. Fisher

CONTENTS

George Tames, chief photographer for the New York Times Washington Bureau for thirty years, made this remarkable photographic record of the National Air and Space Museum. The photographs, because of the deadline, were made six weeks before the July 1 official opening of the Museum. There are omissions, and in many cases photos were made before exhibits were completed. Ms. Lynne Murphy, Director of Public Relations for NASM, provided wise and helpful assistance. Text and captions were written by Associate Editor James J. Haggerty.

The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems;

Foster understanding of the aerospace industry's responsibilities in the space exploration program;

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade;

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

AEROSPACE is published by the Aerospace Industries Association of America, Inc., the national trade association of the designers, developers and manufacturers of aircraft, missiles, spacecraft, their propulsion, navigation and guidance systems and other aeronautical systems and their components.

Publication Office: 1725 De Sales Street, N.W., Washington, D. C. 20036

NATIONAL AIR AND SPACE MUS

Starting in July, visitors to the nation's capital will find a new attraction on Washington's West Mall. It is a handsome marble-and-glass edifice, three city blocks long, that houses some of the most fascinating historical exhibits in a city replete with such memorabilia.

The building is the Smithsonian Institution's National Air and Space Museum, permanent home for the world's greatest collection of aviation and space artifacts. A highlight of the bicentennial celebration, the formal opening of the NASM takes place less than four years after the start of construction, in itself a remarkable achievement.

Director of the NASM is former Apollo astronaut Michael Collins, one of the three men who participated in the first lunar landing mission. Design and installation of the many and varied exhibits, a monumental task accomplished in just one year, was personally supervised by Deputy Director Melvin Zisfein.

Focal point of the museum is the Milestones of Flight exhibit, which includes such important craft as the 1903 Wright Flyer, the first practical powered airplane; the Spirit of St. Louis, in which Charles A. Lindbergh solo-spanned the Atlantic in 1927; the X-1 research plane, in which Capt. Charles E. Yeager became the first person to fly faster than sound; the X-15, fastest of all manned atmospheric vehicles; and the Apollo 11 Command Module, which took Collins, Neil Armstrong and Edwin Aldrin to the moon in 1969.

HISTORY

An Act of Congress granted formal recognition to the National Air Museum in 1946, but the Smithsonian Institution's interest in aeronautics dates back more than a century. Joseph Henry, first secretary of the Smithsonian, persuaded President Lincoln in 1861 to support Thaddeus S. C. Lowe when the latter proposed use of balloons for observation during the Civil War. The first aeronautical exhibit came in 1876, when a group of kites displayed at the Philadelphia Centennial Exposition was acquired from the Chinese Imperial Commission.

Around the turn of the century, Samuel P. Langley, third secretary of the Smithsonian, experimented with steam-driven unmanned "aerodrome" models launched from a houseboat on the Potomac River. One of those models is now on display in the NASM.

Smithsonian officials were prominent among the group which, in 1912, began to petition Congress for an aeronautical research and policy center. Their efforts bore fruit, with Congressional establishment in 1915 of the National Advisory Committee for Aeronautics, organizational ancestor of NASA. Starting in 1916 and for three decades thereafter, the Smithsonian published and pro-

A

A — Smithsonian Institution's National Air and Space Museum, located along the Mall in Washington, D. C., houses the world's greatest collection of aviation and space artifacts.

B — Photo at right symbolizes the full span of the powered flight era. NASM Director Michael Collins (left) chats with historian emeritus and Ramsey Fellow Paul Garber, who has been with the Smithsonian Institution for 56 years. Behind them is the Apollo Command Module which Collins piloted on the Apollo 11 mission, the first lunar landing in 1969. In background at upper right, the other end of the flying machine spectrum — the Wright Flyer which first achieved practical powered flight in 1903. In upper left background, the Ryan Spirit of St. Louis, which took Charles A. Lindbergh across the Atlantic solo in 1927.

UM – HISTORICAL PERSPECTIVE

vided funding for the work of Dr. Robert H. Goddard, father of the liquid fuel rocket.

The law passed in 1946 made the museum a separate bureau of the Smithsonian but did not provide a modern facility; the growing collection of aviation treasures was housed in a temporary building not far from the present site. Twenty years after passage of the original law, Congress charged the Smithsonian with memorializing space flight as well as aviation and changed the bureau's name to National Air and Space Museum.

The 1966 amendment authorized construction of a new permanent home, but appropriations were deferred because of heavy expenditures for the war in Vietnam. Planning went forward, however, and in 1972 the building design was approved by the Commission of Fine Arts and the National Capital Planning Commission. In June of that year, Congress appropriated $40 million for the magnificent building and ground was broken five months later.

THE BUILDING

Designed by Gyo Obata of the architectural firm of Hellmuth, Obata & Kassabaum, the NASM relates aesthetically to other buildings of the West Mall and to its across-the-Mall neighbor, the National Gallery of Art. It is built in four levels, the lowermost being an underground parking garage. On the top level are the NASM library and offices for the museum staff. The main level and the second level contain the exhibits.

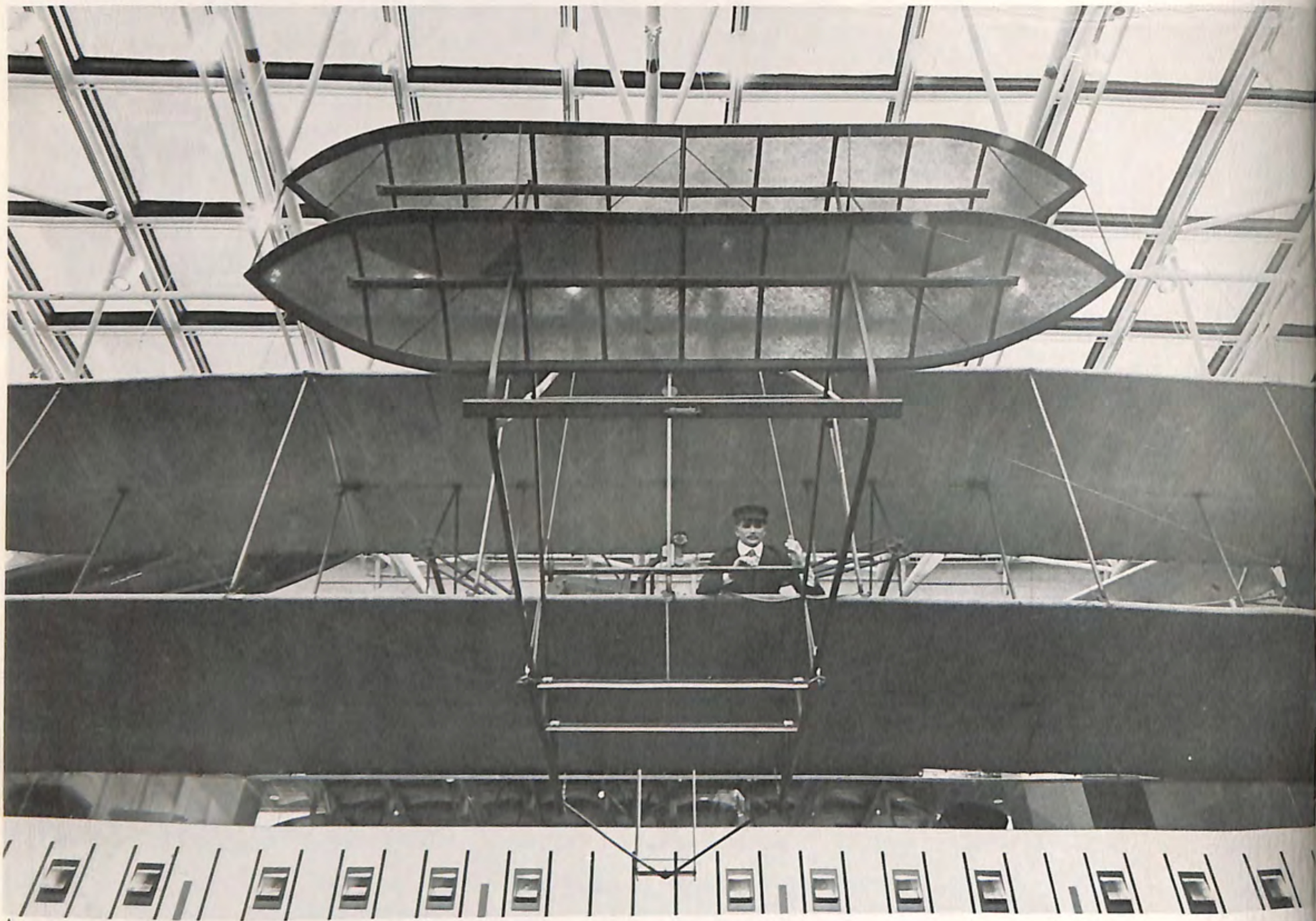
The exterior design consists of four huge geometric blocks, windowless and faced in marble, which alternate with three glass-enclosed bays. The center bay houses the aforementioned Milestones of Flight display; the other two bays are Air Transportation Hall and Space Hall. All three glass bays extend from the main floor through the second level.

Along with the three dominant displays, the main level has a series of specialized exhibits: Vertical Flight, General Aviation, Exhibition Flight, Life in the Universe, Flight Testing, Satellites, Benefits from Flight, and Rocketry and Space Flight. Nine more display rooms — for example, Sea-Air Operations and Air Traffic Control — range along the second level. A special feature of the second level is the Spacearium, in which simulated star positions are projected on a 70-foot-diameter dome. Nucleus of the Spacearium is a planetarium instrument donated by the West German government as a bicentennial gift.

It is expected that NASM will host some 50,000 visitors a day. On the pages that follow are representative samples of the exhibits they will view.

B

MILESTONES OF FLIGHT



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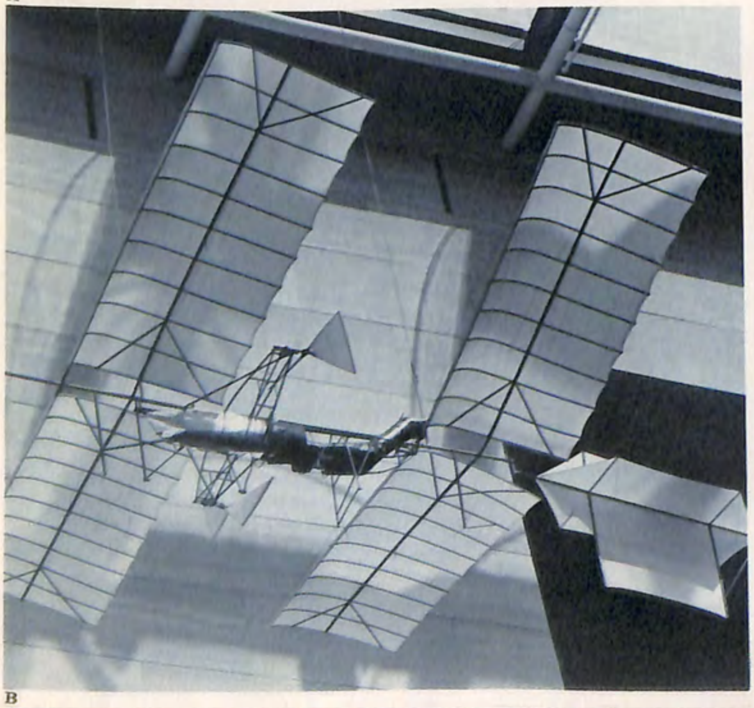

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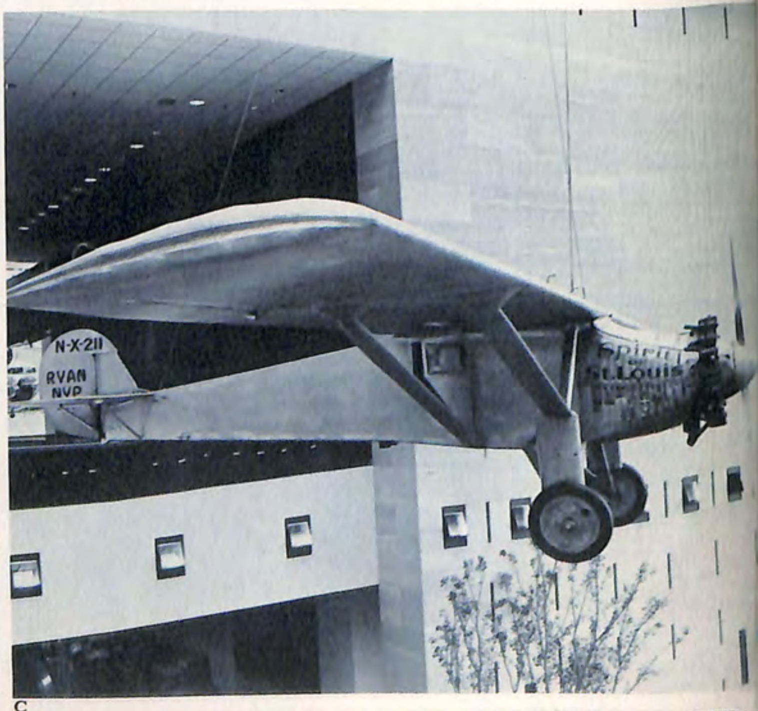

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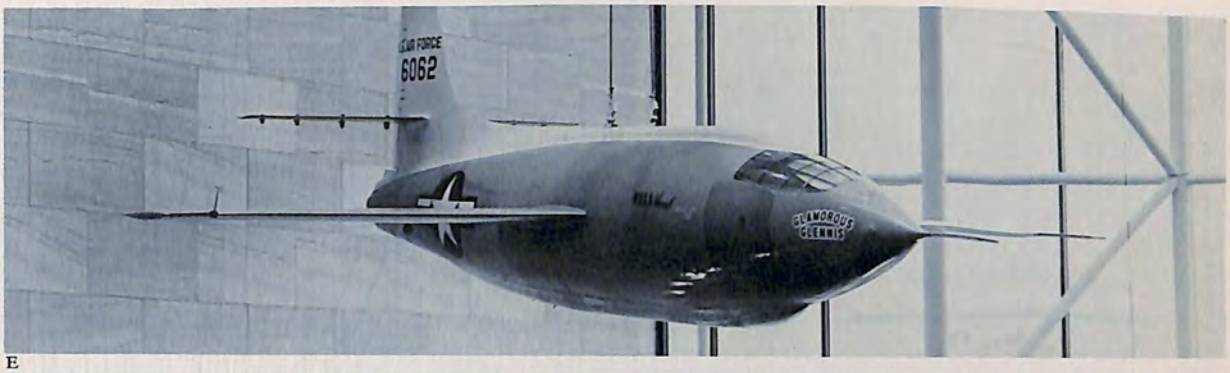
D



E

F

A — *The 1903 Wright Flyer, first aircraft to achieve practical, powered flight.*

B — *Langley Model No. 5, unmanned test vehicle, forerunner of Samuel Langley's Aerodrome, which unsuccessfully attempted first powered flight just before the success of the Wright Brothers at Kitty Hawk, N. C.*

C — *The Spirit of St. Louis, in which Charles A. Lindbergh made the first solo crossing of the Atlantic in 1927.*

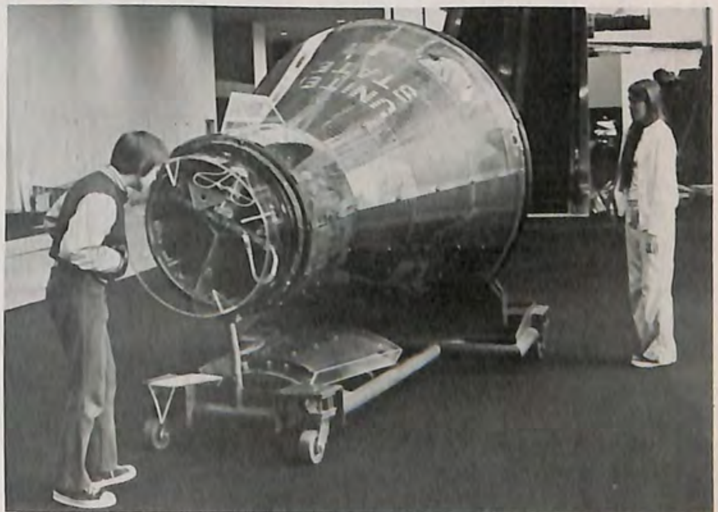
D — *A liquid rocket constructed by Dr. Robert H. Goddard, who successfully launched first liquid-propellant rocket in 1926.*

E — *The Bell X-1, piloted on first supersonic flight in 1947 by Capt. Charles Yeager, USAF.*

F — *The North American X-15 research airplane, fastest man-carrying atmospheric flight vehicle, which topped 4,500 miles per hour.*

G — *The Friendship 7 Mercury capsule which carried John H. Glenn, now a U. S. Senator, on first U. S. orbital flight.*

H — *Mariner 2, which made a fly-by exploration of Venus in 1962.*



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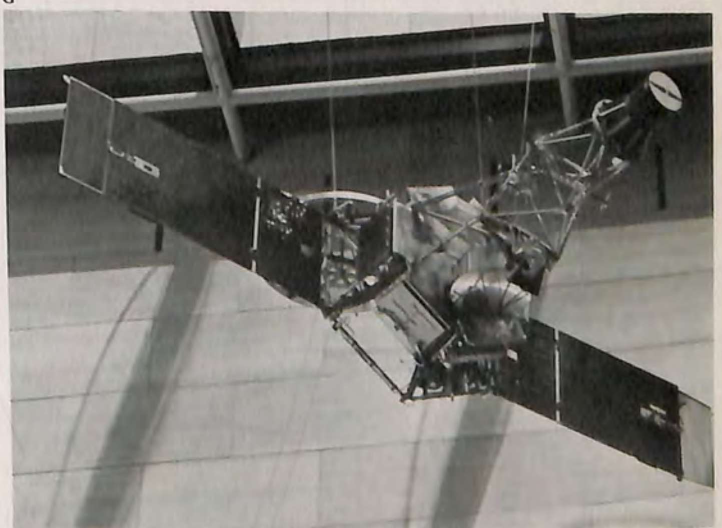
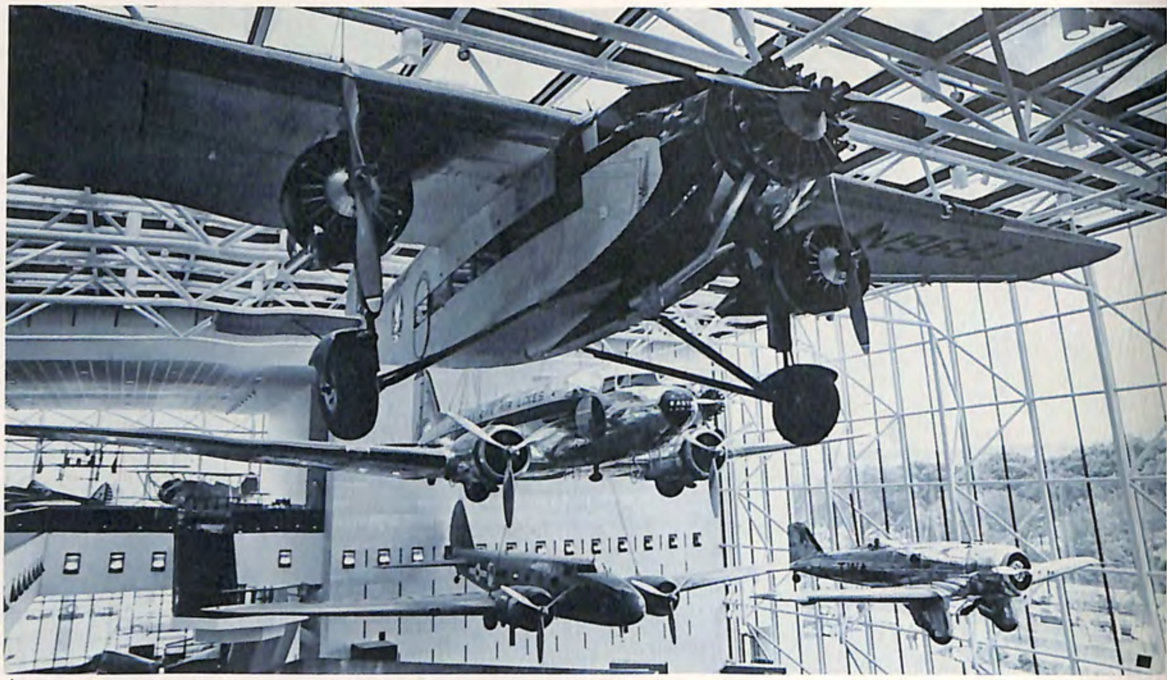


H

AIR TRANSPORTATION

A — *A collection of airplanes which played important roles in the development of air transportation. In foreground is the Ford Trimotor; just below it the Douglas DC-3; below the DC-3 is the Boeing 247; and at far right is the Northrop Alpha.*

B — *The Pitcairn Mailwing of 1927, designed for efficient and economical operation on U. S. mail routes.*



A

B

GENERAL AVIATION

C — *"City of Washington", Piper PA-12, made the first round-the-world flight by a light plane.*

D — *Nose section of a Learjet business transport.*

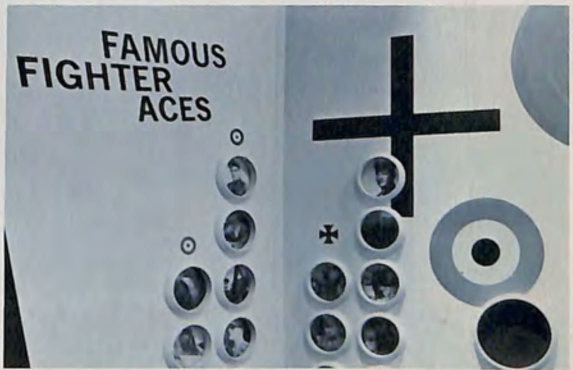
C

D

WORLD WAR I

A

B



C

D

A — Pilots await call at World War I air base. In right rear background is a captured German Fokker D-VII.

B — Billy Mitchell's SPAD XVI "flying" over a panel display of famous World War I aces.

C — Wall panel lists greatest Allied/German aces of World War I.

D — World War I air base headquarters.

WORLD WAR II AND OTHER AIRCRAFT

A — *Reproduction of an aircraft carrier hangar deck with exhibits of representative Navy planes. In foreground, the Douglas A4C Skyhawk; hanging above it (biplane) is an early Marine Corps fighter, the Boeing F4B-4. In background are the Douglas SBD Dauntless and the Grumman F4F Wildcat fighter.*

B — *Curtiss P-40E Warhawk, a World War II fighter.*

C — *Messerschmitt Bf. 109 World War II German fight*

D — *The British Spitfire fighter, which played a key role in the Battle of Britain.*

E — *Group of early militar aircraft. Lower left is the Boeing P-26 Peashooter; at right is the Grumman Gulfhawk II (F3F); and in the background is the Wright 1909 military flyer.*

A

B

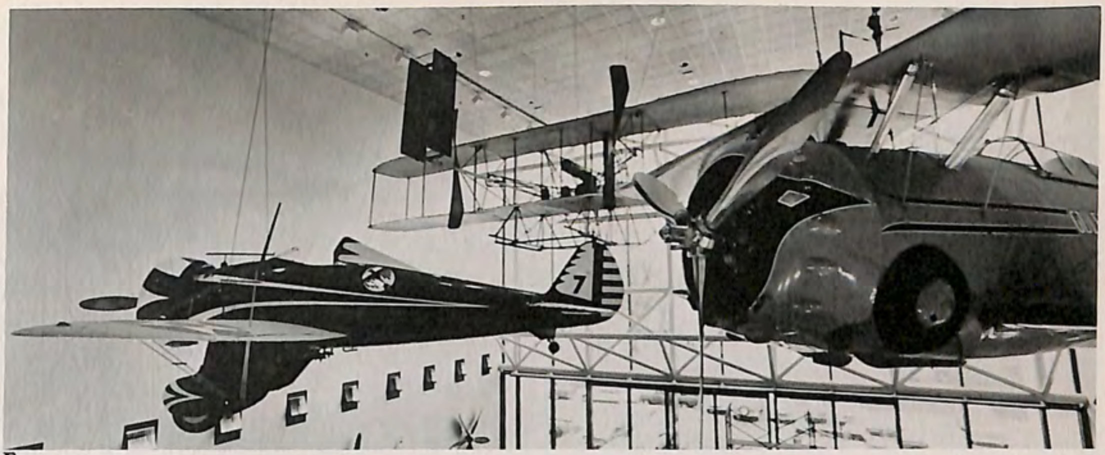
C

D

F — A mural of the Boeing B-17, painted by Keith Ferris, is viewed over the wing of a Japanese Mitsubishi Zero fighter.

G — North American P-51 Mustang fighter.

H — Nose section of a Martin B-26 Marauder bomber — "Flak-Bait."



E

F

G

H

VERTICAL FLIGHT

A

B

C

D

E

F

A — The Bell VH-13J Ranger executive transport helicopter, in which President Eisenhower became the first Chief Executive to travel by helicopter (1957).

B — Model of Sir George Cayley's 1843 convertiplane design.

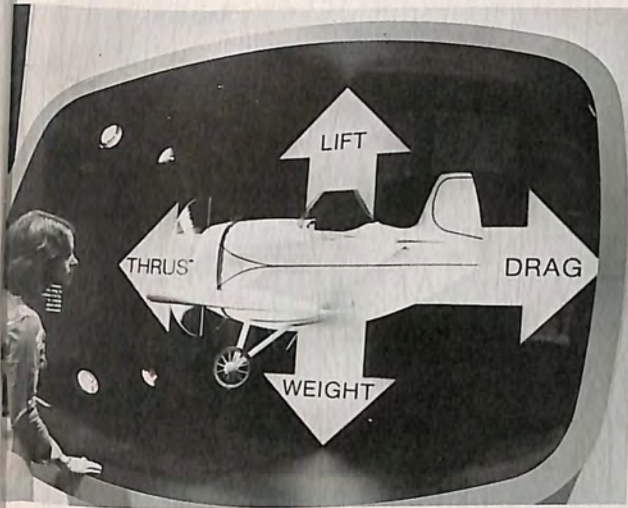
C — The first production helicopter, the 1942 Sikorsky XR-4, built for military use in World War II.

D — Examples of unique vertical lift devices: left is Bell rocket belt, right is the Pentecost Hoppi-Copter.

E — The Pitcairn Autogiro, which made history by landing on the White House lawn in 1931.

F — The 1943 Kellett XO-60 autogiro.

FLIGHT TECHNOLOGY



A

B

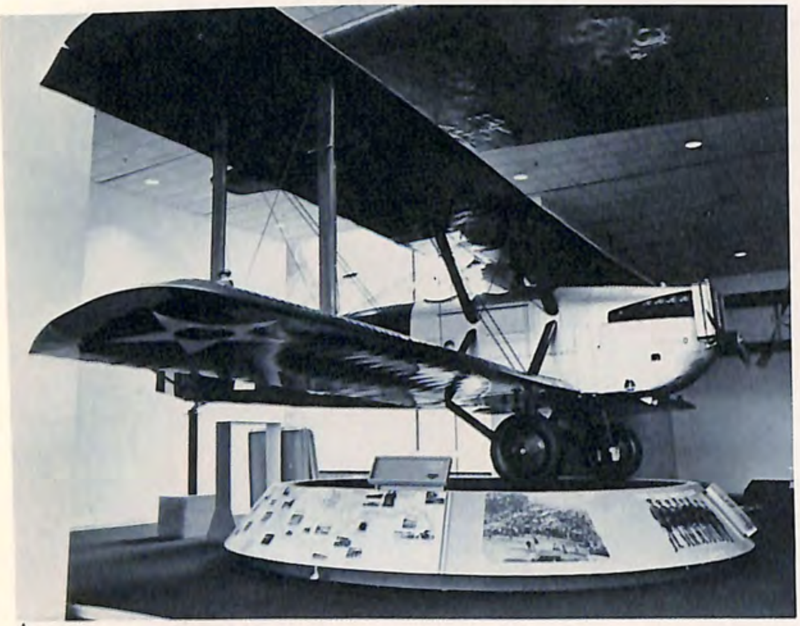
A — Instructional display, among many others, shows the four forces of flight.

B — Wind tunnel model shows the working of this vital aerodynamic tool.

C — Centerpiece of the flight technology exhibit is the Hughes H-1, milestone in speed development, which set a world speed record of 325 miles per hour in 1935.

C

SPECIAL EXHIBITS



A

B

C

D

A — *The "Chicago," one of two military Douglas World Cruisers, which made, in 1924, the first round-the-world flight and the first trans-Pacific crossing.*

B — *The Lockheed Vega, in which Amerlia Earhart made a solo trans-Atlantic flight in 1932.*

C — *A Lockheed F-104 fighter used by the National Aeronautics and Space Administration as a research aircraft.*

D — *The Douglas D-558 Skyrocket research aircraft.*

AIR TRAFFIC CONTROL

E — *Wall panel commemorates the Berlin Air Lift, made possible by the development of Ground Controlled Approach (GCA).*

F — *Air Traffic Control (ATC) exhibit. Technical accomplishments in both ground and airborne avionics have made possible the spectacular performance gains in both aircraft and spacecraft.*

E

F

EXHIBITION FLIGHT

A

A — *A wing-walker poised on an aircraft wing.*

B — *The Wittman Buster aerobatic plane and, above it, an 18th Century Montgolfier hot-air balloon.*

B

FLIGHT TESTING

C — *The Lockheed Vega "Winnie Mae," in which Wiley Post made a 1933 round-the-world solo flight.*

D — *The Bell XP-59 Airacomet, first U. S. jet airplane (1942). In upper left background, the Hawker-Siddeley Kestrel, a Vertical Take-off and Landing fighter.*

C

D

SPACE

A — *An ant's eye view of four important boost systems. Counterclockwise from top left, the Vanguard space launch vehicle, the Minuteman III ICBM, the Scout launch vehicle and the Jupiter launch vehicle.*

B — *Skylab, the long-duration earth-orbital space station launched by NASA, is the largest exhibit in the museum.*

C — *The F-1, a 1.5 million-pound-thrust rocket engine, five of which powered the Saturn V moon-booster. A unique mirror arrangement allows visitors to "see" all five engines.*

D — *Simulation of the Apollo astronauts and their Lunar Module on the moon.*

E — *The NASA M2-F3 lifting body research aircraft.*

F — *A huge lobby mural by Robert McCall depicts placement of the American flag on the moon during the Apollo mission of 1969. Mural copyright, Smithsonian Institution, 1976.*

G — *The Apollo portion of the Apollo-Soyuz Test Project, a 1975 joint space mission with the Soviet Union.*

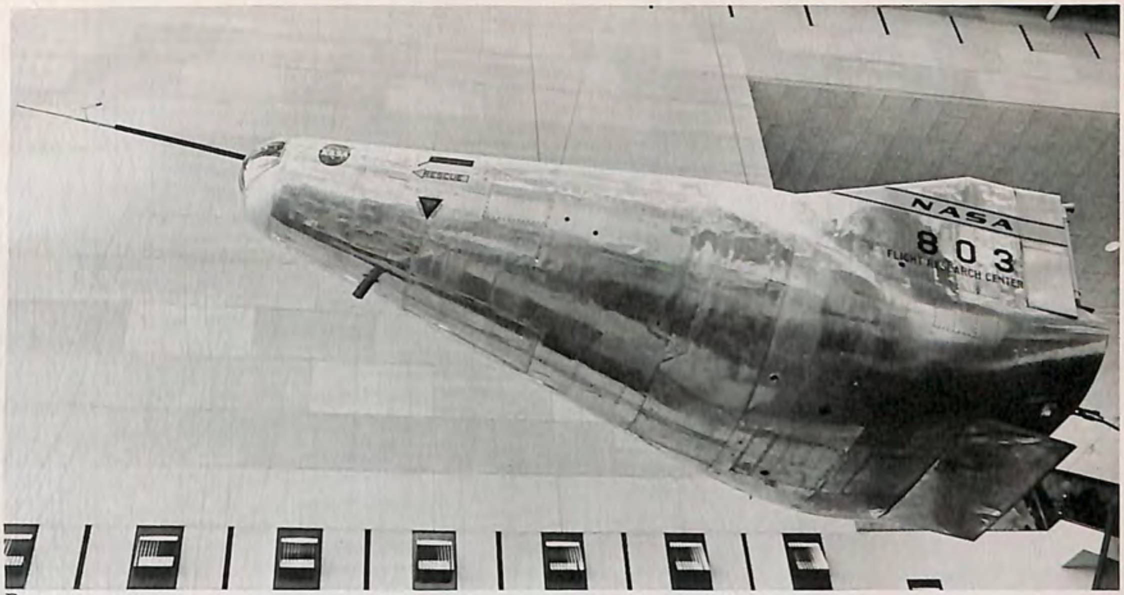
H — *Russian technicians assemble the Soyuz spacecraft, last major exhibit to arrive at the NASM. In this photo, two of the three Soyuz sections are joined; the third,at right, is the command capsule. Soyuz was being mated with the Apollo spacecraft as a commemorative of the joint Apollo-Soyuz mission.*

A


B


C

D



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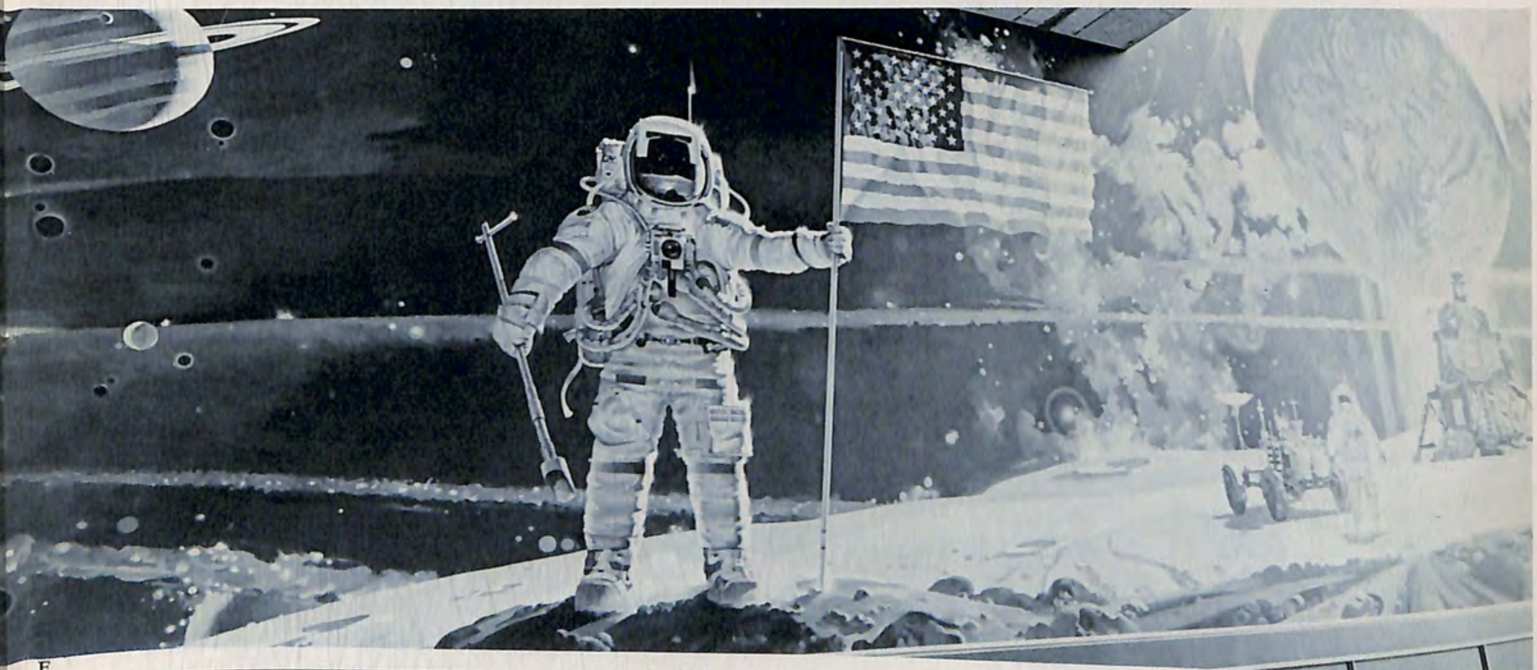

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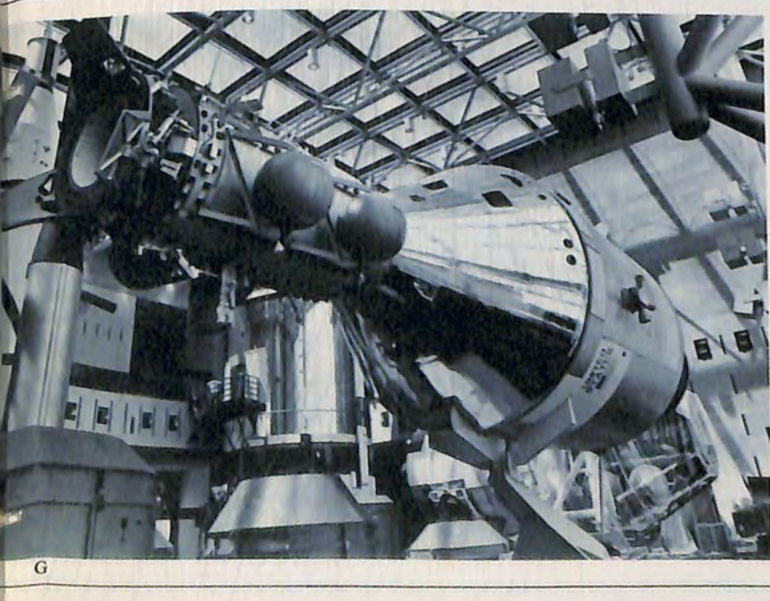

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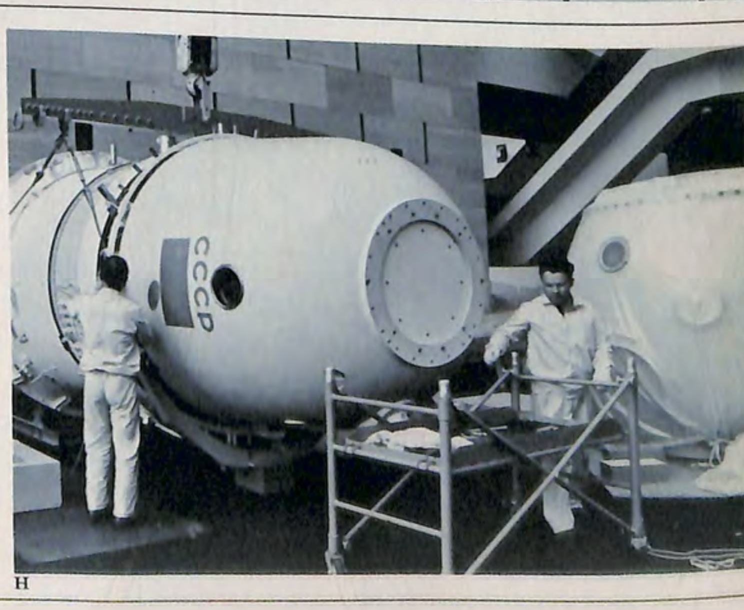

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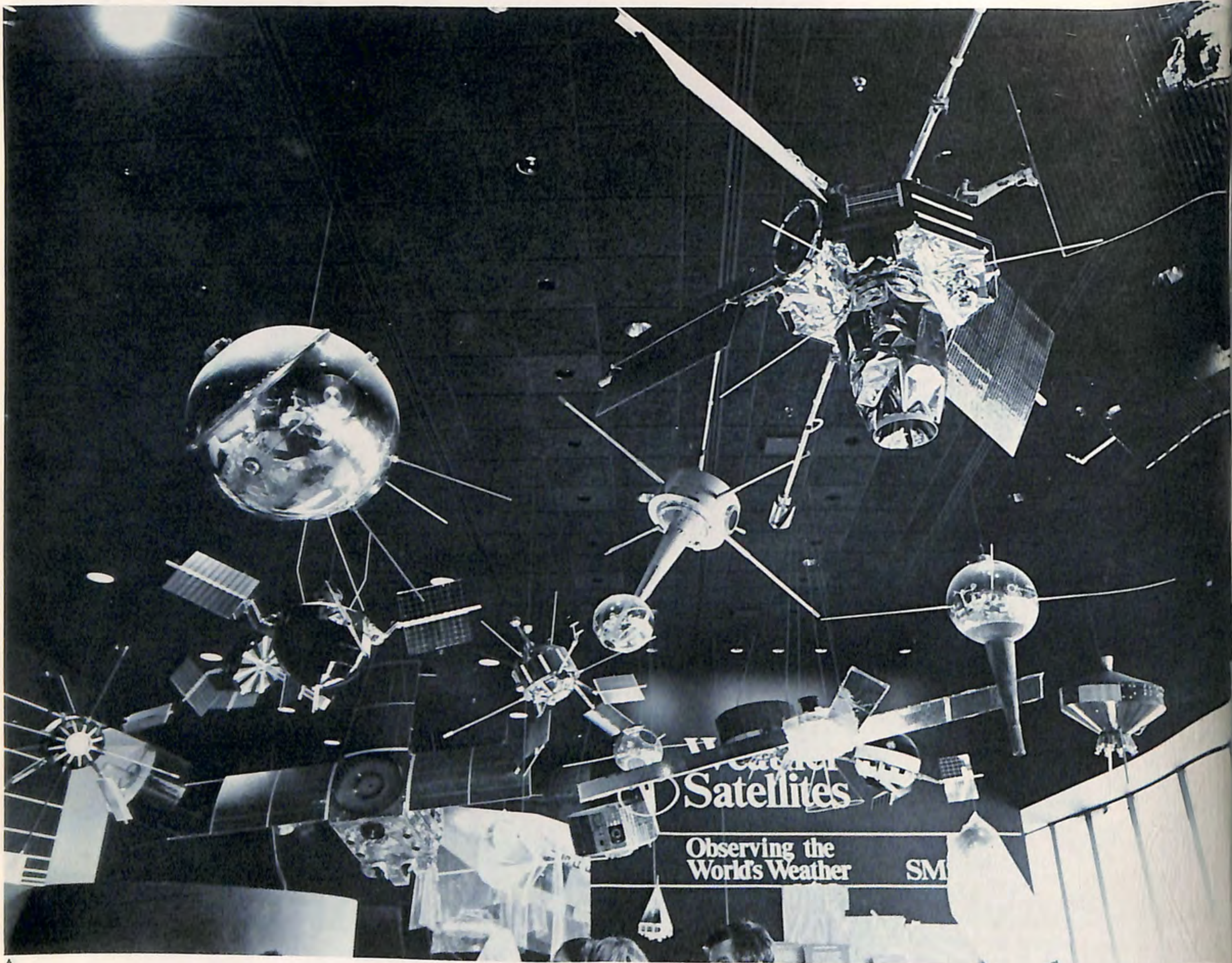
SATELLITES

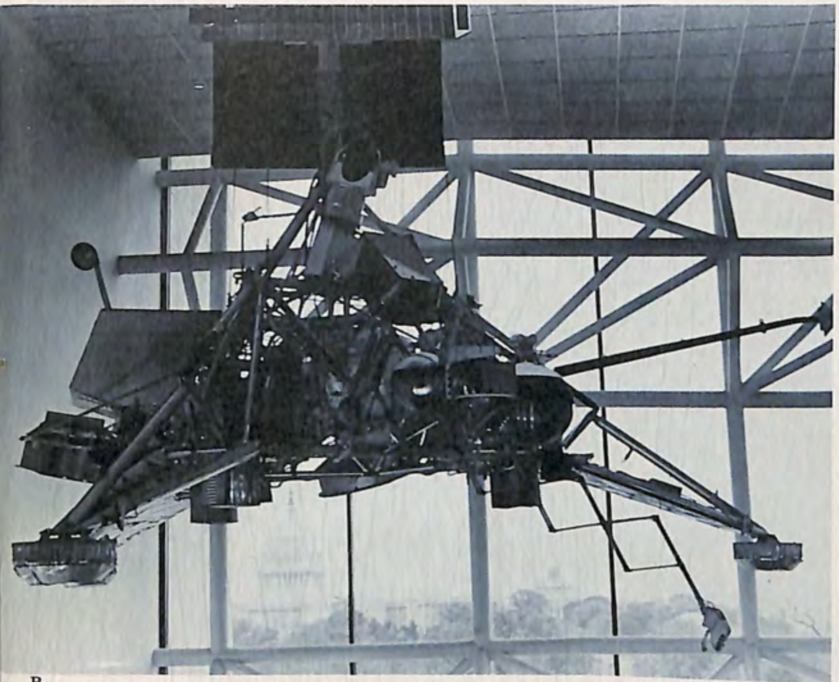


A

A — *A collection of unmanned satellites which returned valuable information to earth.*

B — *The Surveyor unmanned lunar explorer. Five spacecraft of this type landed on the moon in 1966-68, sent back thousands of photos and soil analysis data.*

C — *Lunar Orbiter, companion craft to Surveyor. In 1966-67, five of these spacecraft, operating in lunar orbit, carried out a thorough photographic mapping of the moon's surface as a prelude to manned landings.*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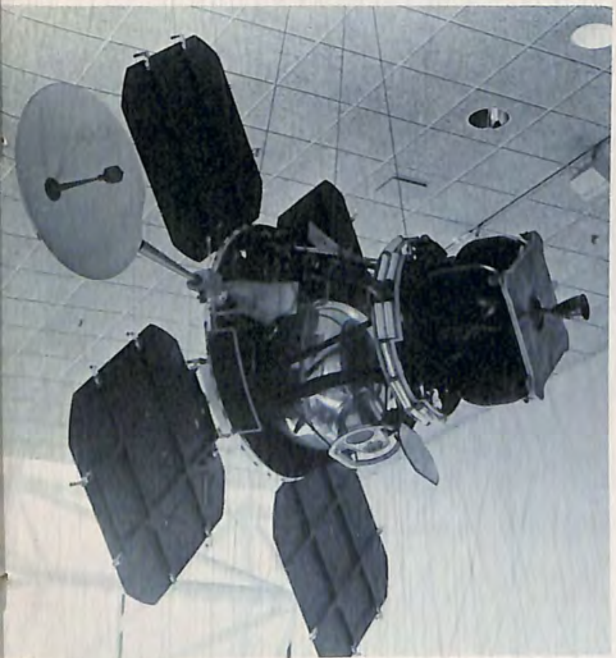
C

AIA

MANUFACTURING MEMBERS

Abex Corporation
Aerojet-General Corporation
Aeronca, Inc.
Aeronutronic Ford Corporation
Avco Corporation
The Bendix Corporation
The Boeing Company
CCI Corporation
  The Marquardt Company
Chandler Evans, Inc.
  Control Systems Division of
  Colt Industries Inc.
E-Systems, Inc.
The Garrett Corporation
Gates Learjet Corporation
General Dynamics Corporation
General Electric Company
  Aerospace Group
  Aircraft Engine Group
General Motors Corporation
  Detroit Diesel Allison Division
The B. F. Goodrich Company
  Engineered Systems Co.
Goodyear Aerospace Corporation
Grumman Corporation
Heath Tecna Corporation
Hercules Incorporated
Honeywell Inc.
Hughes Aircraft Company
IBM Corporation
  Federal Systems Division
ITT Aerospace, Electronics, Components & Energy Group
  ITT Aerospace/Optical Division
  ITT Avionics Division
  ITT Defense Communications Division
Kaiser Aerospace & Electronics Corporation
Lear Siegler, Inc.
Lockheed Aircraft Corporation
Martin Marietta Aerospace
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Pneumo Corporation
  Cleveland Pneumatic Co.
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The Singer Company
Sperry Rand Corporation
Sundstrand Corporation
  Sundstrand Aviation Division
Teledyne CAE
Teledyne Ryan Aeronautical
Textron Inc.
  Bell Aerospace Textron
  Bell Helicopter Textron
  Hydraulic Research
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TRE Corp.
TRW Inc.
United Technologies Corporation
Vought Corporation
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"The whole problem is confined within these limits: to make a surface support a given weight by the application of power to the resistance of air."
—Sir George Cayley, 1809

"I suppose we shall soon travel by air vessels; make air instead of sea voyages and at length find our way to the moon, in spite of the want of atmosphere."
—Lord Byron, 1822

"It must not remain our desire only to acquire the art of the bird; nay, it is our duty not to rest until we have attained to a perfect scientific conception of the problem of flight."
—Otto Lilienthal, 1891

"Let us hope that the advent of a successful flying machine . . . will bring nothing but good into the world, that it shall abridge distance, make all parts of the globe accessible, bring men into closer relations with each other, advance civilization, and hasten the promised era in which there shall be nothing but peace and good will among all men."
—Octave Chanute, 1894

"For some years I have been afflicted with the belief that flight is possible to man. My disease has increased in severity and I feel soon will cost me an increased amount of money if not my life."
—Wilbur Wright, 1900

aerospace

OFFICIAL PUBLICATION OF THE AEROSPACE INDUSTRIES ASSOCIATION • SEPTEMBER 1976

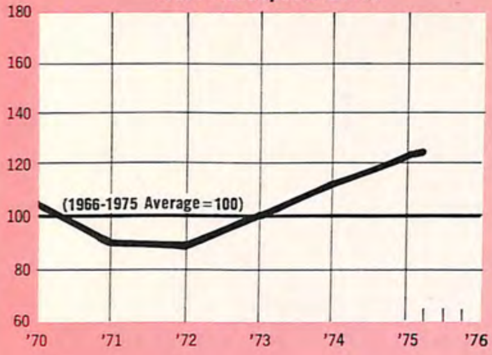
1976

- ECONOMIC UNDERSTANDING
- AEROSPACE ECONOMICS

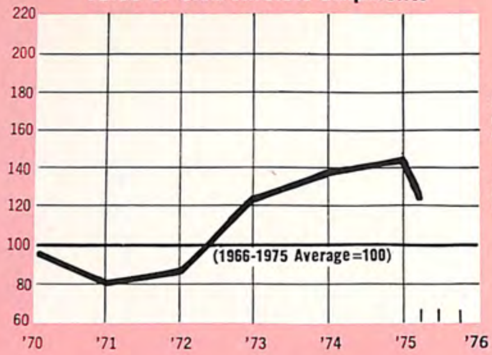
AEROSPACE ECONOMIC INDICATORS

CURRENT

Total Aerospace Sales

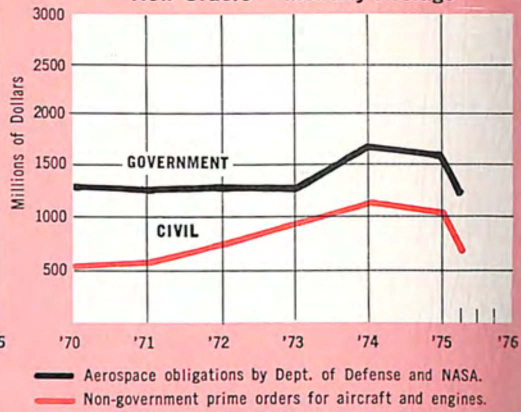


Value of Civil Aircraft Shipments



OUTLOOK

New Orders — Monthly Average



ITEM	UNIT	PERIOD	AVERAGE 1966-1975 *	SAME PERIOD YEAR AGO	PRECEDING PERIOD †	LATEST PERIOD 1st QTR. 1976
AEROSPACE SALES: TOTAL	**Billion $**	**Annually**	**26.6**	**27.5**	**29.2**	**29.6**
	Billion $	**Quarterly**	**6.4**	**6.9**	**7.4**	**7.3**
AEROSPACE SALES: TOTAL (In Constant Dollars, 1972=100)	***Billion $***	***Annually***	***27.3***	***22.2***	***22.4***	***22.5***
	Billion $	***Quarterly***	***6.9***	***5.6***	***5.7***	***5.6***
DEPARTMENT OF DEFENSE						
Aerospace obligations: TOTAL	Million $	Quarterly	3,792	3,422	3,353	3,643
Aircraft	Million $	Quarterly	2,361	2,289	1,922	2,320
Missiles & Space	Million $	Quarterly	1,431	1,133	1,431	1,323
Aerospace outlays: TOTAL	Million $	Quarterly	3,411	3,480	3,147	3,382
Aircraft	Million $	Quarterly	2,031	2,064	1,905	2,048
Missiles & Space	Million $	Quarterly	1,380	1,416	1,242	1,334
Aerospace Military Prime Contract Awards: TOTAL	Million $	Quarterly	3,327	2,858	3,060	3,828
Aircraft	Million $	Quarterly	2,109	1,992	1,673	2,966
Missiles & Space	Million $	Quarterly	1,218	866	1,387	862
NASA RESEARCH AND DEVELOPMENT						
Obligations	Million $	Quarterly	780	656	767	749
Expenditures	Million $	Quarterly	789	690	721	640
BACKLOG (46 Aerospace Mfrs.): TOTAL	Billion $	Quarterly	28.6	35.2	35.0	33.2
U.S. Government	Billion $	Quarterly	15.9	21.0	22.2	21.4
Nongovernment	Billion $	Quarterly	12.7	14.2	12.8	11.8
EXPORTS						
Total (Including military)	Million $	Quarterly	1,038	2,023	2,035	2,050
New Commercial Transports	Million $	Quarterly	345	832	502	859
PROFITS						
Aerospace — Based on Sales	Percent	Quarterly	2.7	2.5	2.9	3.4
All Manufacturing — Based on Sales	Percent	Quarterly	4.8	3.7	5.1	5.2
EMPLOYMENT: TOTAL	Thousands	End of Quarter	1,166	931	925	908
Aircraft	Thousands	End of Quarter	650	506	503	490
Missiles & Space	Thousands	End of Quarter	114	92	89	87
AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS	Dollars	End of Quarter	4.38	5.76	6.30	6.35

* 1966-1975 average is computed by dividing total year data by 4 to yield quarterly averages.
† Preceding period refers to quarter preceding latest period shown.

Source: Aerospace Industries Association

'A Historic Irony'


Karl G. Harr, Jr.

By KARL G. HARR, JR.
President, Aerospace Industries Association

In a recent perceptive essay on profits, capital and the U.S. economy, *Time* makes this comment:

"It is time for a more sober analysis of profits and their importance as the engine of economic growth. It is a historic irony that in the U.S., the stronghold of world capitalism, so few citizens understand that profits provide the basis for the prosperity on which rests the well-being of both individuals and the nation."

We heartily agree that better public understanding of the economic scene is essential. Our national leadership needs the support of an enlightened electorate to make the vital decisions as to which measures offer the best approach to tuning up a sputtering economy.

It seems clear that an improved educational effort on the part of the business community would be helpful. Toward that end, we devote this issue of *Aerospace* to a discussion of the economy in general and the unique role of the aerospace industry in U.S. economics.

We are privileged to have, as guest commentator, the distinguished economist Dr. Murray L. Weidenbaum. Dr. Weidenbaum speaks bluntly, in down-to-earth terms, on the shape and direction of the U.S. economy. In the accompanying article, we detail the complex considerations that influence the economic posture of the aerospace industry. We trust that you will find both articles interesting and informative.

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Official Publication of the
Aerospace Industries Association of America, Inc.

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EDITOR • Gerald J. McAllister
ASSOCIATE EDITORS • James J. Haggerty
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CONTENTS

The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems;

Foster understanding of the aerospace industry's responsibilities in the space exploration program;

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade;

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

AEROSPACE is published by the Aerospace Industries Association of America, Inc., the national trade association of the designers, developers and manufacturers of aircraft, missiles, spacecraft, their propulsion, navigation and guidance systems and other aeronautical systems and their components.

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AN ECONOMIST'S VIEW OF ECONOMIC UNDERSTANDING 1976

Dr. Murray L. Weidenbaum is Director of the Center for the Study of American Business at Washington University in St. Louis, Missouri.

He has held a variety of business, academic and government positions. During 1969-71 Dr. Weidenbaum served as Assistant Secretary of the Treasury for Economic Policy. He joined the Washington University faculty in 1964 and was chairman of the Economics Department from 1966 to 1969. He has held the Mallinckrodt Distinguished University Professorship since 1971. From 1949 to 1957 he was a Fiscal Economist in the U.S. Bureau of the Budget, and from 1958 to 1963 he was the Corporate Economist at The Boeing Company. He is the consulting economist to the First National Bank in St. Louis and to Mallinckrodt, Inc., and also is a consultant to the Secretary of the Treasury.

Dr. Weidenbaum is a member of the Board of Editors of the *Journal of Economic Issues, Publius, the Journal of Federalism*, and *Challenge, the Magazine of Economic Affairs* and of the Board of Economists of *Time*.

Editor's Note: The lack of economic literacy within our society has of recent date been subject to increased concern and attention. Sharing the forefront among those concerned is business leadership, which senses in the confusion and conflicts over philosophies and values serious harm to society itself. The following interview with economist Dr. Murray L. Weidenbaum explores some of the currently worrisome aspects of how the complex U.S. economic system is perceived. The association's Vice President for Public Affairs, Carlyle H. Jones, posed the questions to Dr. Weidenbaum.

Q. *Dr. Weidenbaum, a common bromide about economics is that it is the "dismal science." Survey after survey indicates that it is also dismally understood. Why is this so?*

A. There are lots of reasons, but I think the main one is that many people often confuse simple, wishful thinking with economic analysis. Let's face it, often the real answers provided by economics are difficult to accept. Let me give you a current example. There is a growing debate in the United States about how to get back to full employment. We are all in favor of high and rising employment. But the hard and honest answer is that, unless we take a sensible measured approach to getting back to full employment, all we will do is fuel another round of double digit inflation. That is the heart of the problem.

Q. *What are some of the major misconceptions about our economic system?*

A. Most assuredly, the role of profits is poorly understood. Unfortunately, many business executives, unwittingly, may exacerbate that situation. After all, if you feel obliged to talk about profits in every public address that you give, don't be surprised if the public concludes that is all that is on your mind. And as a consequence it is not uncommon to find people jumping to the conclusion that profits are much higher than they really are.

Let me try to provide what I consider to be some factual and conceptual elements critical to economic literacy. First of all there is a fundamental difference between the crucial role of the profit motive in business and the actual rather modest portion of prices that is represented by profits. As Adam Smith pointed out 200 years ago, it is not charitable impulse but economic self-interest that compels the baker to produce bread for you and me.

And while we are on the subject of bread, let me refute that economic nonsense that we read and hear too often—that the capitalistic system does not care if people starve so long as business makes its profits. The fact of the matter, which is apparent from reading the daily newspapers, is that it is by and large the capitalistic nations, especially the United States, that produce the food that feeds the hungry populations of the socialistic and communistic nations whose economies are less efficient than ours. By any objective measure, the profit motive does work.

Moreover, the actual amount of profit earned by business is a relatively small share of the income produced by our society. In 1974, for example, wages, salaries, and other labor income accounted for 77 percent of the national income of the United States. Corporate profits came to 8 percent of national income (and about half of that was paid to the government in the form of taxes on profits). The remaining 15 percent of the national income went to farmers, unincorporated businesses, landlords, and bondholders.

The historical trend is also worthy of some attention. The labor share has risen noticeably over the past 20 years (it was 70 percent in 1954) while the share going to profits has dropped (it was 12 percent in the same year).

Q. *Do you believe that business is being unduly criticized as a culprit responsible for economic frustrations?*

A. The answer is certainly "yes." Business takes it on the chin because business is most visible. Let's take the question of inflation. If government policies cause a new burst of inflation, how will it show up? The consumer will see it as another round of price increases by business, chargeable to the consumer. But business will be the middle man. The real culprit in that case will have been government policy.

Q. *What caused the low public regard for business?*

A. Frankly, we need some perspective. There is low public regard for institutions generally, not just business institutions, but government and labor unions as well. To put it candidly, George Meany is no campus hero either, these days. We need to understand that some of the low regard for some businesses is well earned. In many instances, business standards just have to be raised. In fact, I sense that this is just what has occurred during the past year, as the public awareness of business performance has increased. I think there is no better response than the one that David Packard gave to the defense industry in one of his last speeches before he left the Pentagon. I'll paraphrase him roughly. Dave Packard said, "We'll just have to do a better job."

Q. *I gather then that you believe that, if the public had a better understanding of the role of private enterprise, they would have a more favorable attitude toward business. What are some of the basics you have in mind?*

A. Let me give you some examples which really get the point across. The public as a whole is, I think, properly concerned about the environment, about energy, about safety and all of the other, what we now call, social concerns. However, in practice, so many of the regulations which have been imposed in order to attempt to achieve some of those social objectives have put tremendous and at times unsustainable burdens on business. That result hasn't been deliberate. It really flowed from the lack of understanding of how the business system operates. Thus so much of the inflation that we are now experiencing, as well as some of the unemployment, results from the overregulation by government of business. One increase in the statutory minimum wage, for example, priced over 300,000 teenagers out of the labor market.

This is a case where I do think we need to remind the public of the economic ABCs. Business is the major employer of people, the major provider of jobs. Business firms are the major producers of income and wealth. Business is the major source of new products, of technological progress, and of a rising standard of living in this country. As I look around the world, one of the key and perhaps the single fundamental difference that I can see between our society and the totalitarian forms of government is the large, strong private sector of the American economy.

Q. *Do most critics of or dissidents about our system desire fundamental structural changes or do they just want the system to work better?*

A. Frankly, most do want the system to work better, although they may disagree on how to go about it. To be sure, there is a small minority of people who want to see the American society, as we know it, undermined or replaced. But I do believe that we would have a much healthier debate if we understood that most of the critics share the same ultimate objectives. I really think it is a fact that getting back to the earlier point, they don't understand the impact of the policies they propose on the American business system. I find that regulation is such a striking and visible case in point that I have used it to explain to the public the adverse effects of so many of the well-intentioned government policies.

Q. *We are conscious of the fact that you have spoken out about government regulation as a significant deterrent to economic vitality and growth. You mentioned some of your rationale on this score. Do you have any further comment with respect to regulation?*

A. Yes indeed. First of all, there is a very fundamental distinction that needs to be made. In my criticism of government regulation I have not been focusing on the traditional type of industrial regulation, such as by the Civil Aeronautics Board or by the Interstate Commerce Commission. Currently, I don't think that is where the key problems lie, although important difficulties do arise in that area from time to time. Rather, I am concerned about what I call the new wave of government regulation of business —the Occupational Safety and Health Administration, the Environmental Protection Agency, the Equal Employment Opportunity Commission, and the Consumer Product Safety Commission. Those to me are the "big four" in terms of the regulatory problem. Those four regulatory agencies, all of which are relatively new, extend their powers to virtually every company in every industry in this nation. Not only that, but they are concerned with just one sliver of a company or industry's operation. They seem to be oblivious to the rest. Surely a cleaner environment is an important national objective, but it certainly isn't the only national objective. I characterize this new breed of agencies as having blinders on them. Rather than being attacked for having too great a concern for the industries they regulate, it's the other way around. This new breed of government regulators is not concerned with the adverse impact of their activities on such basic factors as jobs, productivity, prices, or the introduction of new products.

Q. *Well, that leads logically to the next question: not only on the subject of regulation but from other statements you have made in recent months, one would be led to believe that you think some government officials share the public's ignorance of the workings of a market economy. Would you care to elaborate on this point?*

A. I would be pleased to do so. Let us take the subject of unemployment. I think it's quite clear that one of the major obstacles to getting back to a fully employed economy in the U.S. is that this country will run out of capacity, sheer production capacity, long before we ever reach full employment. Yet so many government policies, whether they are budget deficits that compete for funds with private investment or tax policies that reduce the incentive to save and invest, make it more difficult to attract the resources for capital investment which, let's face it, are basic to the job-creation process.

Q. *Do you see any danger to the survival of our way of life in this public lack of understanding of how the market economy works?*

A. Frankly, I would not put it that strongly. I do see needless unemployment and needless inflation. These situations have resulted from the continuation, and certainly from the expansion, of the kinds of government policies that we have been discussing—notably the large budget deficits that impinge on private investment, and the increasing power of government which reduces the initiative available to the private sector.

Q. *Well then, what can be done to improve the situation?*

A. There are no panaceas. I think that is the first point. There is no quick or easy solution. The thing we need to learn and understand from the past is how we got into some of the problems now facing this country—people selling us quick and easy solutions.

At the company level, I suggest the best route, and this frankly may be unpopular with some of my friends in industry, is not vague speechifying on the merits of the free enterprise system. Frankly, that is viewed by the public as so self-serving that it just doesn't sell.

There are important, positive things that businesses can do. On that very point, there are some lessons that I have learned in the past year and a half from the operations of our Center for the Study of American Business at Washington University. One of them is to take a leaf out of the book of those who are attacking the American business system. I don't mean to single him out, but take Ralph Nader, just as an example. Nader rarely, if ever, defends his principles of economics. I don't know what they are, and I wonder if he does. He is always on the offensive, he is always attacking at least what he thinks is the weak point in the other fellow's armour.

Taking that leaf out of Nader's book, I have found it most effective to home in on the very specific problems, not the broad, general theory but the particular problems of inflation, unemployment and so forth and show how well-intentioned government activities reduce the ability of the American business system both to provide jobs and to produce goods and services in a non-inflationary environment.

Q. *You have mentioned, and we read a lot about, a capital shortage. What is that all about?*

A. This is a hard one to explain to the public because when people think about capital they think of bankers and wealthy coupon clippers. Well, it is a "green-eye shade" subject so to speak. But to an economist, capital is a very basic aspect of our society. When we are talking about capital formation, we literally are talking about the ability to create more jobs and to provide a better standard of living for our society. Again, from the viewpoint of economics, that's not even limited to the capitalistic system. Any type of society needs a growing stock of capital—productive facilities, factories and equipment—in order to provide more jobs, and in order to deliver an improved living standard to its citizens.

It is becoming quite clear that the United States will be fully utilizing—running out—of capital equipment long before the American labor force becomes fully employed. This relative lack of productive capital is occurring for several reasons, most notably the tendency of our tax system to favor current consumption over saving (which is the basic source of new capital financing). Moreover, other government policies, such as environmental regulations, are diverting business investment from increasing the capacity to produce goods and services to achieving social objectives.

Q. *Well now, for a tough one. With various segments of our society having such widely differing views as to the shortcomings of our economic system, how can the system ever work effectively to the satisfaction of a majority?*

A. I like the last part of your question best—to the satisfaction of the majority of our people, because I think so much of the criticism that we hear comes from a small minority. To the extent that we deliver to that great majority of the public, we can frankly pay less attention to the professional dissidents. Specifically, I think the way to truly satisfy the American people on a long-term sustainable basis is by our economic system producing higher employment, a lower rate of inflation, and a rising living standard for the average family. With one proviso—not only as a proviso but I think it's a necessary ingredient that unfortunately we don't hear enough about—to do all that in an environment of maximum freedom for the individual.

Q. *Thank you very much, Dr. Weidenbaum. Now how about summing up? What is the problem and what should be done about the whole thing?*

A. Well, if I've tried to say anything, it's that there are no easy answers, and there are certainly no quick solutions. The most fundamental response to the widespread public dissatisfaction with the business system is simply, and it may not be so simple when you think about it, for American business to do a better job of so-to-speak "minding the store." American business firms need to use both capital and the skills of labor more effectively to produce existing products at lower cost and to develop better goods and services for the public. Thus we all need to emphasize the basic economic function of the business system which is to meet the needs of the consumer. If we give it the opportunity, the American system certainly has the capability to deliver; and the resultant flow of goods, of income, and of wealth, will not only provide a higher living standard but also will provide society with the resources for achieving our individual as well as our social objectives.

There are constructive policies that government can and should undertake. To clear the air, I am not an anarchist. I do believe that government should set rules for society. There are very important functions for government to perform. After all it is the responsibility of the government to protect society, to provide for the national defense as well as for internal law enforcement. It is the function of the government to levy taxes, to carry out civilian as well as military services, and to provide those common systems—airports, seaports, highways, just to cite a few examples in the transportation area—which are necessary for private individuals and private enterprise to function.

But the very ways in which the government collects taxes and spends the income from those taxes can help or hinder the achievement of society's basic goals. For example, an ill-conceived tax designed to finance a new employment program may offset the effects of those expenditures by reducing the incentive and ability of business to invest in private job-creating projects. Moreover, the government program may turn out to be competitive with private employment and thus be self-defeating, despite its good intentions.

A Short Course in AEROSPACE ECONOMICS 1976

BY KARL G. HARR, JR.
President, Aerospace Industries Association

On the preceding pages, economist Dr. Murray L. Weidenbaum discusses the general lack of public understanding about economics, notwithstanding the critical importance of that subject to our society.

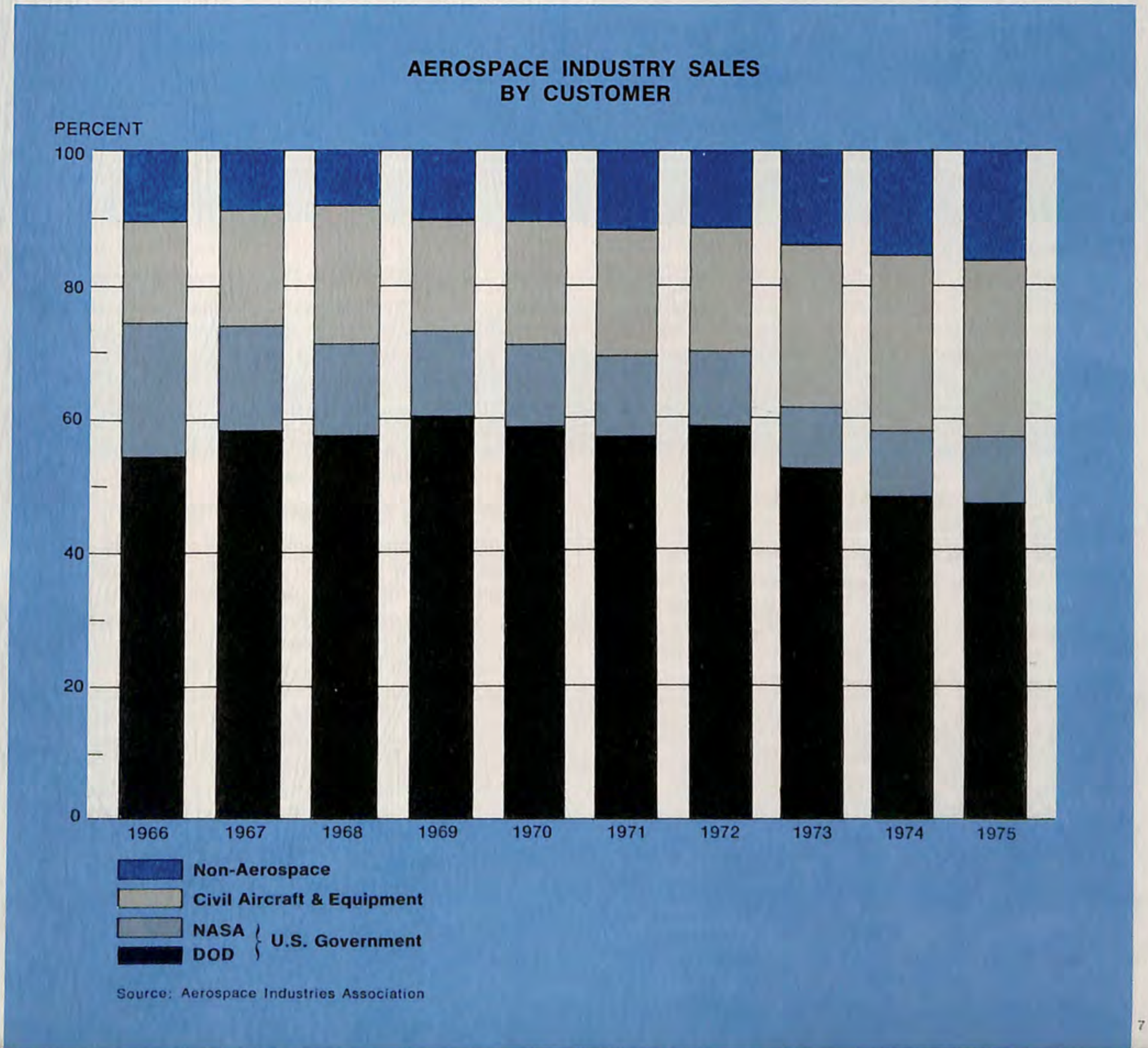
Such lack of understanding—and perhaps even worse, lack of interest—embodies staggering ignorance about the major industrial components of the American system, particularly aerospace, which ranks among the least understood. In news commentary, speeches and testimony critical of our industry and its performance, and in the ever-mounting body of regulations to which we are subjected, it is often apparent that the authors of the published material and the regulatory proposals simply have not viewed in proper perspective this complex, high-technology business we call aerospace.

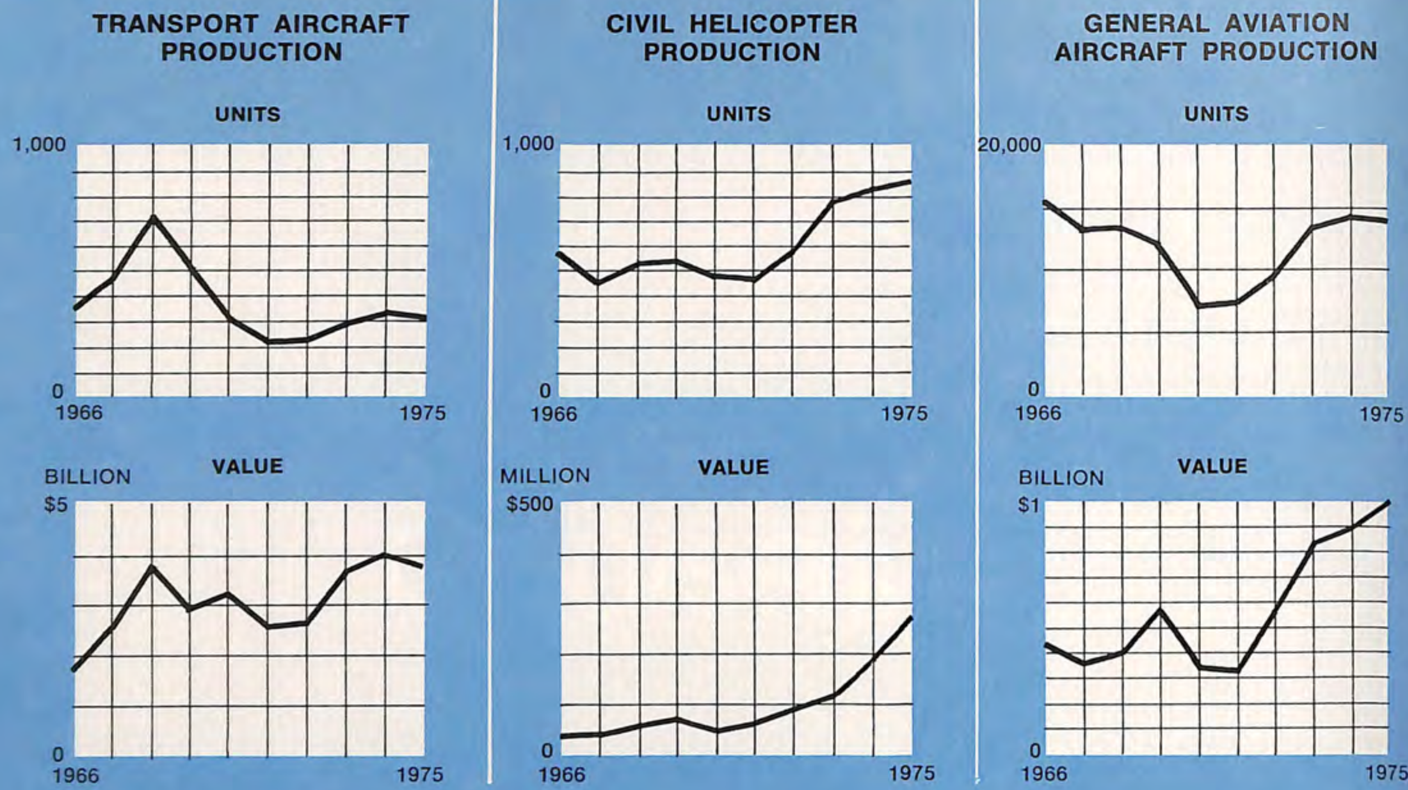
We of the aerospace industry develop on occasion a profile of who and what we are, and where we fit into the American political, social and economic scheme. On the pages that follow, we present highlights of our 1976 inventory-taking in the hope that this resume will contribute to better understanding of how the aerospace industry operates and why its economic health is vital to the national interest.

Last year almost 60 percent of the aerospace industry's output went to the federal government, and during the decade past the figure has ranged as high as 74 percent.

At the same time, the aerospace industry is the world's largest producer of civil aircraft and equipment. Roughly four of every five transports operating with the world's civil airlines are of American manufacture and the industry additionally turns out almost 15,000 civil helicopters and general aviation planes yearly.

These facts underline the unique status of the aerospace industry. Its role as principal developer and producer of defense, space and other government-required systems dictates in large measure the industry's size, structure and product line. Operating under federal procurement policies and practices, the industry is subject to controls markedly different from the economic disciplines of the commercial marketplace. But aerospace is also a commercial entity, and it must compete in the civil market for economic and human resources with other industries less fettered by government constraints.





Source: Aerospace Industries Association
General Aviation Manufacturers Association

Its dual nature as government and commercial supplier makes the aerospace industry particularly important to the national interest. Its technological capabilities influence national security, foreign policy, space aims and other national goals. Also, the efficacy of the national air transportation system is dependent to considerable degree on the quality and performance of equipment produced for the airlines and the airways operators.

Naturally, such an industry constitutes a vital factor in the U.S. economy, especially in these areas:

• ***Trade balance.*** The excellence of American aerospace products has created strong demand abroad, with the result that the industry consistently records a large international trade surplus. The significance of the industry's export performace is underscored by this fact: in 1975 the aerospace surplus was equivalent to more than 70 percent of the national total trade balance.

• ***Employment.*** Despite several years of manpower decline, the aerospace industry remains one of the nation's largest manufacturing employers.

• ***Research and development.*** The industry conducts more research and development than any other industry, and R&D is a major long-term determinant of national economic growth.

• ***Impact on other industries.*** Aerospace effort has brought forth a great many new products and processes, "spinoff" from the initial aerospace requirement, which have provided value to other industries, both in sales and in productive efficiency. Additionally, the aerospace industry is a large-scale user of other industries' goods and services; it has been estimated that for every 100 aerospace jobs created, another 73 are created in other industries.

Each of these factors represents a significant contribution to the U.S. economy; collectively, they elevate the aerospace industry to a key position among the nation's major economic entities.

The Industry in a Changing World

A critical matter in the aerospace economy is the fact that the industry operates in an environment which it has little or no ability to control. More than any other industry, aerospace is closely tied to the dictates of national policy and the impact of international events. Thus, the industry is especially vulnerable to abrupt shifts in government requirements, reordering of national priorities and world happenings, such as the 1973 energy crisis and subsequent world recession. The point is illustrated by a brief summary of the aerospace industry's performance in the years since 1960.

The decade of the sixties was characterized by intense industry activity generated by a number of government requirements. U.S. defense policy centered on build-up of the Triad, the three-sided strategic deterrent force of land-based intercontinental missiles, sea-launched ballistic missiles and long-range bombers. During the same period, new generations of tactical aircraft were being added to the military inventory. Additionally, the Vietnam war demanded increased output in certain categories of aerospace production. Concurrently with these military programs, the industry was spearheading history's greatest technological thrust to meet the man-on-the-moon commitment. Topping off a decade of extraordinary effort, production of civil jetliners also increased and the introduction of the highly-productive wide-body transports late in the decade launched a period of even more dramatic gains. Under these multiple influences, aerospace sales and employment climbed to all-time peaks in 1968.

The industry's view of the summit was brief. With the attainment of Triad force levels and the end of the Vietnam war, there came a reordering of national priorities in which defense was subordinated to social programs, Over the years since 1968, defense outlays dropped from 42.5 percent of the total U.S. budget to 26 percent; at the same time, the aerospace industry share of defense outlays also dropped, because of shifting military requirements. The industry's space program workload followed a similar path. With Apollo goals achieved, NASA's budget experienced marked decline and the aerospace share of NASA funding was reduced.

In the seventies, the defense/space decline was offset to a degree by still-increasing sales of the wide-body family of jetliners, which climbed each year to a record level in 1974. But even before the peak was attained, world events reversed the trend. Global recession halted airline growth, the energy crisis sent fuel costs soaring and inflation produced mounting labor and other costs. These factors conspired to cause cancellation or deferral of airline re-equipment plans. Lead time deferred the impact on the aerospace industry but it is now very much in evidence and the decline in civil transport deliveries will continue for some time despite a general upturn in the economy.

Since 1960, fluctuating government demands and a variety of international events have teamed to produce a rollercoaster-like sales curve, up to a peak, down to a valley. Industry sales have declined over the past seven years to the point where constant-dollar volume is approximately 60 percent of what it was in 1968, the peak year.

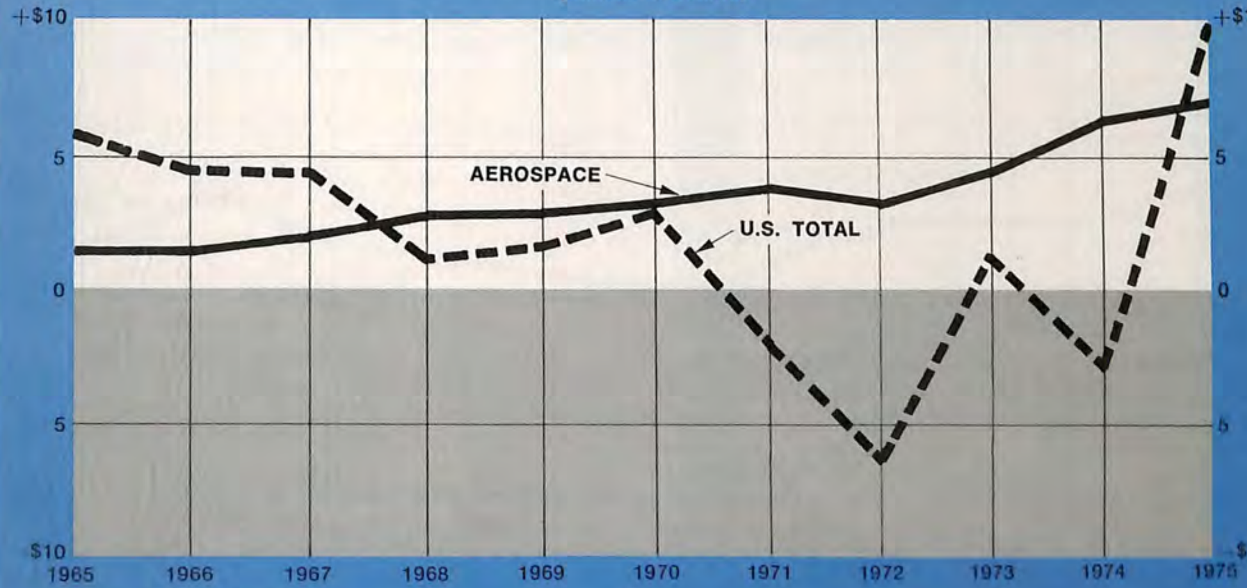
Characteristics of the Industry

The history of the aerospace industry has been a saga of continuing adjustment to changing national policy and economic conditions. Over the years, the industry's operation has become increasingly complex, each increment of complexity heightening the problem of adapting to change. Today, the industry's unique characteristics impose extraordinary difficulties in the adaptive process. An understanding of such difficulties is best served by a recollection of how the industry has been transformed in the past quarter of a century.

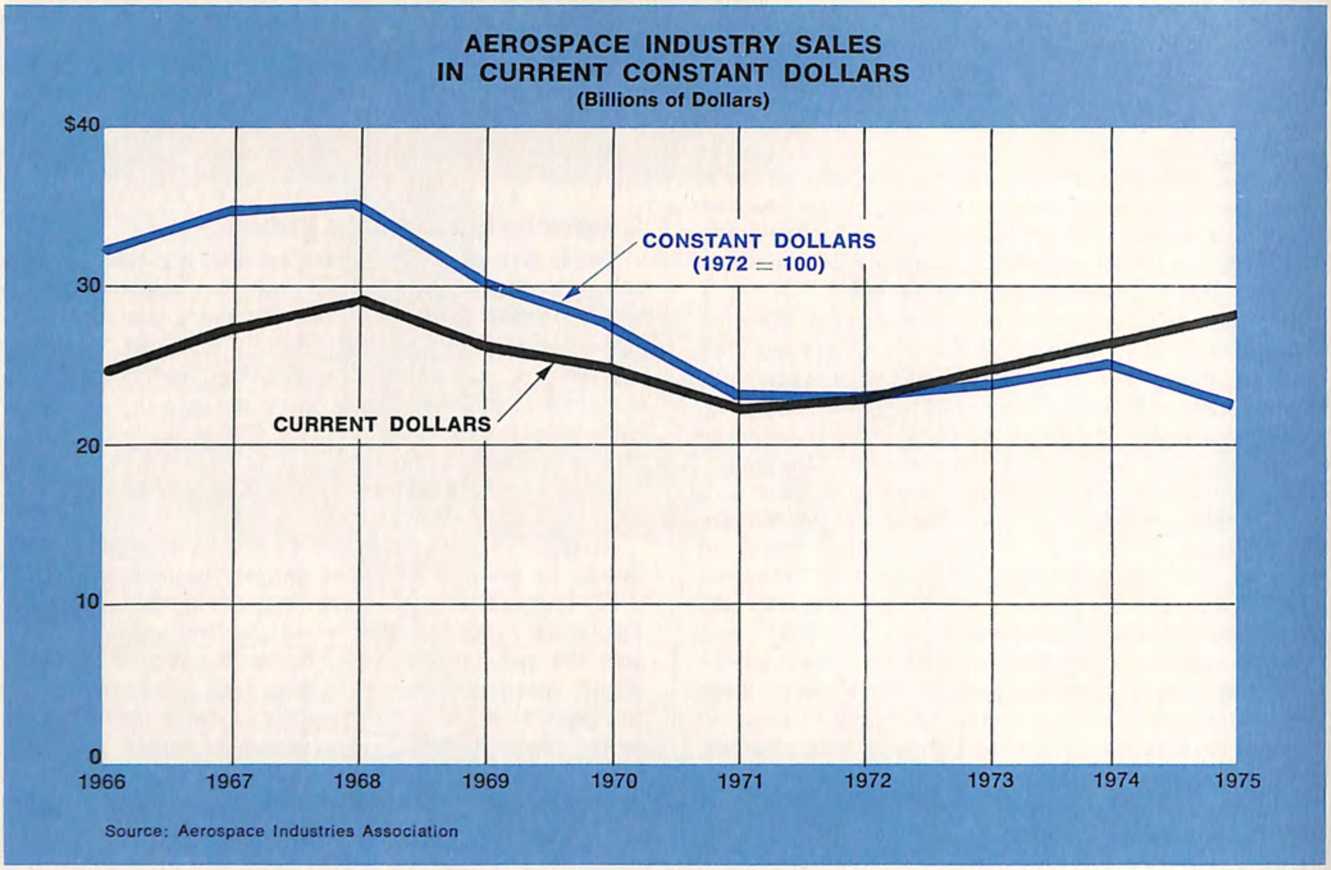
Prior to 1950, the industry was relatively unsophisticated. Its product line was entirely aeronautical—aircraft, engines, propellors, avionic components, and accessories. Long-run production of many airplane types was the order of the day. The labor force, in the post World War II retrenchment, was less than one-fifth of the peak to come. Three-fourths of the manpower was in the moderately-skilled production worker category. Research and development was an essential prelude to production, but the subsonic aircraft being built were less demanding of technological advance and R&D represented a considerably less significant portion of the total workload than it does today.

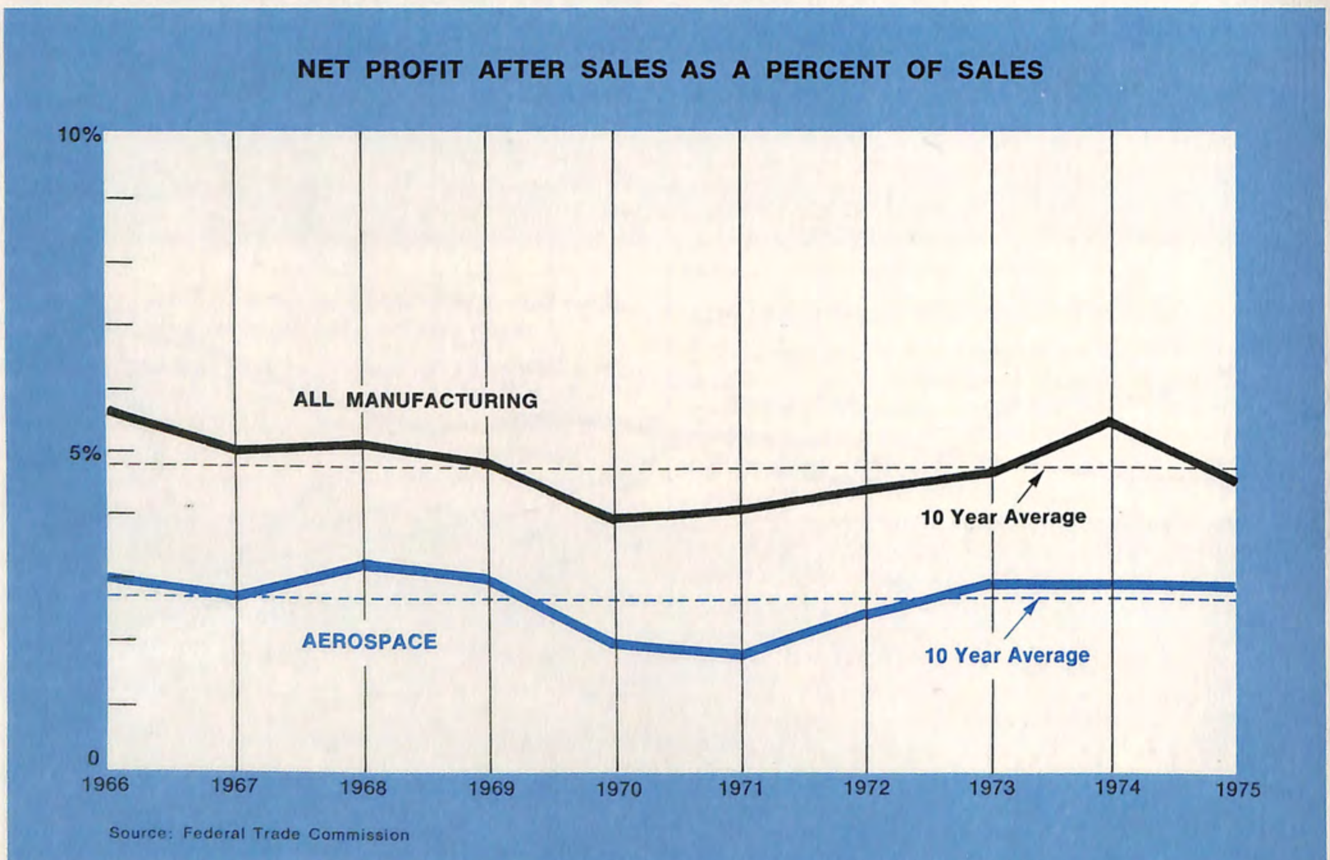
The transformation began in the early fifties, with the coming to production of the jet-powered supersonic military airplane, which induced across-the-board changes in the industry—new types of engines, totally different

BALANCE OF TRADE
U.S. TOTAL AND AEROSPACE
(Billions of Dollars)



Source: U.S. Department of Commerce


AEROSPACE INDUSTRY SALES
IN CURRENT CONSTANT DOLLARS
(Billions of Dollars)
$40
30
20
10
0
CONSTANT DOLLARS
(1972 = 100)
CURRENT DOLLARS
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
Source: Aerospace Industries Association


NET PROFIT AFTER SALES AS A PERCENT OF SALES
10%
5%
0
ALL MANUFACTURING
10 Year Average
AEROSPACE
10 Year Average
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
Source: Federal Trade Commission

airframes, different on-board equipment, new tooling and facilities, most of all a vastly greater degree of complexity in the product and in the methods of producing it. New airplane performance dictated far more emphasis on research and development. The combination of R&D and product complexity demanded a major shift in the composition of the work force to include ever-increasing numbers of scientists, engineers and highly-skilled technicians. All this placed much greater emphasis on an ever more sophisticated managerial process.

While the industry was adjusting to these changes, it fell heir to a new responsibility—development and production of guided missiles, particularly the long-ranging ballistic weapons. Then came another major change: the application of turbine power to commercial airliners, whose resemblance to military jets ended with the propulsion system; the requirements for transporting large numbers of people at high subsonic speeds and multimile altitudes involved a further modification of the industry's modus operandi. Finally, in the latter fifties, the industry was assigned still another responsibility: fabrication of equipment to meet the nation's goals in space exploration.

Each of the foregoing evolutions compounded industry change—more R&D, more product complexity, more personnel per unit produced, higher manpower skill levels, longer program time and greater need for new facilities with only single-program utility because of their specialized natures. Such changes contributed to higher costs of the end products, and the demand in the sixties and seventies for still more advanced aerospace systems further escalated both change and cost. In defense output, cost—together with the greater capability of the individual system—influenced a trend away from volume production toward "tailored" manufacture of fewer weapon types and fewer numbers of each type.

A quarter century of evolution has left the aerospace industry with a set of chacteristics unique in American manufacturing:

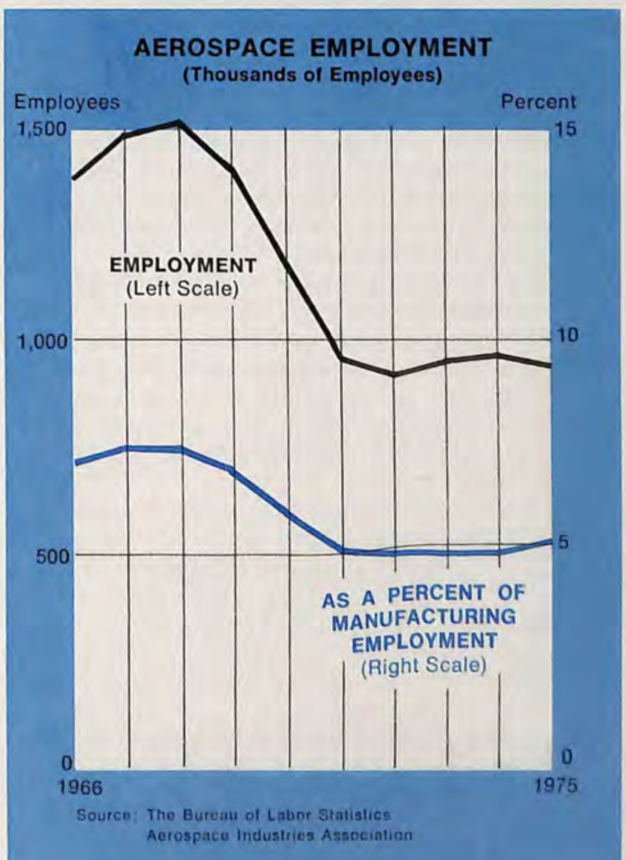
- Performance demands for new systems require continual advancement of the technological frontier, which in turn involves unusual degrees of uncertainty and risk.
- Since the government is the principal customer, the product line is subject to revisions in program levels occasioned by changing requirements and funding availability.
- Equipment that challenges the state of the art is necessarily costly, the more so since requirements generally dictate short production runs, negating the economies of large-scale production.
- Technologically-demanding programs require personnel emphasis in the higher skill levels, hence labor input per unit of output is substantially larger than that of other manufacturing industries.
- The combination of technological uncertainty and long lead times—often 7-10 years and frequently longer between program initiation and completion—makes advance estimation of costs particularly difficult.
- Few customers and relatively few programs make competition for the available business intense.
- All such characteristics contribute in one way or another to exceptional demand for industry capital, yet profits as a percentage of sales are consistently well below the average for all manufacturing industries.

Economic Profile of the Aerospace Industry

The aerospace industry is composed of about 50 major firms operating some 1200 facilities, backed by tiers of thousands of subcontractors, vendors and suppliers. The principal product line—aircraft, missiles, space systems and related engines, parts and equipment—is characterized by high performance and high reliability, hence high technology and high unit value.

Activity as measured by sales volume focuses on aircraft, civil and military, which account for almost 55 percent of the industry's workload. Missile systems represent about 17 percent of the total, space fabrication about 11½ percent. In addition, almost 17 percent comes from non-aerospace sales, which embrace the industry's growing efforts to transfer to the non-aeropace sector some of the technology acquired in aerospace endeavor.

Sales in 1975 amounted to $28 billion, broken down this way; aircraft $15.2 billion; missiles $4.8 billion; space $3.3 billion; and non-aerospace $4.7 billion. The overall figure is statistically the second highest ever recored by the industry, topped only by the all-time peak of $29 billion in 1968, but it is illusory due to the impact of inflation; adjusted to 1972 constant dollars, last



year's volume was $13 billion below that of 1968.

Aerospace sales in 1975 made a direct contribution of 1.9 percent to the Gross National Product; they accounted for 5.4 percent of durable goods production and 2.6 percent of all manufacturing sales.

In 1975, the industry showed a net profit after taxes of 2.9 percent on sales, which compared with the all-manufacturing average of 4.6 percent. It marked the sixth consecutive year in which profits remained below the three percent level, a matter of considerable concern in an industry which increasingly requires large amounts of capital to finance its programs.

Still one of the nation's largest employers, the industry had 942,000 workers on the rolls in 1975. This represented 5.1 percent of the manufacturing labor force and 1.5 percent of all U.S. civilian employment. Combined with multiplier effects on other industries, it is estimated that the aerospace industry accounted directly or indirectly for 1,600,000 American jobs in 1975.

A labor-intensive industry, aerospace employs as many salaried as production workers, the highest such ratio among comparable indutries. The emphasis on high-technology research and development in the aerospace industry demands a greater number of scientists, engineers and technicians than are utilized by most industries. At peak, aerospace employed almost 30 percent of all U.S. scientists and engineers engaged in R&D. In 1975, even after years of decline, the figure was still relatively high at 18.7 percent.

Testifying to the excellence of American aerospace products is the strong performance of the industry in the international market, which has significant influence on the U.S. balance of trade. Back in 1967, aerospace exports reached the $2 billion-a-year level and in succeeding years they have risen sharply, due for the most part to deliveries abroad of advanced technology commercial jetliners. In 1973, the industry set an all-time export record of more than $5 billion, but the following year that figure was topped by almost $2 billion. Last year saw another substantial increase to a new record of $7.8 billion. While inflation is a factor in these mounting values, export dollar volume in recent years has far outstripped inflation rates.

At the same time, aerospace imports have traditionally amounted to only a fraction of the export value—less than 10 percent last year. Thus, aerospace has consistently shown a substantial trade surplus. In 1975, it reached a new high of $7 billion. The importance of this surplus to the U.S. economy is evident in the fact that it was equivalent to 73.4 percent of the total U.S. trade balance.

The lengthy duration and high value of major aerospace programs have considerable effect on another industry financial characteristic, the debt/equity ratio. With low profits and high demand for capital, industry depends heavily on large-scale borrowings to finance new programs. As a result, the industry's debt structure has risen sharply over the last decade and the debt/equity ratio is high. Additionally, debt itself must be financed at high interest rates that increase the cost of doing business. And, to complicate aerospace economics, government regulations (at least to date) generally do not permit payment for interest costs in the price of contracted goods and services. This combination of factors reduces the attractiveness of aerospace as an investment and heightens the task of finding new capital.

Despite economic difficulties in several areas, aerospace remains a viable industry whose importance to the nation cannot be overemphasized. Its contributions to the U.S. economy become clear in this capsule summary of the industry's performance in the decade 1965-1975:

- Total sales amounted to $256 billion, an annual average of 2.5 percent of the Gross National Product.
- Export sales totaled $41.5 billion, while imports were approximately a ninth of this value at $4.8 billion, leaving a favorable aerospace balance of trade of $36.7 billion.
- Employment average 1,166,000 workers annually and the aggregate payroll was $129 billion, about eight percent of the total U.S. manufacturing payroll.
- Over the decade, the industry paid federal corporate income taxes totaling $5.2 billion.

These facts become even more impressive when one considers that the industry has been in decline for most of the past decade. Since inflation distorts dollar figures, what has happened to the work force better indicates the extent of the industry's downturn.

Since 1968, when aerospace labor rolls numbered more than 1,500,000 persons, employment has dropped at an average rate of five percent annually. Through 1975, some 560,000 jobs were lost in the aerospace industry, including 72,000 among scientists, engineers and technicians, the hard core of the technical teams responsible for advancing the state of the art. Adding the multiplier effect, it is estimated that the contraction of aerospace industry represents an aggregate loss to the U.S. economy of more than 900,000 jobs and $10 billion in disposable income. And the downward trend has not yet bottomed; industry employment is expected to drop to the 900,000 level during 1976.

The Government Market

Despite growing percentages of non-government and non-aerospace business, industry activity is still dominated by government contracts with the Department of Defense and NASA, a factor which has major effects on the industry's economic status. Periodic surveys and studies point out that federal procurement policies designed to protect the government and the taxpayer have tended to place a greater burden of risk on the contractor and restrict profits to low levels.

Government contracts are awarded and administered under a detailed set of rules unlike any other buyer-seller agreements. For example, the Department of Defense, principal aerospace customer, operates under the Armed Services Procurement Regulation, which needs more than 3,000 printed pages to spell out the guidelines for defense contracting. But this is only the top of the iceberg—there are many thousands of additional directives, instructions, procedures and manuals governing the procurement process, all of which have the force and effect of law when written into a contract.

Explicit procurement policies, of course, are essential if the government is to make most effective use of the funds available. But, where overregulation occurs, industry as well as government efficiency is impaired. There is hope for the future in the fact that both Pentagon management and the Office of Federal Procurement Policy (OFPP) are aware of the major problem areas in government/industry contractual relationships and are attempting to do something about them. Although OFPP has existed for less than two years, it has made encouraging progress toward implementation of a majority of the 149 recommendations for reform made by the Commission on Government Procurement, but improvements in procedures will take time to become practice throughout the layers of the procurement organizations. In addition, the Congress is encouraging and monitoring the reforms through the active leadership of Senator Lawton Chiles, chairman of a Government Operations Subcommittee.

The complexity of the unique government/industry, buyer/seller relationship unfortunately is well understood by only a limited number of people and by the general public hardly at all. Through the media, the public gets critical reports about end results of this complex relationship but too seldom are the reports accompanied by solid explanations of how the situation developed. Frequently difficulties stem from pitfalls inherent in the system rather than from industry or government lapse. A few examples of existing policies and procedures are illustrative of the involved characteristic of defense procurement.

The contracting process for a major system begins with the Request for Proposal, issued by the government to interested bidders. Where RFPs usually contain intensely detailed specifications as to what the government wants in the product, they reduce contractor flexibility and work against making cost-saving tradeoffs.

Since there are few major programs authorized and competition is intense, the contractor who needs the business to keep his manpower teams and perhaps his company intact must really "sharpen the pencil," driving down potential profit. Should, after all bids are in, a procuring agency resort to "auctioning" (i.e., asking contractors in the competitive range for "best and final offers")—the potential for an equitable profit is further diminished and the chances for cost growth increased.

Government programs are dependent upon Congressional appropriations made mostly on a year-to-year basis. Thus, there exists the threat to a contractor of program delays, stretchouts or terminations brought on by reduced, eliminated or delayed funding. Terminations have chaotic effect. The manufacturer who had planned on several years of activity on the contract is suddenly confronted with facilities and machinery that cannot be converted easily, if at all, to other programs and a large, specialized work force that must therefore be laid off.

Government regulations and practices consider certain necessary costs of doing business as not allowable or non-recoverable. The prime example, mentioned earlier, is interest on the extensive borrowings industry must make to finance high-technology, high-value programs. In the commercial market, interest and other government disallowances—advertising, for example—are considered normal business costs and are recovered in the price of goods and services sold. They are recognized by the government itself as acceptable deductions for tax purposes. But when government is the customer these expenses must be borne by the contractor out of profits.

A related matter is the subject of the recovery of costs for Independent Research and Development. The word *independent* refers to that R&D initiated and funded by individual companies for the purpose of advancing their general technological capabilities, improving their products or developing new ones. IR&D is essential to a company's competitive status. It is a function common to all manufacturing industries, but in the consumer market its expense is recoverable; when an auto manufacturer improves his product, he adds the R&D cost to the price of future car sales. But when the buyer is the Department of Defense, for example, legislative and regulatory constraints limit to about 40 percent the amount of IR&D costs recoverable. Furthermore, recovery for a particular company is governed by the value of government contracts it is able to win.

Finally, should the contractor on his annual defense and space business realize a profit, it will be subject to renegotiation. The Renegotiation Board may decide —on the basis of criteria that industry regards as subjective and inconsistent—that the profit level is "unreasonable" and that a portion of the profit must be refunded to the government.

In addition to satisfying regulatory requirements, there are the ever-present risks inherent in technical uncertainty. When the government contracts for a major new aerospace program, it is not asking simply for production of an established, technically-familiar item. It is asking for an advanced system, or a series of integrated systems, which do not exit, and whose development requires pushing technology to new frontiers. Long experience as the world leader in technological advancement has given the industry the know-how and confidence to cope with the "known unknowns," i.e., the predictable problems of a limit-challenging development. There always exists, however, the possibility of encountering the "unknown unknown," the unexpected, serious problem that crops up in the course of a program and stubbornly resists solution. A solution is usually found, but at the expense of substantial additional effort not contemplated in the original proposal, with attendant increases in development time and costs.

The foregoing barely skims the surface. Generally, these and myriad other intricacies in the government/industry relationship add up to severe impact on the industry's economic posture. The impact is summarized in a recent study by The Conference Board entitled "The Defense Industry: Some Perspectives from the Financial Community." The study group interviewed a cross-section of commercial bankers, investment bankers and executives of public accounting, rating service and life insurance firms. Chief among the findings were these:

"As compared with the profits of industries oriented to commercial markets, defense contractor profits are too low for the risks defense contractors face and for their long-term viability.

"Uncertainty is the principal risk perceived by the survey participants—uncertainty pertaining both to the fulfillment of present contracts and the winning of future contracts."

Because of these and other "negatives," the study concludes that "defense contractors are perceived as less attractive risks among the corporate clients of banks and other financial institutions."

The Conference Board study draws this conclusion:

"Unless these problems can be reduced, if not eliminated, the defense industry is likely to find it increasingly difficult to secure both the short-term and long-term financing it requires—especially if, as some respondents believe, the U.S. economy encounters a severe shortage of capital in the next decade."

The Commercial Market

In its commercial manufacturing operations the aerospace industry encounters a different set of problems, some of them of exceptional magnitude.

The principal commercial product is the airline transport. The traditional and obvious difficulty in this area is the fact that sales are dependent upon the financial health of another industry—the world's airlines. The commercial airplane segment of the aerospace industry is now experiencing sharply declining sales volume as a result of the airline slump of recent years. However, this is a temporary situation, and one often encountered in the past. The air transportation industry is beginning to make a recovery and, although the *when* is cloudy, there is strong likelihood of near-future resumption of airline re-equipment programs postponed during the lean years.

The need for new jetliners is evident. The world transport fleet is aging and there is a requirement for replacing the older, less efficient aircraft in service. Additionally, projections indicate that temporary over-capacity will give way to demand for more capacity as the world economy improves.

There exists an opportunity for development of a new generation of transport aircraft which will be very attractive to operators because they will be far more fuel-efficient than existing types. NASA research over several years has provided the design approach, a combination of significant advances in both aerodynamics and propulsion which promises reduction in fuel consumption of as much as 50 percent.

Such a development is tremendously important in view of the fact that airline fuel costs have trebled and quadrupled in recent years—one of the biggest problems of airline operation. A fleet of fuel-efficient jetliners offers enormous potential for the future financial health of the world's airlines. The traveling public would similarly benefit from fare structures adjusted to reduced operating costs. And there is substantial bonus value in fuel conservation.

From the technical standpoint, the fuel-efficient transport could be available by 1985. But there is a greater barrier: money. NASA has done an outstanding job of laying the foundation, but it falls to industry to build on the foundation. The fuel-efficient airplane is not just an incremental improvement over today's aircraft; it is an entirely new aeronautical system integrating a different wing and other aerodynamic innovations, new structural techniques, highly-advanced engines and superior electronics. Putting them all together in an airplane certifiable for passenger service demands years of additional research, development and test.

R&D has become incredibly costly. Inflation is a factor, of course, but the problem goes beyond that. Advancing technology becomes more difficult with each increment of progress; the greater the advance, the greater the cost. Cost is further influenced by a new consideration: civil aircraft manufacturers can no longer count on fallout benefit from military projects, which in the past offered a cost-reducing headstart occasioned by the applicability of developmental effort already accomplished. It was pointed out in NASA's recent *Outlook for Aeronautics* study that "substantially fewer spinoffs will be possible between military and commercial aircraft programs due to fewer military starts and diverging technical emphasis." Thus, commercial plane builders will have to finance additional R&D effort which once accrued as bonus.

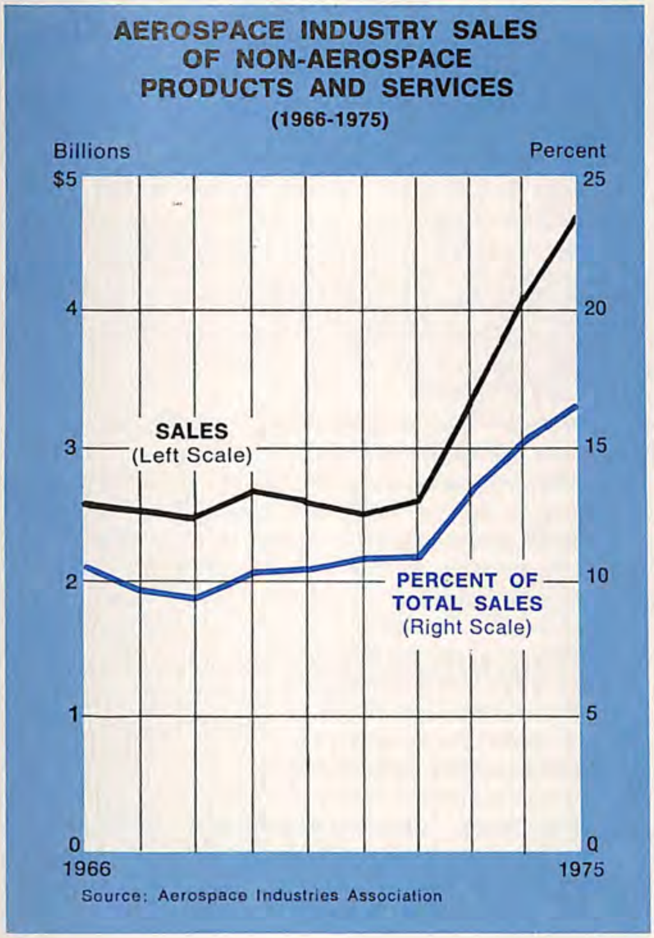
When the new airplane is developed it must be produced in quantity. This means more heavy starting costs—for facilities, tooling, equipment, materials and high-priced labor. It all adds up to this: a manufacturer might have to lay out, in R&D and production costs over a period of several years, something like $1.75 to $2 billion before he begins to recover the investment. Such a sum is considerably more than the net worth of any aerospace company; it is roughly double the 1975 combined net profit of the *entire* prime industry.

How to finance such a program is the paramount problem of commercial airplane manufacturing. Partial payments by the customers provide only a fraction of the requisite funding. The developer must raise the rest in a financial atmosphere of little current enthusiasm for aerospace investment. A risk requiring several hundred sales to break even is unattractive, particularly when an overall capital shortage is projected.

Compounding the difficulties of commercial plane manufacture is the matter of foreign competition. There has always been a degree of competition from abroad, but U.S. industry has consistently dominated the world market, its share at times topping 90 percent. A contributing reason has been the normally strong domestic market for airliners, which gives U.S. plane builders a headstart on the production base and permits more attractive pricing by virtue of the economies inherent in large scale production. Superior marketing techniques and post-sale support programs have also enhanced the U.S. competitive position. But the principal factor in American dominance of the market has been the greater technological capability of the U.S. aerospace industry.

Over the past decade and a half, the situation has been changing. Foreign governments, particularly those of Europe, have recognized the importance of research and development to their economic futures and have made increasingly large investments, most notably in aerospace. In contrast, the growth rate of U. S. R&D has declined. The result has been a substantial narrowing of the technology gap.

Additionally, foreign nations have taken a hard look at the extraordinarily large commercial airplane market—estimated at $50 billion for the decade ending in 1985 despite current uncertainties—and they have thirsted for a greater piece of the action. Toward that end, they



have sponsored airplane developments, usually on a multinational basis, and have provided other economic incentives to strengthen their aircraft industries. Effort-pooling allows sharing of the heavy development costs and has another big benefit: the larger joint market—the airlines of several participating nations—makes feasible developments that the transport needs of a single nation would not justify, thereby offsetting to some degree the traditional American advantage of domestic market breadth. Foreign competitors are strengthened by another tactic, made possible by the fact that most of the world's airlines are wholly or partially government-owned. Their governments may resort to "directed procurement," in which an airline is told which airplane it will buy, without regard for technological merit.

All these factors add up to a vastly improved competitive posture on the part of foreign manufacturers. Aside from the influence on sales of existing American aircraft, this posture also influences new start decisions. Since the magnitude of development costs demands potential sales of several hundred units to justify a start, the market dilution of greater competition becomes another obstacle to a manufacturer's attempts to find investment capital for the program.

In sum, while the U.S. is still holding on to its dominant position in transport sales, foreign gains pose a strong threat for the future. The determined efforts of other nations are beginning to pay off, as is evidenced in the growing number of foreign commercial aircraft that have found their way into the world inventory. Examples: the British/French Concorde SST, for which there is no American counterpart; France's A-300 Airbus subsonic long-haul transport; the Canadian DeHavilland Dash-7 and the German/Dutch VFW-614 short-haul transports; and the French Dauphin helicopter. Such aircraft, says NASA's *Outlook for Aeronautics*, represent technical developments equal to, and in some ways surpassing, American products. The NASA survey adds this comment:

"The sponsorship of advanced technology programs by foreign governments within their aircraft industries will provide severe competition for the U.S. aircraft industry and is a source of concern. Recognizing that foreign governments are in a position to determine which aircraft will be used in their own airline fleets, it may become necessary for U.S. companies to enter into joint arrangements with foreign aircraft manufacturers. It is clear that advanced technology is important to the U.S. aerospace industry, as a means of meeting foreign competition or as a bargaining tool in the process of arriving at joint arrangements."

U.S. manufacturers are, in fact, already entering into agreements with foreign aerospace firms and the trend is toward more such joint ventures. Joint programs, in which the partners share costs, offer a means of generating the requisite capital for advanced commercial airplane and engine developments in the face of high and rising costs. They also give the U.S. teammate access to foreign markets that might otherwise be denied him in view of the trend toward directed procurement. Offsetting these advantages to some extent is the fact that joint U.S./foreign ventures inevitably strengthen the technological capabilities of foreign industry. In short, sharing American know-how might prove costly in the long run because it further enhances the competitive posture of foreign companies. But this factor, it should be remembered, is a two-way street.

Non-aerospace Activities

Technology is simply knowledge and it has a high degree of transferability; the know-how acquired in pushing forward aerospace frontiers can be put to work to provide new products and services of a non-aerospace nature, with resultant benefit to the economy as a whole.

For many years, the aerospace industry has pursued a program of technology transfer in an effort to make broader use of its wealth of know-how. A retardant to the transfer process is lack of an aggregated market such as is provided by the federal government or the airlines in aerospace work. In non-aerospace activity, the industry has operated largely on a single-project, single-locale basis, working with individual federal, state and local government agencies and other customers to transfer technology in such areas as medical instrumentation, hospital management, mass transportation, public safety, environmental protection and energy.

Despite the lack of an aggregated market, the results have been impressive in terms of industry sales volume, particularly in most recent years. In 1973, non-aerospace sales topped the $3 billion level and in the following year climbed above $4 billion. Last year they reached $4.7 billion. While inflation must be considered in any statistical reporting, it is significant that in the last three years non-aerospace sales have increased some 80 percent, far in excess of cumulative inflation. As a percentage of total industry sales, non-aerospace effort has jumped substantially ahead of space fabrication and is challenging missile systems output for second place—behind aircraft—among the major categories of industry workload. This is an encouraging indicator for the future.

Effects of Inflation

In addition to the foregoing general difficulties inherent in the aerospace operation, other major problems crop up as results of special circumstances or events. An example is inflation, which reached extraordinary levels in the past decade and which remains a matter of concern despite a dip in the inflation rate.

Inflation is a problem to government, industry and consumer alike, but it impacts some more than others. By virute of its unique characteristics, the aerospace industry is especially vulnerable to rapidly changing costs.

For one thing, the industry has little resilience in adjusting its prices when inflation dictates. The manufacturer of consumer goods spreads his higher costs over large-volume sales, minimizing the impact per unit. In aerospace production, characterized by few customers and basically high product value, the impact per customer and per unit is dramatic. Inflation-induced price increases may bring about disruptive reduction of the customer's planned number of units, or, because of intense competition in the industry, may force the manufacturer to absorb a considerable portion of the inflated costs.

In aerospace, labor and materials constitute a greater proportion of the end product value than is the case in other U.S. manufacturing industries. Because of this circumstance, the aerospace industry requires substantially more working capital per dollar of sales than the all-manufacturing average. Since labor and materials tend to rise most rapidly in periods of inflation, the capital requirement is increased. If the company must borrow to get the capital, inflation produces an extra effect on debt/equity ratio and interest costs, which are traditionally higher in inflationary times.

Inflation effect is especially severe with regard to depreciation of tools and equipment. Depreciation is an accounting procedure whereby a manufacturer spreads the cost of equipment necessary to the manufacturing operation over a period of years equal to the useful life of the equipment. In theory, this sets up a fund which enables the manufacturer to buy replacement equipment when the original equipment is no longer useful. In practice, however, government procurement regulations and tax laws do not recognize the erosive effects of inflation; they allow depreciation only to the extent of the cost of the original equipment, which might have been purchased seven, eight or 10 years earlier.

Obviously, in times of high inflation rates, replacement equipment costs a great deal more than the original. No one expects to replace a 10-year-old auto for the same money originally paid for it. Neither can aerospace depreciation allowances based on historical cost finance the purchase of replacement equipment. The additional outlays necessary to keep facilities modern and efficient—the difference between depreciation allowances and actual replacement costs—represents erosion of capital. The enormity of the problem is evident in the findings of an independent 1976 economic study on this subject: inadequate depreciation allowances reduced the capital formation potential of the aerospace industry by more than $1.6 billion in the 10-year span from 1965 through 1974. Assuming an optimistic annual inflation rate of five percent, it will cost the industry some $4.8 billion in the 1975-84 decade.

Military Exports

An event that has potential for reducing industry sales was the 1976 enactment of a new law further regulating deliveries of military aircraft and other aerospace products to foreign nations. Such sales represent a substantial portion of total aerospace exports; last year they amounted to $2.5 billion. Any dilutlon of foreign military exports would affect not only overall industry activity but also the nation's international trade balance.

Military exports are arranged in two ways: Foreign Military Sales (FMS), which is a government-to-government transaction, and direct sales, in which the manufacturer contracts directly with the foreign government. In either case, the equipment is built by industry and sales are subjected to a long chain of reviews by a number of interested government agencies. The State Department has the final word. A sale is allowed when it furthers U.S. foreign policy objectives and serves the best interests of the U.S. Purchases of equipment which the reviewers feel the foreign nation does not need or cannot afford are discouraged.

With regard to possible effect on the aerospace industry, the provisions of the new law assign to Congress greater involvement in the military export process and, in effect, impose additional controls. The question is whether more control will negatively affect approvals of foreign requests, which would mean a further reduction of aerospace activity. It is too early to answer the question, but the possibility exists.

The Industry Outlook

Taking a look at the future, there appears to be promise for improvement in the industry's activity level. The question of defense funding for coming years is cloudy, but a number of major weapons projects are ready for transition from development to full production status and their approval would mean higher-than-current defense workload for the industry. NASA's Space Shuttle of the 1980s will usher in a new era of routinely repetitive, highly productive, relatively low cost space operations which will require additional fabrication effort on industry's part. And although commercial sales will decline further in the immediate future, the indicated financial recovery of the world's airlines and resumption of traffic growth will undoubtedly renew demand for transport aircraft in the eighties.

Thus, there is potential for a brighter industry future, from the standpoint of productive activity. However, heightened activity alone will not effect the requisite degree of financial health; it must be accompanied by improvement in the problem areas described.

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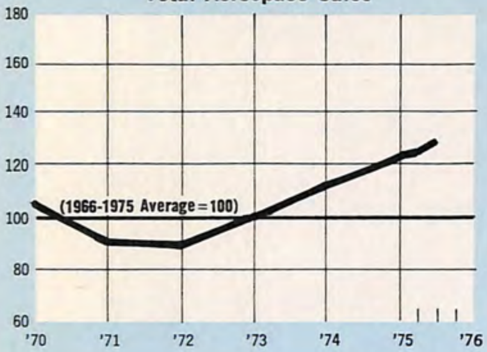
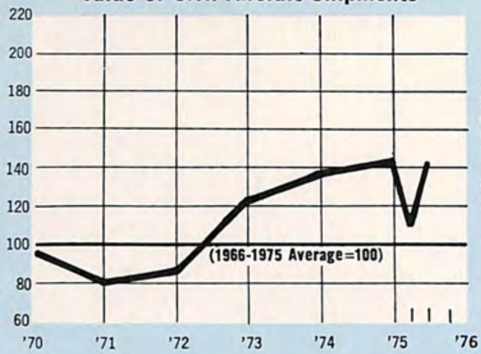
AEROSPACE ECONOMIC INDICATORS

CURRENT

Total Aerospace Sales

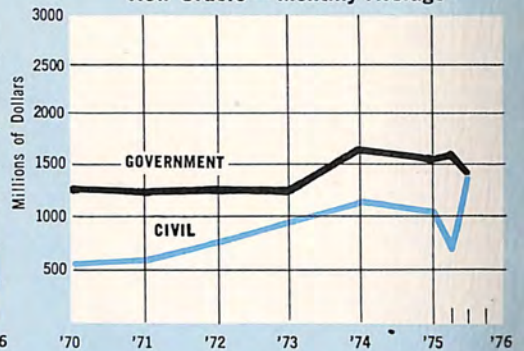


Value of Civil Aircraft Shipments



OUTLOOK

New Orders — Monthly Average



Aerospace obligations by Dept. of Defense and NASA.
Non-government prime orders for aircraft and engines.

ITEM	UNIT	PERIOD	AVERAGE 1966-1975 *	SAME PERIOD YEAR AGO	PRECEDING PERIOD†	LATEST PERIOD 2nd QTR. 1976
AEROSPACE SALES: TOTAL	Billion $	Annually	26.6	27.8	29.9	30.8
	Billion $	Quarterly	6.4	7.4	7.4	8.3
AEROSPACE SALES: TOTAL (In Constant Dollars, 1972=100)	*Billion $*	*Annually*	*27.3*	*22.1*	*22.8*	*23.2*
	Billion $	*Quarterly*	*6.9*	*5.9*	*5.6*	*6.2*
DEPARTMENT OF DEFENSE						
Aerospace obligations: TOTAL	Million $	Quarterly	3,792	3,012	3,643	4,072
Aircraft	Million $	Quarterly	2,361	1,861	2,320	2,841
Missiles & Space	Million $	Quarterly	1,431	1,151	1,323	1,231
Aerospace outlays: TOTAL	Million $	Quarterly	3,411	3,205	3,380	3,461
Aircraft	Million $	Quarterly	2,031	1,825	2,046	2,156
Missiles & Space	Million $	Quarterly	1,380	1,380	1,334	1,305
Aerospace Military Prime Contract Awards: TOTAL	Million $	Quarterly	3,327	2,588	3,828	3,210
Aircraft	Million $	Quarterly	2,109	1,432	2,966	2,464
Missiles & Space	Million $	Quarterly	1,218	1,156	862	746
NASA RESEARCH AND DEVELOPMENT						
Obligations	Million $	Quarterly	780	631	749	646
Expenditures	Million $	Quarterly	789	548	640	619
BACKLOG (46 Aerospace Mfrs.): TOTAL	Billion $	Quarterly	28.6	33.6	34.4	34.4
U.S. Government	Billion $	Quarterly	15.9	20.4	22.6	21.8
Nongovernment	Billion $	Quarterly	12.7	13.2	11.8	12.6
EXPORTS						
Total (Including military)	Million $	Quarterly	1,038	1,985	1,774	2,125
New Commercial Transports	Million $	Quarterly	345	653	413	787
PROFITS						
Aerospace — Based on Sales	Percent	Quarterly	2.7	3.0	3.4	3.6
All Manufacturing — Based on Sales	Percent	Quarterly	4.8	4.7	5.2	5.9
EMPLOYMENT: TOTAL	Thousands	End of Quarter	1,166	934	908	895
Aircraft	Thousands	End of Quarter	650	509	490	483
Missiles & Space	Thousands	End of Quarter	114	92	87	84
AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS	Dollars	End of Quarter	4.38	5.97	6.35	6.36

* 1966-1975 average is computed by dividing total year data by 4 to yield quarterly averages.
† Preceding period refers to quarter preceding latest period shown.

Source: Aerospace Industries Association

As We Look to the New Year...


Karl G. Harr, Jr.

By KARL G. HARR, JR.
President, Aerospace Industries Association

In the nation's Bicentennial year, there has been much looking backward—to the educational and spiritual benefit of us all. Fortunately, and by necessity, there also has been much assessing of where we are and what problems the nation must solve.

As a major industry, we find ourselves in the midst of many of the problems being addressed. One of the critical ones is the status of that part of the industrial base which supports our country's national defense posture and programs. Hearings on this subject were held just recently in the Congress, and the defense segment of the aerospace industry welcomed the public enlightenment provided in the testimony.

The essence of the problem was expressed by William P. Clements, Deputy Secretary of Defense, as follows: "We have suspected for some time that the industrial base was suffering from a low level of private investment, and have suspected that low level is in part traceable to a relatively low level of profitability."

For private investment to be at an adequate level in any business, there must be adequate profits. This is so whether the profits provide an internal source for investment funds or attract outside capital. As to prospects for defense industrial base funds from the outside, it was reported that the Conference Board interviewed 53 account executives of 31 financial institutions. The findings: "They reported that these financial institutions, an important source of funds for defense industry, felt that defense business was not sufficiently profitable for the risks involved."

Well, what are the facts on the comparable profitability of commercial and government business? The recent Profit '76 study reveals these comparisons on five-year average pre-tax returns on sales:

5,000 durable goods manufacturers	6.7%
147 defense business facilities	4.7%

As we look to the new year, this industry's most devout wish is that policies affecting it—whether as to profits, regulations, taxation, trade or technology—be developed from facts. The fewer the falsely based obstacles that are placed in its path, the greater the future contribution of aerospace in America's third century.

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CONTENTS

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NASA's versatile Space Shuttle, to be used initially as a platform for manned experiments and as a payload deployment and retrieval vehicle, offers future potential for erecting large structures in space.

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Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems;

Foster understanding of the aerospace industry's responsibilities in the space exploration program;

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade;

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

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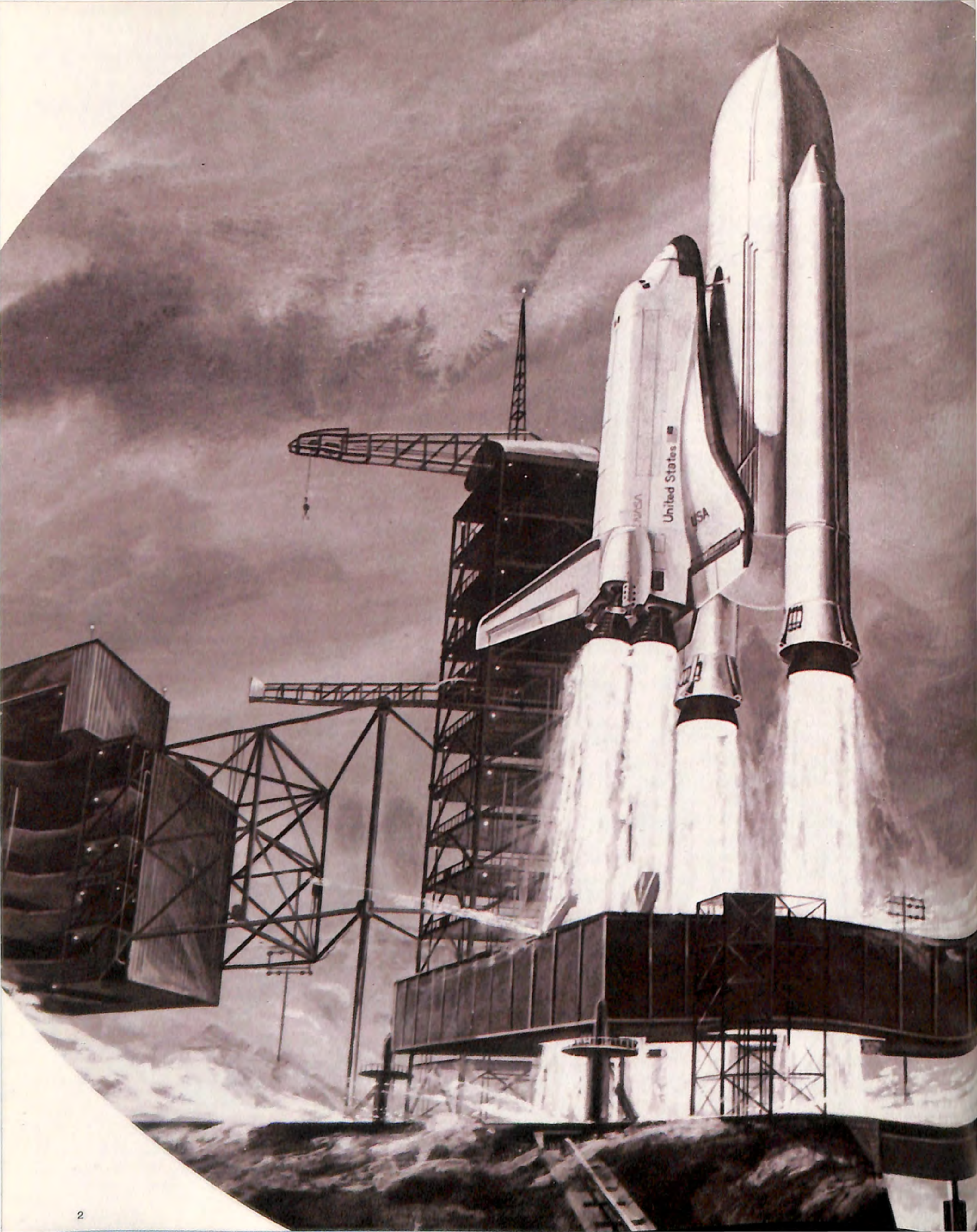
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NASA's Space Shuttle is launched by the combined power of two large solid rockets and the Orbiter's three main engines, which produce an aggregate 6.8 million pounds of thrust.

SPACE SHUTTLE

Next Giant Step for Mankind

BY JAMES J. HAGGERTY
Associate Editor, Aerospace Magazine

Can you picture an orbital solar power station more than 10 miles long, harnessing the sun's energy and transmitting it earthward to power a whole city?

Or a giant mirror in space picking up the sun's rays when it is nighttime on earth to light an entire megalopolis spanning a couple of hundred miles?

Or low cost electronic mail, with coast-to-coast transmissions in minutes made possible by an enormous space-based antenna? Or perhaps using a similar supersize antenna to make available to everyone that great invention Dick Tracy has been using for several decades—the wrist radio?

Sounds pretty wild, doesn't it? So did the idea of going to the moon.

Actually, the possibilities mentioned —and some even more fantastic— are not at all wild, although they are some distance down the pike. They represent potential projects being given serious consideration in National Aeronautics and Space Administration studies on erecting large structures in orbit.

Construction in space is one of many exciting capabilities of NASA's Space Shuttle, which will inaugurate a new era of routine and economical access to space. The reusable Shuttle, which will eliminate the need for expendable launch vehicles, will be able to deliver payloads to orbit several at a time; to service payloads in space or bring them back to earth for rework, thereby extending the useful life of costly satellites; to pave the way for manufacture in space of certain items better fabricated in the weightless environment; and to transport teams of scientists, who will be able to work in orbit and personally conduct experiments hitherto accomplished by unmanned satellites.

These capabilities afford NASA opportunity to take full advantage of the enormous potential space offers. Reduced operating costs can be translated into more payloads for direct earth benefit and for greater accumulation of scientific knowledge, tomorrow's practical benefit.

The new era formally begins in 1980 with first operational use of the Shuttle. In a sense, however, 1977 is the Year of the Shuttle, the year in which the principal segment of the Shuttle system—the Orbiter—will first take to the air.

The Orbiter is the manned portion of the Space Shuttle Transportation System, which also includes a pair of recoverable 150-foot solid rocket boosters and a huge external tank. At launch, power is supplied by the boosters and by the Orbiter's three main rocket engines, which draw their fuel from the big tank. After the boost phase, the solid rockets separate to descend by parachute for ocean recovery. The fuel tank is jettisoned when it has served its purpose and is not recovered. The Orbiter, using internal fuel for flight path corrections, operates as a maneuverable spacecraft for the duration of its mission, then returns to an earth landing like an airplane.

In its debut, the Orbiter will operate only as an airplane, because 1977 flights are confined to the atmosphere. Manned orbital development flights will begin in 1979 and the following year the Shuttle Era will become official with the first operational flights.

With operational advent of the Shuttle, a broad new vista of space opportunity will open to NASA. Some of the potential is not even imaginable yet; NASA officials feel that experience with the Shuttle will suggest entirely new avenues for pursuit of scientific gain or practical benefit. In the meantime, a resume of Shuttle uses already apparent and planned gives an idea of this versatile system's exceptional capability.

Payload Delivery

One of the greatest money-saving uses of the Shuttle is delivery of payloads to orbit, obviating the need for expensive boost vehicles. In this role, the Shuttle is often likened to a "space truck," dropping off a number of payloads at selected points in space in the manner that a newspaper truck drops its bundles at street corners. It's not a bad analogy, but the job isn't quite that easy.

A satellite, of course, is not dumped willy-nilly into space. To be effective in its job—reporting weather, earth resources or scientific data, for instance—it must operate in a specific orbit; thus it must be delivered to a specific point in the heavens.

The requisite orbit and inclination —the angle of the orbit to earth's equator—dictate the point of launch. Shuttle flights will depart from one of two locations: Kennedy Space Center, Florida, for inclinations of less than 60 degrees, and Vandenberg Air Force Base, California, for higher inclinations and polar orbits. From these two bases, the Shuttle can attain any desired orbit.

The type of orbit influences maximum payload of the Shuttle Orbiter. Launched from Kennedy into low-inclination orbit; the Shuttle can deliver 65,000 pounds to space; as much as 40,000 pounds can be lifted from Vandenberg into polar orbit.

Weight is not the whole story, however, as far as satellite deployment is concerned. The number of satellites that can be accommodated is limited by the dimensions of the Orbiter's cargo bay—65 feet long and 15 feet across. The Orbiter may carry as many as five small payloads but in some cases a single large satellite will fill the bay.

Once in space, the Orbiter is flown automatically by computer most of the time, although the two pilots have manual control options. Navigation is accomplished by a combination of on-board equipment and data supplied by the ground-based tracking network.

Frequently forgotten, because space movies make everything appear to be standing still, is the speed of an object in orbit; the Orbiter travels at about 17,500 miles per hour. The key to its ability to deploy payloads is the fact that anything ejected from an orbiting vehicle assumes the same velocity and orbital path. Therefore, a satellite deployed by the Orbiter will not "fall down;" it will travel along with Orbiter.

As the Orbiter approaches the release point for a satellite deployment, the cargo bay doors on the upper side of the spacecraft fuselage are opened. Mission specialists—normally there will be two scientists or technicians in addition to the two pilots—direct the deployment from positions at the rear of the flight deck. The deployment team works at a console which contains displays and monitoring devices, controls for maneuvering the Orbiter, and controls for the Remote Manipulator System.

The RMS is a triple-jointed extendable-retractable robot arm with an "effector" at its extremity, a fitting with which the arm grips payloads for deployment or retrieval. The arm is mounted along the side of the cargo bay; for some missions it may be desirable or necessary to use two arms, in which case the second would be mounted on the opposite side of the fuselage. Equipped with a remotely controlled TV camera to give its operators a close-up of the deployment, the arm can be extended 50 feet in any direction. The RMS represents one of two major international cooperation projects within the overall Shuttle program; it is being funded, designed, developed and built by a Canadian industrial team under direction of the National Research Council of Canada.

For deployment operations, the manipulator is inserted into the satellite's fitting, the robot arm extracts the satellite from its transport cradle and moves it well clear of the Orbiter —to protect the Orbiter from collision and to protect the satellite from the Orbiter's station-keeping thrusters. Then the satellite is released and its orbit refined by firing the satellite's own thrusters. The orbit-refining process may be handled by the Orbiter crew or by a payload specialist team on earth.

The foregoing assumes that the satellite is destined for low-altitude orbit. A number of spacecraft, however, are designed for high-altitude circular or elliptical orbits, for high-altitude launch into deep space, or for geosynchronous or stationary orbits 22,000 miles up. The Shuttle was not designed to reach such heights; it would have greatly increased costs and complicated the development task. The Shuttle operates in the 100-150 mile altitude zone and for higher orbits a supplementary system is required.

In such cases, the satellite will be equipped with a solid fuel propulsion stage to lift the satellite from Shuttle altitude to the desired altitude. After deployment, the Orbiter will move a safe distance away while the propulsion stage is fired by radio command from earth or from the Orbiter. In the event of a propulsion stage malfunction, there will be no loss of expensive equipment, as happened many times in earth launches. The Orbiter crew, monitoring visually and by data displays on their console, can recover the stage and the satellite for on-the-spot repairs or, if the trouble is complicated, for return to earth. Initially NASA will employ an Interim Upper Stage which is not reusable; later there will be recoverable/reusable upper stages for moving from low to high altitude orbits, and perhaps a manned space tug for certain types of orbit transfers.

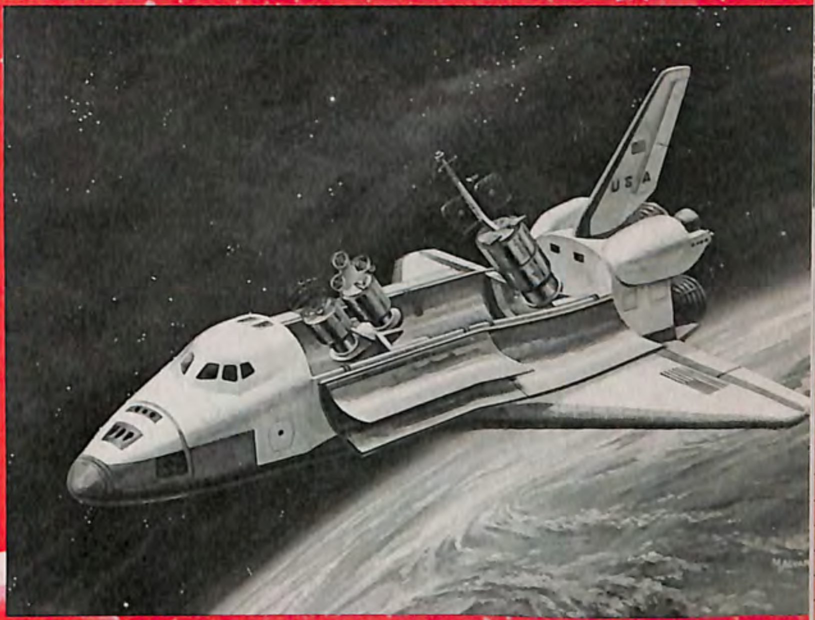
Extravehicular Activity

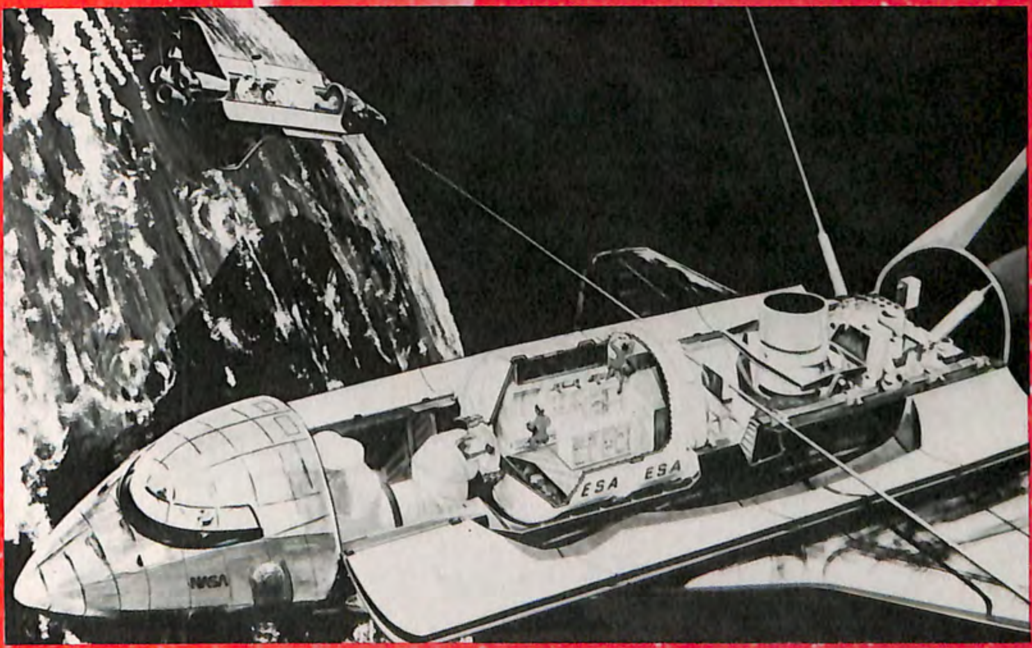
Payload deployment will most likely be automated in most missions, but there may be times when astronauts are needed in the cargo bay or outside the spacecraft, or there may be occasions when extravehicular activity (EVA) is not planned but becomes essential to the accomplishment of the mission. In any event, other types of missions will demand EVA and NASA is conducting extensive training and development toward that end.

NASA has already acquired 265 hours of EVA experience in the Gemini, Apollo and Skylab programs, so EVA techniques and equipment are well developed. An advanced EVA system for the Shuttle is the Extravehicular Mobility Unit (EMU), which includes a pressure suit with thermal and micrometeoroid protection, a life support system and a communications system. With the EMU, an astronaut can work in the cargo bay—or outside of it—for six hours at a time. For occasions when the astronaut must move a considerable distance from the Orbiter, there is the Manned Maneuvering Unit, a backpack device which is attached to the EMU. With the Manned Maneuvering Unit's thrust-

Manipulating the robot arm controlled from the flight deck, the Orbiter crew prepares to capture an orbiting satellite for on-the-spot servicing or return to earth for rework. This Shuttle capability affords large savings in satellite life extension.

Orbiter normally deploys satellites at altitudes below 500 miles. In this photo, satellites intended for higher altitude operation are equipped with solid propulsion stages which provide secondary boost.





Spacelab, a pressurized module which fits in the Orbiter's cargo bay, permits human-directed experiments in space.

ers, the astronaut can fly unencumbered in space. Another adjunct to EVA operations is the airlock, which provides a means of transfer from the shirtsleeve environment of the cabin to the vacuum of space (the cargo bay is not pressurized.)

Payload Retrieval

Retrieving a satellite for rework and reuse is another obvious area where the Shuttle offers large-scale savings. This operation will also be accomplished by the robot arm under flight deck control, but again there may be instances where EVA is necessary.

It may be possible to retrieve some currently-operating satellites by EVA or by using two remote manipulator arms, but generally speaking a satellite must be designed for retrieval. It needs, for example, a fitting compatible with the manipulator and it needs radio and visual beacons to assist the Shuttle in the rendezvous.

Guided by earth control and its own navigation system, with help from the satellite's beacons in the final stages of the rendezvous, the Orbiter is jockeyed by firings of its rocket thrusters until it is within "arm's length"—the 50-foot length of the robot arm—of the satellite to be captured. An essential prefacing step to the retrieval is deactivation of the satellite by radio command. This is necessary because the satellite has thrusters of its own, which are programmed to keep the spacecraft in a particular orbit; if they detect a deviation, the thrusters will fire to correct it. Thus they would resist the robot arm's attempt to move the satellite. After deactivation, the manipulator hooks into the satellite's capture fitting, pulls it into the cargo bay and locks it in place in the transport cradle for the return to earth.

The Space Shuttle makes possible erection of multi-occupant space stations. Individual modules delivered by the Orbiter are maneuvered to dockings with a central core.

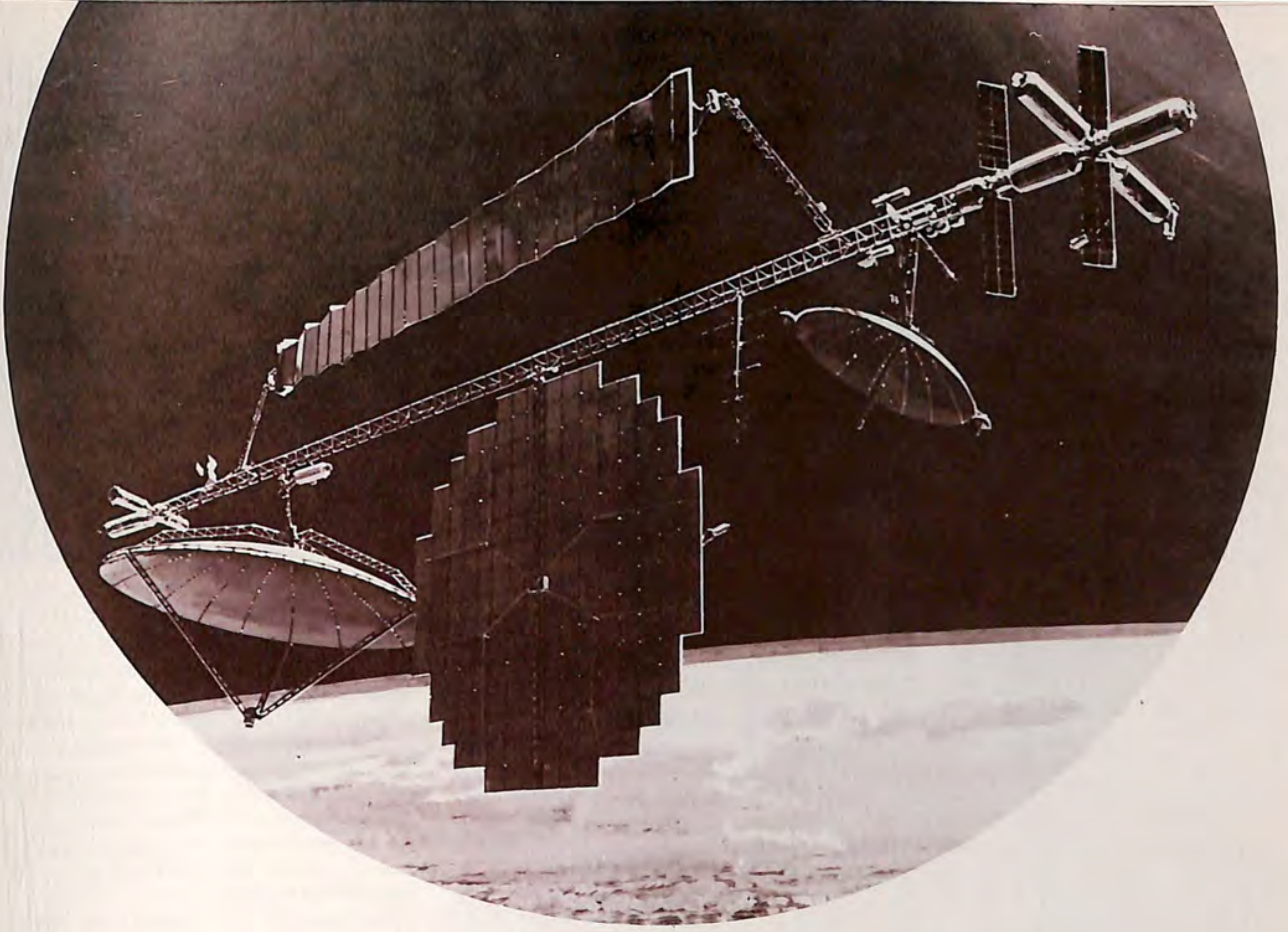
On-orbit Servicing

One of the most interesting and economically important Shuttle advantages is its ability to service a satellite in space—"on-orbit servicing," NASA calls it. This capability is a money-saver not only because it extends the service life of satellites but also because it gives the payload designer new latitude; he can design for lower cost and better performance by employing standard hardware in exchangeable modules. NASA is planning a family of on-orbit serviceable satellites whose modular subsystems can be extracted and replaced.

Difficult as it sounds, the replacement operation can be accomplished by human-directed automation without extravehicular activity on the part of the astronauts.

For on-orbit servicing, the Orbiter's cargo bay is equipped with a rotary magazine containing a number of replacement modules and a module exchanger. The robot arm captures the satellite and moves it to a work platform in the cargo bay. Then, under control of the mission specialists, the replacement modules are presented to the exchange mechanism, automatically and on a predetermined schedule. The exchanger removes the old module from the satellite, stows it temporarily, takes the new module from the magazine, inserts it into the satellite, then deposits the old module in the rotary magazine. After checkout, the satellite is again deployed in orbit by the robot arm.

Obviously, human astronauts working in extravehicular gear could also handle this basic replacement assignment. And a great many others that may prove exceptionally difficult to automate or that cannot effectively be automated since human judgment is essential. So there will undoubtedly be a number of servicing jobs better accomplished by human extravehicular activity than automation, possibly tasks like these: inspection of orbiting spacecraft, photography, use of tools, cleaning of optical surfaces, connecting or disconnecting fluid or electrical lines, and repositioning and calibrating antennas or solar panels. Decision as to whether a particular assignment should be automated or manned will depend on cost-effectiveness and which mode offers greatest probability of task success. In some cases, mechanized operation may prove the simplest way of doing the job; in others EVA may obviate the need for a highly complex automated system.



A possible near-future demonstration project is this Shuttle-erected orbital structure supporting solar energy arrays and large antennas.

Spacelab

A very important element of the Shuttle system is the Spacelab, an international program under the aegis of the European Space Agency. Eleven European nations are spending almost half a billion dollars to develop and build the initial flight unit of the space laboratory and they will later handle follow-on production.

Spacelab will permit human observation and direction of experiments hitherto accomplished by unmanned satellites. In a pressurized module that fits into the Orbiter's cargo bay, scientists may work in shirtsleeve environment for seven to 30 days. In an alternate Spacelab configuration, an unpressurized instrument "pallet" is substituted for the pressurized module; in this unmanned configuration, experiments are controlled by the payload specialists from their positions on the aft flight deck and the specialists may enter the cargo bay in extravehicular garb when instrument servicing is needed.

Spacelab offers an exciting extension of the earth-based laboratory, making possible a broad variety of experiments accomplished more effectively in space—for instance, telescopic viewing of deep space undistorted by earth's layer of atmosphere, or observations under long-term gravity-free conditions. The ability to operate manned observation posts in space on a regular basis also opens up enormous potential for further advancing the rapidly expanding art of improving earth resources management by orbital survey. An interesting sidebar to earth-viewing missions is that the Orbiter will spend a major part of its time upside-down, in order to orient instruments earthward. Inverted flight will make no difference to the crews, since in the weightless environment of space there is no up, no down.

Building in Space

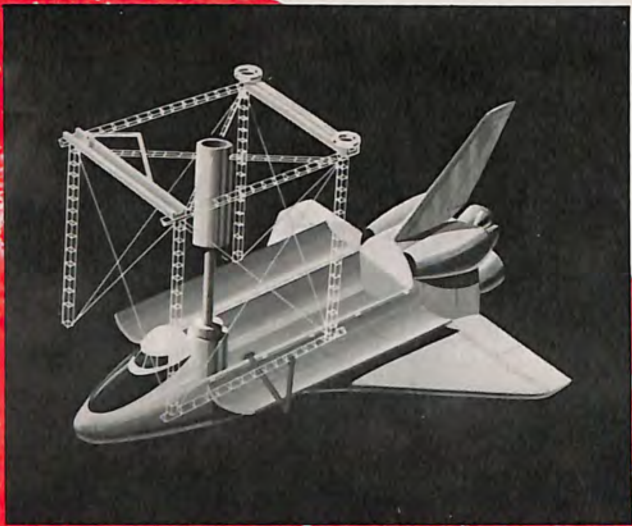
Perhaps the most fascinating aspect of Shuttle capability is its potential as both a materials delivery truck and a construction base for erecting large structures in orbit.

That familiar product of science fiction, the large, long-duration, multi-occupant space station, can become a reality in the Shuttle era—in fact, it is one of the least demanding of the structure-erecting tasks envisioned.

The space station would be built on the modular approach, each module designed to fit in the Orbiter's cargo bay and each equipped with a docking mechanism. The Shuttle would begin assembling the station by delivering to orbit a central core containing several docking positions. On successive trips, it would bring new modules—living quarters, equipment modules, life support modules, etc. Using its own thrusters, the Orbiter would maneuver until the module in its bay docked with the central core or with another module. The Orbiter would then disengage and move on to its next mission.

Using this Tinker Toy approach, the space station could be expanded to any size, for use as a scientific laboratory, an earth resources survey center, a space manufacturing facility, or all of these in combination. Food, water and other expendables, packed in dockable resupply modules, would be shuttled to the station on a regular basis.

Space scientists contemplate a number of possible structures that do not require human occupancy. Some examples include a giant radiotelescope, larger than anything of its type on earth, picking up electromagnetic radiations from distant space; huge



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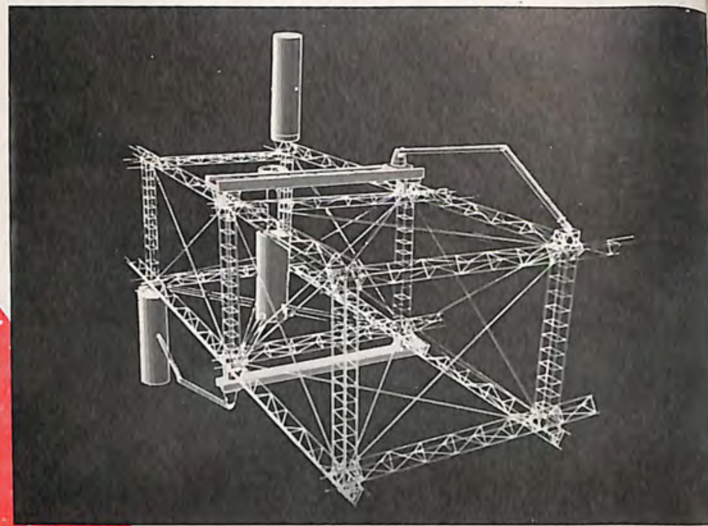


B

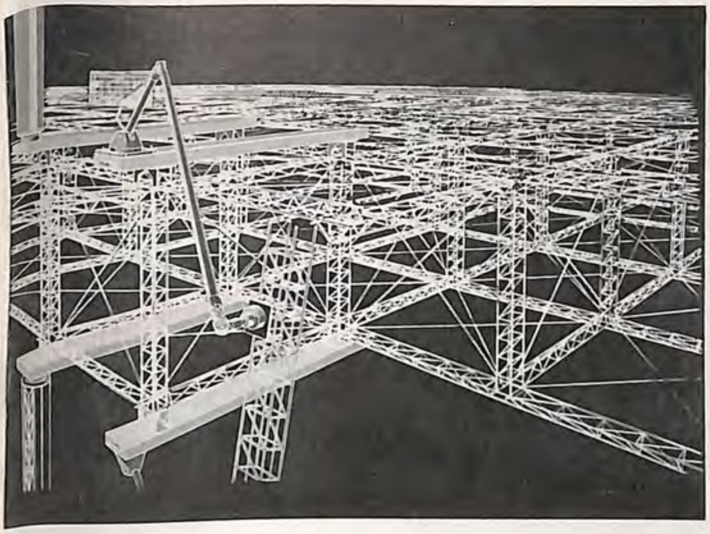
Long range plans contemplate erection of very large structures in space for such applications as earth illumination and harnessing solar energy for earth use. In photo sequence, first step (A) is construction of an initial cube from foldable aluminum beams; (B) a second cube is mated to the first by remotely-controlled robot arm or, alternately, by extra-vehicular construction crews; (C) structure is expanded by addition of more cubes. For high altitude use, (D) structural subsections are boosted by space tug.

solar-powered antennas relaying signals from one point on earth to another, their power so great that earth power requirements for transmission would be minimal; enormous mirrors, so positioned in orbit that they could catch and reflect the sun's rays for illuminating portions of the earth where it was nighttime; and a space-based system of supplying solar energy for earth use.

In this latter concept, a great "farm" of solar cells would capture the sun's energy and convert it to electrical current, as is done on a regular basis in spacecraft. The electricity would be directed to a central power station within the space structure, where it would be converted to radio energy for microwave transmission to earth. On earth it would be reconverted to electricity. Planners are thinking in terms of orbital stations that could generate 5,000 to 10,000 megawatts of power; this suggests a structure more than 10 miles long to provide a platform for the solar farm, composed of thousands of cells, and the associated energy conversion and transmitting equipment. In addition, the station would operate in stationary orbit, 22,300 miles high, a factor which complicates the construction task.

A structure like this would also be assembled Tinker Toy fashion, with a platform in the Orbiter's cargo bay serving as a construction base. Key to the concept is the individual beam, which must be designed to fold up into a compact package for delivery to orbit, then unfolded into an open-framework unit about a yard wide and 60 feet long.

Taking the space solar power station as an example, the erection process would begin with assembly atop the Orbiter of a cubical core



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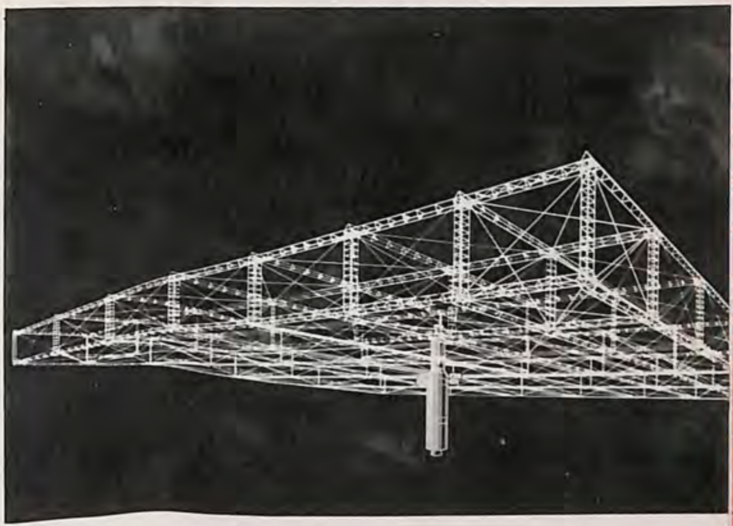


D

from a supply of foldable aluminum beams carried in canisters in the cargo bay. The Orbiter's robot manipulator would extract the beams from their canisters, extend them to full length, then mate one beam with another by merging their fittings; the mating could also be handled by human extravehicular assembly specialists.

The core cube completed, it would be disengaged to float in orbit while the Orbiter's robot arm went to work to produce a second cube. The two cubes would be mated in one of several ways: by the Orbiter's robot arm, or perhaps two of them; by a remotely-controlled manipulator affixed to the core cube; or by human extravehicular activity. By adding one cube at a time, the structure could be expanded to any desired size.

The merged cubes make up only the basic platform, which must be topped by the solar cells—possibly unfolded in sheets from canisters—and the energy conversion system—most likely delivered in modules, docked together and joined to the platform.

All this takes place at low orbital altitude—less than 500 miles—because of the Shuttle's limitations. The next step would be boosting the platform to its operational altitude of 22,300 miles, where it would be stationary with reference to a point on earth. The station would be transferred in sections by a space tug, in a manner comparable to the movement of barges by surface tugboats. The space tug would necessarily be powerful, sophisticated and probably manned, for there would remain the final step of mating the sections in stationary orbit.

It must be emphasized that construction tasks of this order are some distance in the future. They require extensive technology development in such areas as manned or automated assembly in orbit and moving very large structures from one altitude to another. But the concept has been given a lot of study and space construction definitely figures in NASA's plans.

The first step, early in the Shuttle era, will probably be a simple experiment involving use of the Orbiter's robot arm to unfold and erect a single aluminum beam. On a later flight, a Shuttle crew may use a manipulator to build a framework cube. Then, possibly within a decade, will come a structural assembly demonstration project. One study suggests construction of an orbital platform measuring about 240 feet by more than 100 feet, assembled from 500 foldable aluminum beams carried aloft on six Shuttle missions. The demonstration would include an actual working system, perhaps a supersize communications relay antenna or a king-size radiotelescope used as a listening post for extraterrestrial signals.

Initial Tests

Space construction and other exciting applications of the Shuttle must await future decades, but the Orbiter will make its flight debut in a couple of months. Orbiter, the airplane/spaceplane, will be an airplane initially, because 1977 flights are confined to the atmosphere. NASA's first job is to check out the aerodynamic and control characteristics of the craft in a series of tests at Dryden Flight Research Center, Edwards Air Force Base, California.

The test program is launched in January when the Orbiter is moved 35 miles to Dryden from the Palmdale, California, facility of Rockwell International's Space Division, where the spaceplane was assembled. In February, the Orbiter will be lifted atop a specially-modified Boeing 747 for a number of captive flights. On these tests, the 747 will carry the unmanned Orbiter piggyback to an altitude of 25,000 feet but will not release it. Next, a two-man crew will fly in the Orbiter on a second series of captive flights to verify the Orbiter's systems.

The approach and landing test phase, consisting of eight manned "free" flights, will begin in July, 1977. Carried aloft by the 747 on these missions, the Orbiter will be released at about 28,000 feet, from which point it will make a five-minute glide flight to a landing at Edwards AFB.

The landing tests will spread over a six-month period, into early 1978. After that the Orbiter will be ferried by the 747 carrier to Marshall Space Flight Center, Huntsville, Alabama, for an extensive series of ground checkouts in NASA's huge Dynamic Test Facility. In this part of the program, the Orbiter will be mated with the other elements of the system—the solid boosters and the big fuel tank. To check out vibration and stress, the launch phase of a space mission will be simulated in the facility. The Orbiter's three main engines and the two solid boosters will fire simultaneously in these tests, producing an aggregate 6.8 million pounds of thrust.

First of six Shuttle development flights is targeted for a March 1979 launch from Kennedy Space Center, Florida. These flights, roughly one every 60 days, will be manned orbital checkouts of all systems. The development phase will conclude in March 1980 and in May of that year the Shuttle Era will officially begin with the first operational flight.

NASA's Tech House, located at Langley Research Center, Hampton, Virginia, incorporates a variety of advanced technology systems to cut home fuel consumption by two-thirds and water usage by half. Panels on roof are solar collectors, principal source of energy for home heating.

On Apollo missions, moonwalking astronauts deposited on the lunar surface a small, portable seismometer to record moonquakes and data on the moon's density and thickness. Hardly the sort of thing one would expect to turn up in home usage, is it?

But it does have such applicability. Already in trial use in a technology demonstration home at NASA's Langley Research Center, Hampton, Virginia, is the Seismic Security Detector, a low cost version of the lunar seismometer, which poses a serious threat to the burglary profession. You plant it beneath your lawn, activate it at night and when a prowler steps on your turf his presence is announced by an alarm within the house—and also in the local police station.

The seismic device is one of many aerospace spinoffs assembled in NASA's Tech House, which incorporates a variety of advanced technology systems in a superefficient home. Tech House design focuses on use of solar energy and other systems to reduce home fuel consumption by two-thirds and on conservation methods to cut water usage in half. Additionally, the house provides bonuses in greater comfort, convenience, security and fire safety.

NASA is not going into the homebuilding business. The agency's aim is to show how large-scale savings can be realized by the individual homeowner, and how great national benefit in resource conservation could accrue from application of advanced technology to new home construction. All of the equipment and design features in Tech House are now publicly available or will be within five years. Most are aerospace spinoffs, but new commercial homebuilding technology is also employed. Each feature was selected because it affords either monetary savings, new levels of convenience or improved safety and security.

The project's main thrust is an attack on utility charges, which are climbing like a rocket. Estimates hold that energy costs will continue to climb at about 10 percent annually. Water charges are rising at a similar rate. In some locales—parts of Alaska, for instance—monthly utility bills already exceed mortgage payments. Experts say that situation will become general in the not-too-distant future. But not if you live in Tech House, or a home like it. A NASA study estimates that the design features of the space age dwelling would pay back the owner more than $23,000 in utility savings over a 20-year mortgage span.

Tech House is a three-bedroom home which could be built for $45,000-$50,000, a figure not far off today's average. It is not intended to be a prototype of a mass production house but a laboratory to verify the savings potential of the many innovations. The home was completed in mid-1976 and, beginning next March, it will be occupied by a selected family of four for a year, during which NASA will run a computerized checkout of all systems.

Solar energy is the key to the energy saving potential of Tech House,

at home with technology

but the home is not entirely independent of electricity; there is an electrically-driven heat pump which serves as an auxiliary to an array of sunlight-capturing solar collectors. However, the sun's rays provide about 80 percent of the energy requirement for heating and cooling the home, and for domestic hot water needs.

The solar collectors—19 of them—are on the roof, facing south for best exposure to the sun. Each panel has a glass outer plate and an inner metal plate, with water pipes running between them. The inner panels have coatings of black chrome, developed in spacecraft solar cell research, which prevent captured solar heat from reradiating outward and increase the efficiency of the solar collection process by 20 percent.

The working fluid for both heating and cooling is water, contained in an insulated 2,000-gallon underground tank. Heat—or coolth—is extracted from the water by a heat exchanger and blown as air through ducts to keep the home's interior at a desired temperature. It works this way:

For heating, the water is circulated from the tank through the solar collectors and heated by the sun's rays to a temperature of 140 to 170 degrees Fahrenheit. When the house needs heating, the heat exchanger automatically blows warm air into the home. If living area warmth is already adequate, the water bypasses the heat exchanger and goes back to the tank, to elevate water temperature for later use.

An obvious question is what happens when it rains for a week, or when lengthy overcast periods block sunlight capture? Then the electric heat pump comes on line automatically; sensing when water temperature in the tank drops below 110 degrees—as it would after five overcast days—the heat pump elevates tank temperature and sends electrically heated water to the heat exchanger. The exchanger draws out the heat, delivers it to the living area, and the water is routed back to the tank.

For cooling, the process is reversed. The storage tank water must first be cooled. This is accomplished by routing it—at nighttime—through radiators on the roof of the house. Heat is radiated out of the water and the cooled water delivered back to the tank, then through the exchanger for conversion to cool air.

Domestic hot water heating is a two-step process. Water in one tank is solar-heated to a certain temperature, say 160 degrees. That isn't hot enough for most household needs, so the water is fed into a second tank for further heating by electricity. The advantage is that electricity is needed for only a part of the heating requirement; preheating by solar energy generally meets about 80 percent of the need.

A big factor in energy saving is the fact that Tech House is insulated like a thermos bottle. The floor is a two-inch-thick cast of prefabricated concrete insulated with a layer of gypsum foam; walls and ceilings have three to six inches of tripolymer foam, a superior insulator. Outer doors are built sandwich fashion, with a core of tripolymer foam between two metal facings. Windows are double-paned and also have exterior "thermal shutters," cousins to venetian blinds, which are rolled down to make a window seal. The shutters are not products of aerospace technology; they have been used for years in Europe, but their insulating qualities made them attractive for Tech House.

All these insulating measures pay off in temperature containment. Where a conventional home of comparable size—1,500 square feet of living area—would need a two-ton air conditioning unit, Tech House keeps the home comfortable with only half that requirement.

A cleverly designed fireplace offers a bonus in heat containment. In the ordinary fireplace, air for combustion is drawn from the already warm living room—which means heat wastage. In Tech House, the air is drawn from the outside through ducts. A glass screen blocks escape of warm room air through the fireplace yet permits fireplace heat to enter the room by radiation. Additionally, the fireplace grate is made of pipes through which water is circulated; the water is heated and returned to the storage tank, elevating tank temperature and easing the job of the electrically-driven heat pump when it is needed.

Other energy saving features include:

- A larger than normal roof overhang on the south wall, which blocks the sun's rays in summer but allows them to enter the home—because of the higher angle of the sun—in winter, when heat gain is desirable.
- A large skylight above the foyer, which admits radiant heat in the winter and, in any season, admits daylight to the central living area, reducing the energy need for artificial light.
- A computer-directed comfort control system, programmed according to the living habits of the occupants, which maintains precise temperature control—no overheating or overcooling—and heats or cools only the rooms in use at a given time.
- A solar cell, located on the garage roof, which converts sunlight directly to electricity for charging a battery. The battery powers infrequently-used electrical equipment —emergency lights and security systems, for instance—with no addition to the utility bill.

What do all these energy saving measures mean in terms of money savings? A study which compared Tech House with a contemporary home of equal size showed a dramatic advantage for the NASA dwelling. The comparison house uses 46,000 kilowatt hours of energy a year, Tech House only 15,000.

Water Conservation

Until recently, homeowners didn't pay much attention to water costs, but they have become a more significant portion of monthly outlay. Growing concern about regional water shortages and a possible national water crisis in the future makes water conservation doubly important.

Tech House has a partial water reclamation system based on spacecraft fluid recycling systems. Water from the kitchen sink, disposal and dishwasher contain organic food particles; treating and filtering this water demands a higher order of technology than is available for home use, so no reclamation is attempted. However, it is possible to re-use water from bathroom sinks, the bathtub and laundry equipment. This water is collected in a holding tank, chlorinated, filtered and recycled for use in toilet flushing, a conservation measure more important than it sounds because flushing accounts for about 40 percent of the average American family's water use. Toilet waste goes directly to the sewer and there is no health hazard in the reclamation system since drinking water plumbing is entirely separate.

Other conservation approaches include a smaller-than-usual but completely effective commode tank and special nozzle inserts in shower heads, which combine to afford substantial water-use savings. Matched against the comparison home, Tech House uses the same amount of water for laundry and cleaning, about 20 percent less for bathing, but none at all for toilet flushing. The overall result: the conventional home's annual water consumption runs about 73,000 gallons; for Tech House it is 34,000 gallons, or well under half.

Security Measures

Recognizing that people are more security-conscious than ever, Tech House designers incorporated a number of protective systems, most of them aerospace spinoffs. Some are already commercially available, others likely to appear on the market in the near future.

Security starts outside the house with the seismic detector. In the Tech House installation, the seismometer's electronic package alerts only the occupants, but it can also be tied into the local police station. The Tech House device, built at NASA's Ames Research Center, cost only $200. It is expected to be produced commercially soon and it has applicability beyond home use—for industrial security, law enforcement, and wildlife research, for example.

Should an intruder somehow manage to escape seismic detection, he'll encounter other obstacles. The exterior doors cannot be removed from their frames by pulling the hinge pins. Each hinge has a set of tabs and slots that lock the door in place when closed, so that it becomes in effect a part of the wall. These inexpensive mechanical locking devices were developed by engineers at Kennedy Space Center to solve a security problem there. The thermal shutters, when rolled down, also lock in place and cannot be raised from the outside.

Should an ingenious intruder manage to foil these exterior safeguards, he has still another problem in an interior security system designed to protect occupants against break-ins during sleeping hours. It consists of wires woven into the screens and stripped beneath the carpets at strategic points. The occupants arm the system—when retiring or on leaving the house—by punching a combination of numbers on a control box that looks like a telephone's pushbutton panel. After that, cutting the screen or stepping on the carpet will set off a loud, siren-like alarm.

For defense against a lurking mugger when a resident returns home at night, there is the Scan personal security device, developed from NASA ultrasonics research. Carried on the person like a fountain pen, it is a small ultrasonic transmitter which sends a signal 30 feet. The returning occupant presses the pen clip on alighting from his car and the signal turns on the porch and yard lights.

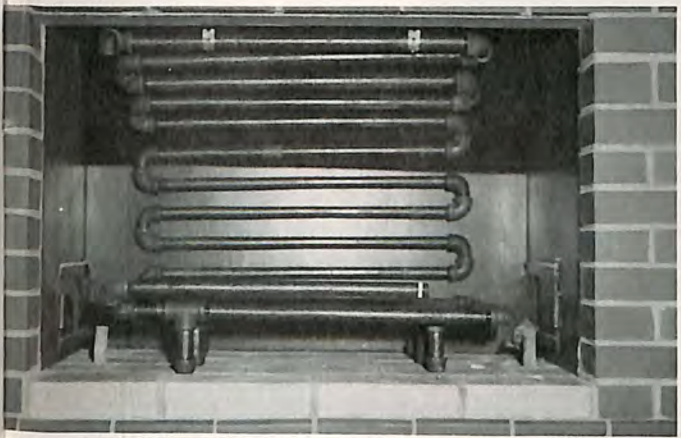
A final security measure is the tornado detector, developed from space research data by a NASA engineer. A simple, low-cost light-sensitive device, the detector is attached to a TV set tuned to an unused channel. Using the television electronics, the system detects a tornado within 18 miles of the home. As long as the tornado is within that range, the detector sounds an alarm, which cuts off automatically when the storm moves away.

Fire Safety

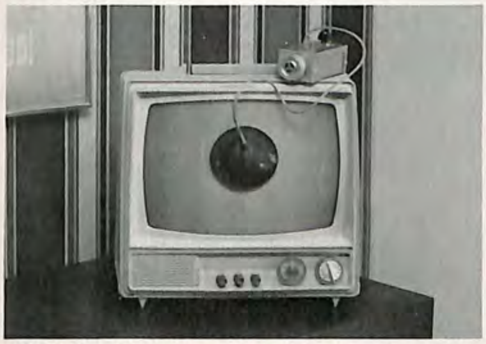
Protection against fire begins with the Tech House insulation, all of it fireproof. The principal insulator—tripolymer foam—forms a charred crust when exposed to flame and immediately extinguishes the flame.

Since most residential fires start in home furnishings rather than the

In Tech House NASA employs non-aerospace as well as aerospace technology. Thermal shutters, European imports, roll down to make a window seal for better insulation, admit light through vents in partially-closed position shown.

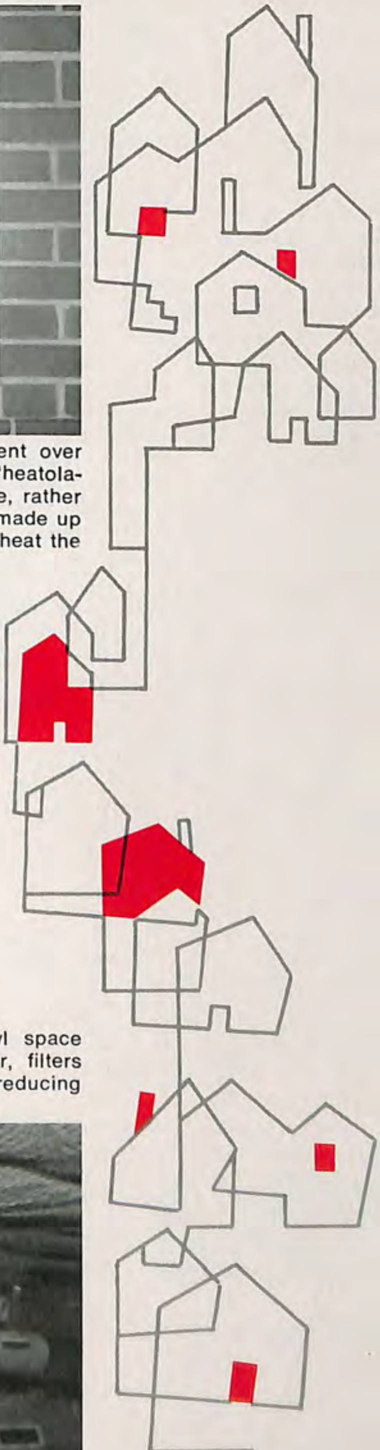


Tech House fireplace provides a vast improvement over the heat efficiency of conventional fireplaces. A "heatolator" system draws air for combustion from outside, rather than wasting already warm room air. The grate is made up of water pipes; fire-heated water is stored to help heat the house.



NASA-invented tornado detector uses the home television's electronics to detect a tornado within 18 miles and sound an alarm.

A water recycling system, located in the crawl space underneath Tech House, recaptures waste water, filters and chlorinates it, and uses it for toilet flushing, reducing water requirements by 50 percent.



structure, fire retardant materials are used in all fabrics, such as carpets, curtains and furniture coverings. Although these materials stop fire-spread, there is still danger of lethal fumes, the cause of most fire-related deaths. So Tech House has a standard, off-the-shelf commercial smoke detector which senses combustion even before it is noticeable to occupants and sounds an alarm.

Tech House Economics

The key to Tech House money savings is the heating and cooling system, which includes the solar collectors and the supplemental electrically-driven heat pump. A study of Tech House economics estimates that contemplated mass production will reduce costs of this system to about $6,000 within five years.

All components of the water system —the partial reclamation equipment plus the efficient water consuming appliances—are already available. They can be incorporated in the home at an extra cost, above standard plumbing, of about $600.

The owner of a home like Tech House would pay more for installation of the conservation equipment—but he would get it back in generous dividends.

The Tech House study assumed current mortgage interest charges and inflation rates for energy and water of 10 percent annually. Comparing Tech House with a conventionally-designed home of comparable size, this picture emerges:

Initially, Tech House has no monetary advantage because the extra costs of the advanced technology equipment would add higher mortgage interest, offsetting utility savings. But after eight years, the greater initial investment is paid back to the owner, and from that point on net savings begin to accumulate.

Over the 20-year mortgage span on which the study is based, the monthly utility bill for a Tech House-type dwelling would average $96.59 lower than conventional home utility costs. That adds up, in 20 years, to $23,381; in other words, potential savings amount to roughly half the basic cost of the home. But, savings to the individual homeowner aside, think of the enormous national benefit if energy and water systems like those in Tech House were to become widely adopted—millions of homes each using only one-third the energy and less than half the water consumed today. Tech House is an interesting experiment with vast potential and, more than that, it is a graphic demonstration of how NASA's technology is paying large dividends in practical benefit.

Little known fact about Lindbergh is that he made four emergency parachute jumps. Pictured with him here is Lindy's trusted friend and parachute packer, Jimmy Tate of the Missouri National Guard. Even after Lindbergh left his St. Louis Guard unit, he brought his parachutes to Tate for packing.

LINDBERGH'S TAK

There is an airplane that is truly unique. It is the only one of its type ever built and it was flown by only one man. It occupies a place of honor in the Smithsonian Institution's National Air and Space Museum and in coming months it will probably attract even more attention than usual. Come next spring, the nation will observe the golden anniversary of a flight that sparked a new era of aviation, an epoch-making accomplishment made possible by the reliability of the little airplane and the skill and courage of the man who flew it.

The airplane is the *Spirit of St. Louis,* built in 60 days in 1927 by Ryan Aeronautical Company of San Diego, California, a single-engine high-wing monoplane powered by a 220 horsepower Wright Whirlwind engine.

The man was Charles Augustus Lindbergh, a former air mail pilot, barnstormer and wing walker, survivor of four bailouts, a 24-year-old captain in the Missouri National Guard at the start of his momentous flight, a colonel and winner of the Congressional Medal of Honor shortly thereafter.

The memorable event, the first solo nonstop transatlantic flight, took place on May 20-21, 1927. Lindbergh and the *Spirit of St. Louis* departed Roosevelt Field, New York, and flew 3,600 miles to LeBourget Field, Paris, in 33 hours and 39 minutes, averaging 107.5 miles per hour.

At LeBourget, Lindbergh's arrival was greeted by a near-hysterical French populace and in the weeks that followed he was acclaimed as the greatest hero of his day. The deluge of publicity, in France and in the rest of the world, had extraordinary effect on the future of aviation. Lindbergh modestly downplayed his role, insisting that the airplane's reliability was the principal factor in the achievement. The flight proved, he said, that the airplane could carry people anywhere on earth. The world accepted his word and aviation was catapulted into an era of unprecedented boom.

Aviation badly needed the impetus that Lindbergh's flight provided. In the wake of World War I, the airplane was maturing but its commercial application was lagging. The passage by Congress of the Air Commerce Act of 1926 had laid the legislative cornerstone for development of American commercial aviation, but something more was needed. While people thrilled to the exploits of the barnstormers and record-setters, the public view of the latter twenties held that the airplane was a dangerous and unpredictable vehicle, that flight was a hazardous pastime for the adventurous. Lindbergh changed that view. In the aftermath of the Atlantic crossing came a wave of realization that the airplane could be a practical instrument of transportation.

The transatlantic flight was replete with the stuff of which legends are made. The flight itself, of course, was a staggering accomplishment, but its impact was heightened by the manner in which it was brought off.

Lindbergh was everyman's champion, the unknown underdog competing against some of aviation's greatest names. A $25,000 prize offered by hotelier Raymond Orteig for the first nonstop transatlantic crossing had excited the interest of such as René Fonck, France's leading ace of World War I; Charles Nungesser, another top ace; Commander Richard E. Byrd and Floyd Bennett, who a year earlier had made the first flight over the North Pole; and noted flyers Clarence Chamberlin and Bert Acosta.

Most of the contenders were well-backed financially and most planned to make the flight in multi-engine aircraft with two-man crews to share the flying. Lindbergh had put up $2,000 of his own money and his St. Louis backers advanced $13,000 more. Money—or the lack of it—was the principal reason why he elected to use a single-engine plane; he pointed out to his backers that they could not afford a larger aircraft.

As for flying solo, without even a radio or parachute, that was also a matter of practicality, although the world preferred to consider it fearless daring. Lindbergh spent weeks trimming every ounce of excess weight from the *Spirit of St. Louis.* He would not tolerate frills like a parachute or a relief pilot/navigator, whose weight would cost him fuel.

There was an added element of drama in the events which preceded his takeoff. René Fonck had crashed—and survived—on an earlier attempt to cross the ocean. Byrd's trimotor Fokker had suffered an accident. U.S. Navy flyers Noel Davis and Stanley Wooster had crashed on takeoff during a final test before their transatlantic departure; both were killed. Only days before Lindbergh lifted off the runway of Roosevelt Field, there had been two other fatalities; Frenchmen Charles Nungesser and Francois Coli had been lost at sea on a planned west-to-east crossing from Paris.

All of these factors combined to capture the imagination of a world ready for a super-hero. The tide of adulation that swept over Lindbergh after his triumph was truly astounding—and so was its impact on aviation.

In the year following the "Lone Eagle's" momentous achievement, people took to the air in unprecedented numbers. Investors, suddenly convinced that flight had matured, opened their purses. The capital they provided went into establishment of new air carrier companies, new aircraft and parts manufacturing firms, or into expansion of existing firms in both fields.

The number of commercial airplanes flying in the United States increased sharply. Airlines doubled their route mileage and quadrupled the number of passengers hauled. American airports, which had numbered about a hundred, rose to more than a thousand. Pilot certificates trebled in 1928 and doubled again in 1929. The demand for air service spurred the government to greater effort in building civil airways and navigation aids; by the end of 1928, there

OFF FOR AVIATION

were more than 15,000 miles of airways, which compared with about 3,000 miles at the time of the Lindbergh flight. And U.S. manufacturers began building larger air transports which brought new levels of speed and comfort to the burgeoning airline industry.

The flight, of course, did not solve all the problems of the adolescent industry. The majority of potential air travelers, though thrilled by the feat, clung stubbornly to the you-couldn't-get-me-in-one-of-those-things persuasion. But, in one master stroke of skill and daring, Lindbergh changed the minds of many, broadened the acceptance of flight and quickened the pace of progress. By whatever standards, the flight of Lindbergh and the *Spirit of St. Louis* must be ranked among the greatest of aviation's milestones.

"We"—Lindbergh and his reliable Ryan monoplane, the *Spirit of St. Louis*.

The Takeoff

In 1967, to commemorate the 40th anniversary of Charles Lindbergh's solo nonstop transatlantic crossing, Aerospace *published an eyewitness account of the flight. It was written by Lauren Dwight (Deac) Lyman, a newspaper reporter at the time of the flight, later a friend of Lindbergh, longtime aviation writer, Pulitzer Prize winner and official of United Technologies. A slightly edited excerpt from Mr. Lyman's article is reprinted here. The scene: Roosevelt Field, New York; the time: morning, May 20, 1927.*

It was still raining long before daylight when Lindbergh came down the stairs into the lobby of the Garden City Hotel and walked onto the stone porch. He looked up at the forbidding clouds and the dripping trees.

"Are you going this morning, Captain?" asked reporter Johnnie Frogge. Lindbergh did not answer immediately, but finally said, "I don't know."

There was a chance of catching the last edition and Frogge asked, "When will you know?" The pilot answered again with more emphasis: "I don't know."

The weary and exciting night turned grey. There was no sunlight in the east, just grey and white low clouds. A truck towed the *Spirit of St. Louis* across Curtiss Field, up the muddy slope to adjacent Roosevelt Field. The slight wind had shifted from east to west, an augury for fair weather but an added hazard for the west to east takeoff. More fuel was added, strained through chamois.

The growing crowds spread along the field, kept well back from the runway. A small group pressed about the plane: veteran pilots who were flying men when Lindbergh was in grade school; officers from Mitchell Field who had been his classmates in cadet days in Texas; Clarence Chamberlin and Guiseppe Bellanca, who were also planning a transatlantic crossing, temporarily thwarted because their plane was immobilized by an injunction. All were tense and silent.

Another contender, Commander Richard E. Byrd, ran from his hangar with a last minute weather forecast to thrust into Lindbergh's hand. Clad in his air mail flying suit, Lindbergh climbed in, fastened the door. Ken Boedecker of the Wright Company spun the propeller slowly against the cold Whirlwind engine's compression. The engine caught and for a few minutes Lindbergh alternately opened and closed the throttle, his head almost out the window as he studied the wet runway.

C. B. Allen of the *New York World* started walking swiftly down the field along side the flier's intended path and I ran to join him. We stopped near the end of the runway, close to the steam roller that had earlier smoothed and hardened the makeshift runway. If the *Spirit of St. Louis* failed to get off, it would be at this point or near it that help would be needed, if there could be any help.

But the silver monoplane did get off, starting slowly, gaining speed with men pushing on the struts, bouncing once and then twice through puddles, then holding the air and climbing sluggishly a few feet off the ground. It appeared to clear the steam roller—and the two tense reporters crouched behind it—by five or ten feet, roared just above the low telephone wires at the end of the field, dropped perceptibly as the pilot sought more flying speed, and disappeared behind the rolling wooded slopes to the east. . . .

There were about a thousand people at Roosevelt Field that morning for the takeoff. A hundred thousand broke down fences, pushed aside the police and a regiment of soldiers to greet Lindbergh the next night at LeBourget Field in France.

The extraordinary achievement of Lindbergh and the *Spirit of St. Louis*, followed within a fortnight by Chamberlin's brilliant flight to Germany with a passenger aboard his Bellanca, provided dramatic illustration of how dynamic the aviation industry already had become. Now millions, instead of a thousand or so, realized that aviation had become a force, not a promise.

LINDBERGH MEMORIAL FUND

General James Doolittle, aviation pioneer and World War II hero (left), and Neil Armstrong, first man to walk on the moon, pose by a medallion commemorating the upcoming 50th anniversary of Charles A. Lindbergh's historic solo nonstop transatlantic flight.

As part of the 50th anniversary celebration of Charles A. Lindbergh's epic New York to Paris flight in 1927, a group of aviation enthusiasts has formed the Lindbergh Memorial Fund. The Fund's goal is to raise $5 million, which will finance fellowship awards in a number of areas in which Lindbergh was particularly interested.

Co-chairmen of the fund raising effort are General J. H. "Jimmy" Doolittle and Neil Armstrong. Named as president of the Lindbergh Fund was Dr. Serge A. Korff, New York University professor emeritus of physics and a world renowned cosmic ray investigator. Sponsors of the Fund are The Explorers Club and the World Wildlife Fund.

Purpose of the Fund is to foster participation, through fellowships, of young scientists in activities advancing technological and humanitarian progress. Each May 21—the anniversary date of Lindbergh's landing in Paris—fellowships will be awarded in aeronautical sciences, field and natural sciences, exploration and anthropology. Lindbergh Fellowships will go principally to undergraduate and graduate students, but professionals in these fields will also be eligible.

A major event planned to spur the fund raising campaign is a "Spirit of St. Louis II" commemorative flight. A Pan American Boeing 747 will depart New York's Kennedy International Airport on May 20, 1977, and follow the exact route Lindbergh flew in his Ryan monoplane half a century earlier, landing at Paris' LeBourget Airport. The passenger list will be made up of 125 Fund Founders, contributors of $10,000 or more. On May 21, the group will attend a Spirit of St. Louis Dinner with French President Giscard d'Estaing and other government officials.

In addition to the Paris banquet, there will be a series of commemorative dinners in the United States. Five such events are planned for Washington, New York, Chicago, St. Louis and Los Angeles; other cities may be added.

AIA

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CCI Corporation
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AEROSPACE INDUSTRIES ASSOCIATION
1725 De Sales St., N.W., Washington, D. C. 20036

RETURN REQUESTED

This bronze bust of Charles A. Lindbergh is located in the International Building in Rockefeller Center, a memorial tribute by the Air Mail Pioneers under the auspices of the National Aeronautic Assn. The bust was executed by sculptor Paul Fjelde. (See *Lindbergh's Take-off For Aviation,* p. 14).

aerospace

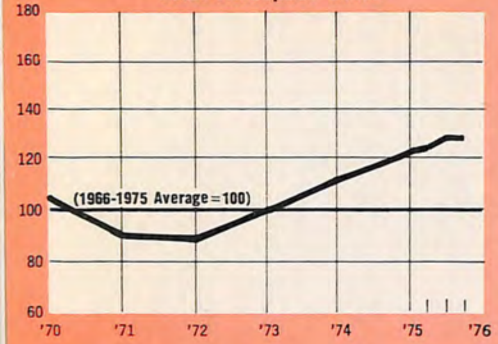
OFFICIAL PUBLICATION OF THE AEROSPACE INDUSTRIES ASSOCIATION • SPRING 1977

AEROSPACE REVIEW AND FORECAST 1976/77

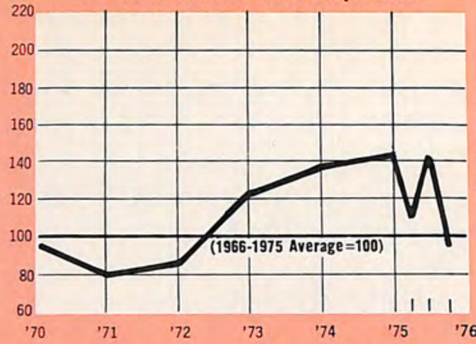
AEROSPACE ECONOMIC INDICATORS

CURRENT

Total Aerospace Sales

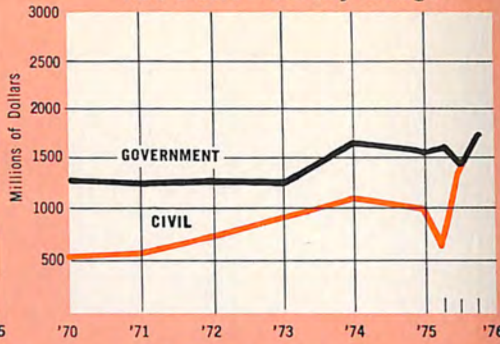


Value of Civil Aircraft Shipments



OUTLOOK

New Orders — Monthly Average



Aerospace obligations by Dept. of Defense and NASA.
Non-government prime orders for aircraft and engines.

ITEM	UNIT	PERIOD	AVERAGE 1966-1975 *	SAME PERIOD YEAR AGO	PRECEDING PERIOD †	LATEST PERIOD 3rd QTR. 1976
AEROSPACE SALES: TOTAL	Billion $	Annually	26.6	29.1	30.8	30.8
	Billion $	Quarterly	6.4	7.6	8.4	7.6
AEROSPACE SALES: TOTAL	*Billion $*	*Annually*	*27.3*	*22.7*	*23.2*	*22.9*
(In Constant Dollars, 1972=100)	*Billion $*	*Quarterly*	*6.9*	*5.9*	*6.3*	*5.7*
DEPARTMENT OF DEFENSE						
Aerospace obligations: TOTAL	Million $	Quarterly	3,792	5,088	4,072	3,750
Aircraft	Million $	Quarterly	2,361	2,763	2,841	2,309
Missiles & Space	Million $	Quarterly	1,431	2,325	1,231	1,441
Aerospace outlays: TOTAL	Million $	Quarterly	3,411	3,306	3,461	3,018
Aircraft	Million $	Quarterly	2,031	2,015	2,156	1,967
Missiles & Space	Million $	Quarterly	1,380	1,291	1,305	1,051
Aerospace Military Prime Contract Awards: TOTAL	Million $	Quarterly	3,327	4,643	3,210	3,359
Aircraft	Million $	Quarterly	2,109	2,533	2,464	2,129
Missiles & Space	Million $	Quarterly	1,218	2,110	746	1,230
NASA RESEARCH AND DEVELOPMENT						
Obligations	Million $	Quarterly	780	785	646	750
Expenditures	Million $	Quarterly	789	769	619	731
BACKLOG (70 Aerospace Mfrs.): TOTAL	Billion $	Quarterly	28.6	34.6	34.4	37.1
U.S. Government	Billion $	Quarterly	15.9	21.4	21.8	22.1
Nongovernment	Billion $	Quarterly	12.7	13.2	12.6	15.0
EXPORTS						
Total (Including military)	Million $	Quarterly	1,038	1,750	2,125	1,791
New Commercial Transports	Million $	Quarterly	345	384	787	543
PROFITS						
Aerospace — Based on Sales	Percent	Quarterly	2.7	3.3	3.6	3.7
All Manufacturing — Based on Sales	Percent	Quarterly	4.8	4.9	5.9	5.3
EMPLOYMENT: TOTAL	Thousands	End of Quarter	1,166	938	895	895
Aircraft	Thousands	End of Quarter	650	512	483	483
Missiles & Space	Thousands	End of Quarter	114	90	84	84
AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS	Dollars	End of Quarter	4.38	6.12	6.36	6.51

* 1966-1975 average is computed by dividing total year data by 4 to yield quarterly averages.
† Preceding period refers to quarter preceding latest period shown.

Source: Aerospace Industries Association

UPGRADING AERONAUTICAL RESEARCH

Karl G. Harr, Jr.

Karl G. Harr, Jr., president of the Aerospace Industries Association, recently testified before the House Subcommittee on Transportation, Aviation and Weather on the subject of the aeronautical portions in the fiscal year 1978 authorization request for the National Aeronautics and Space Administration. Excerpts are reported below:

"It should be obvious to everyone at this time, in the mid-seventies, that research and development funding in the United States, in real dollars, is declining and has been doing so since 1968. We have been commenting on this year after year with negligible results. Perhaps part of the solution would be to concentrate on upgrading. relatively small, manageable areas of research and technology. A case in point would be the aeronautical research and technology base at the National Aeronautics and Space Administration.

"The aeronautical R&T budget has lagged consistently until this year when the requirements of a significant new program are being partially, though in our view inadequately, recognized. I refer to the Aircraft Energy Efficiency Program, about which I will comment later. In total, however, the NASA aeronautical R&T budget has lingered between 6.3 and 7.7 percent of the total NASA R&T budget.

"There are important reasons why these percentages should be increased rather than maintained. In recent years, military programs, particularly those transferable to civil programs, have been sharply reduced in number. In our view, this should be recognized by the government and the resulting slowdown in technological feedback compensated for in the funding of NASA aeronautical programs. Secondly, the regulatory agencies, such as the Federal Aviation Administration and the Environmental Protection Agency, provide limited technology funding to assist industry in the basic research needed to modify their products to meet newly promulgated rules and regulations. Thirdly, the pending shortage of petroleum-based hydrocarbon fuels may result in a requirement for synthetic or alternate fuels having a wider range of characteristics than fuels meeting current specifications.

"Helicopter development is another whole area of endeavor which might properly be addressed by NASA and funded accordingly. Another key area which needs expanded effort is the aerodynamics of high aspect ratio (longer and narrower) wings which can lead to more efficient transport aircraft.

"Fuel conservation, of course, represents the most significant aeronautical program undertaken by NASA in some time. The proposed budget for the Aircraft Energy Efficiency Program, however, is in our view insufficient to continue the progress toward an early application of this technology to the new generation of transport aircraft. The most notable deficiency is in the area of advanced structural composite materials where a 40 percent reduction from the original plan is being considered. We would recommend, therefore, that the FY '78 budget be increased on the order of 25 percent in this area.

"For the last several years, it would seem that NASA's aeronautical R&T budget has been based on the philosophy of holding an approximate ratio with the space program rather than evaluating aeronautical needs on their own merits and in terms of their contributions to the well being of the United States. This relative emphasis must be re-evaluated and the aeronautical portions of this budget increased."

AIA

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Official Publication of the
Aerospace Industries Association of America, Inc.

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CONTENTS

The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems;

Foster understanding of the aerospace industry's responsibilities in the space exploration program;

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade;

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

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AEROSPACE REVIEW AND FORECAST

'76 | '77

Because of inflation, the near-record $29 billion in sales by the aerospace industry in 1976 bought its customers $11 billion less than those same dollars would have purchased in 1968. Using the same 1968 benchmark, industry employment in 1976 was down 40 per cent to 893,000.

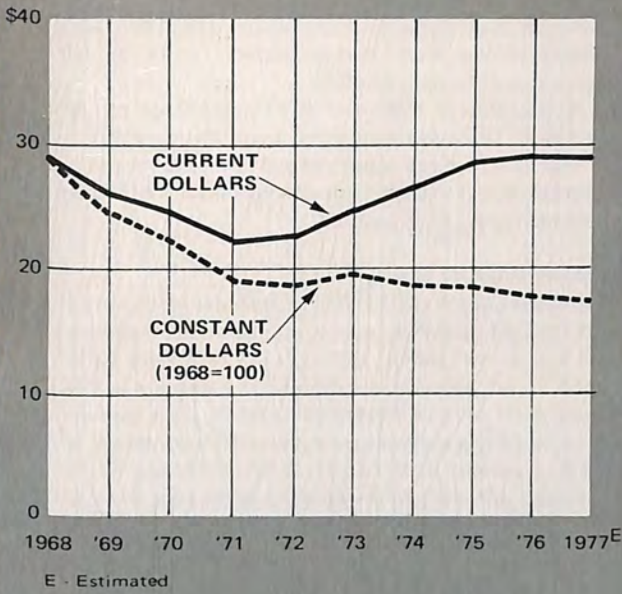
In spite of those facts, the industry, judged by 1976 statistics, is healthy, at the forefront of world technology and:

- Is an essential part of the nation's military security,
- Is a key and positive factor in the nation's trade balance,
- Is, by all measures, one of the major factors in the economic well-being of the nation.

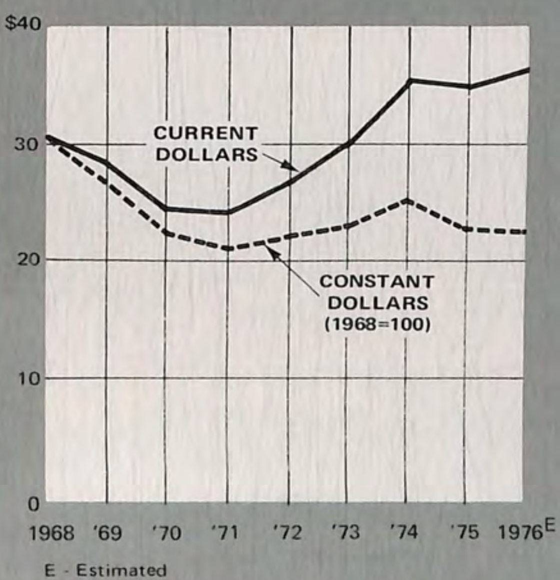
Like the rest of U.S. business, the aerospace industry was hit hard by inflation over the past decade. But, according to AIA's annual review of the industry, the downward impact of inflation on the industry is easing. Today, America's aerospace firms form a maturing industry, stabilizing after rapid growth during the 1960's, inflationary pressures of the 1970's and the cyclical and regulatory problems related to their government-oriented business.

The 1976 statistical review reveals the erosive effects of inflation. Those effects are especially clear in the comparison of sales dollars to constant dollars. Beginning in 1968, sales declined in current and constant dollars until in 1972 when current dollar sales showed the first increase in four years. This increase has continued through 1976, although a slight decline is forecasted for 1977. However, while current dollar sales increased in this period, the sales for the same years measured in constant dollars, dropped steadily.

AEROSPACE INDUSTRY SALES
(Billions of Dollars)



AEROSPACE INDUSTRY BACKLOG
(Billions of Dollars)



Current/Constant Dollars

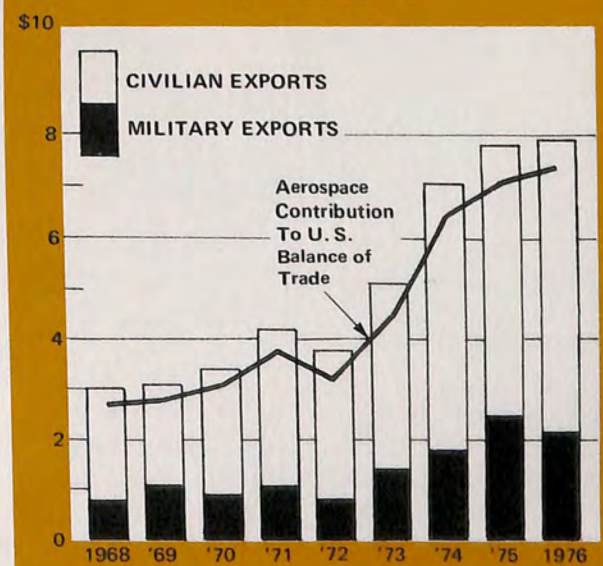
The same pattern—gains in current dollars, declines in constant—is apparent, with minor exceptions, in the industry's backlog record. Again, the backlog started to climb in 1972 after dropping from $30 billion in 1968. In 1972, backlog registered its first gain since 1968, reaching $26.9 billion in current dollars, but amounting to only $22.2 billion in constant dollars. Backlog reached $36 billion in 1976, a *gain of $9.5 billion* over 1972, but measured in constant dollars the increase was only $300 million, statistically virtually the same.

Aerospace Exports

A consistently bright element of the industry has been the export performance of its companies which, in turn, has had far-reaching effects on the overall national economy. The aerospace contribution to the balance of trade has been high and consistent, climbing from $2.7 billion in 1968 to $7.1 billion in 1975. The aerospace trade balance for 1976 reached a new high — $7.3 billion.

Contrary to the general public belief, the value of civilian aerospace exports far outstrip military aerospace exports. In 1968, total exports were $3 billion; military exports made up only $800 million. In 1971, total exports were $4.2 billion; military exports accounted for $1.1 billion. In 1974, total exports were $7.1 billion; military exports were $1.8 billion. In 1976, total exports reached $7.9 billion, military exports were only $2.2 billion of that total.

AEROSPACE EXPORTS
(Billions of Dollars)



Aerospace Customer Mix

The largest customer for aerospace products remains the Department of Defense. The percentage of total products sold to DoD during recent years has fluctuated, due largely to changes in budget priorities on types of equipment DoD ordered. In 1968, 57.2 percent of aerospace sales were made to DoD, 20.4 percent to commercial customers, 13.6 percent to the National Aeronautics and Space Administration and other government agencies, and 8.8 percent were non-aerospace sales (products not directly associated with aerospace, but manufactured in aerospace facilities).

By 1971, the percentage of sales mix had shifted to 56.8 percent to DoD; 19.4 percent for commercial; 12.4 percent for NASA and other federal agencies; and 11.4 percent for non-aerospace products.

In 1974, percentage sales were 47.9 to DoD, 27.1 percent to commercial customers, 15.4 percent to non-aerospace, and 9.5 percent to NASA and other government agencies.

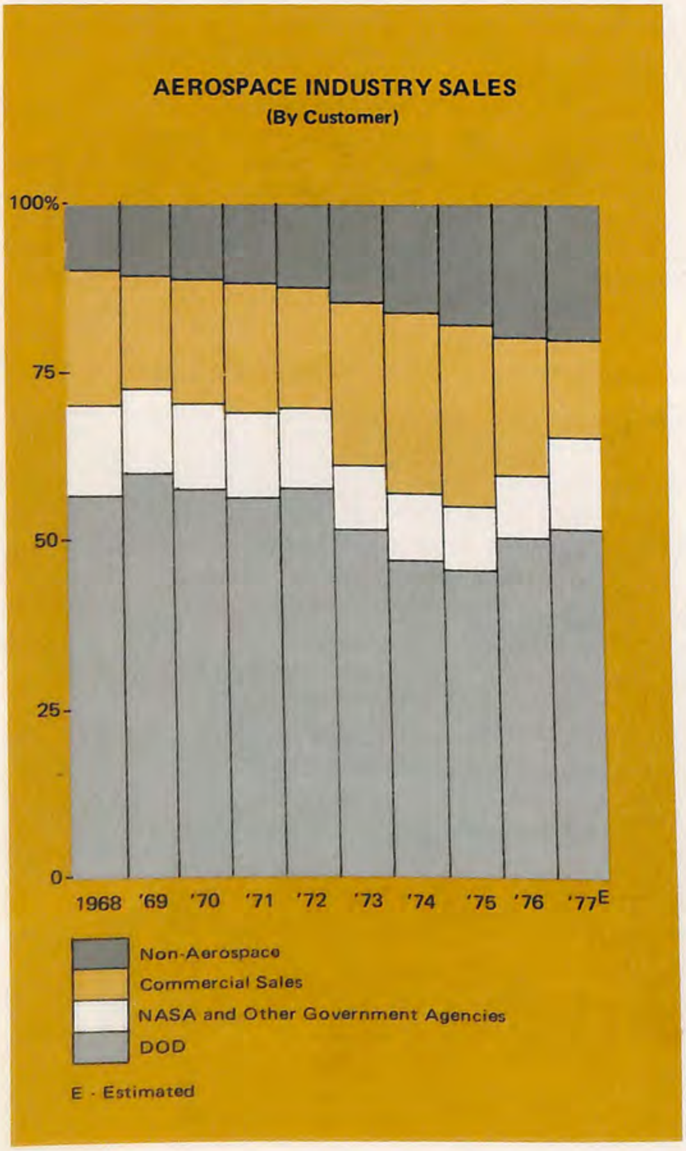
The gain in the commercial sales percentage were due largely to deliveries to the wide-bodied jet transports—the Boeing 747, the Lockheed L-1011 and the McDonnell Douglas DC-10. The drop in sales for NASA was caused largely by the completion of the Apollo manned space flight program.

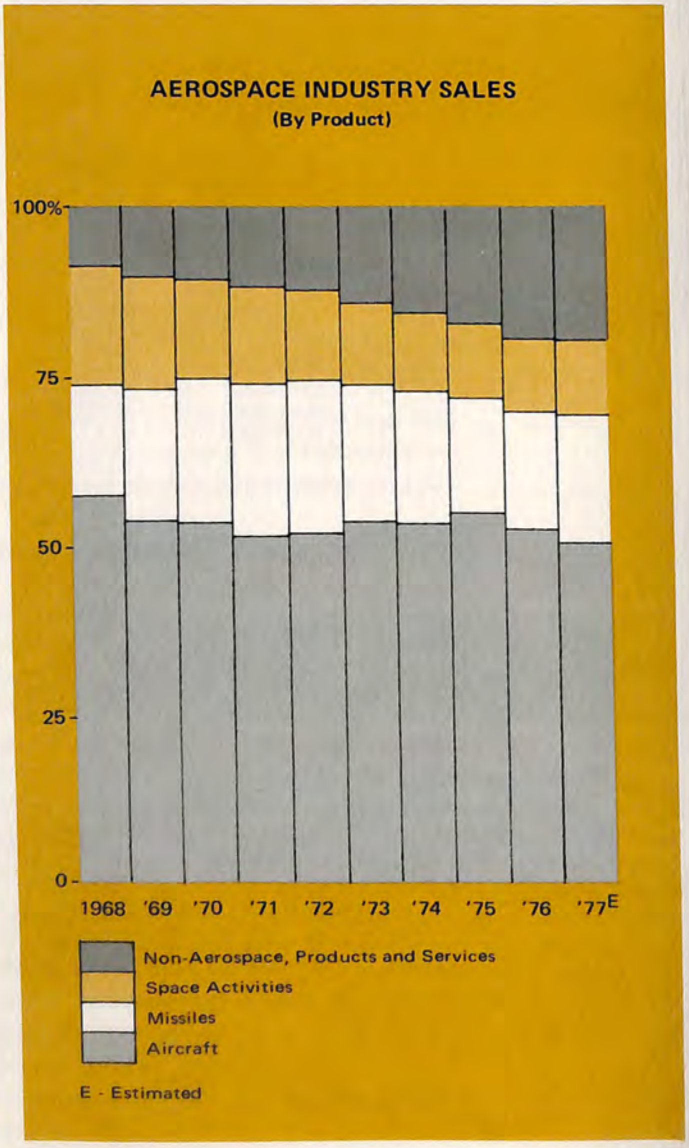
During 1977, it is expected that sales to DoD will amount to 52.1 percent of the aerospace total, 19.4 percent will be commercial sales, 19 percent non-aerospace, and 9.5 percent to NASA and other federal agencies. Noteworthy is the fact that, as a percentage of the total, non-aerospace sales in 1977 will approximate commercial sales.

In a comparison of 1968 and 1977 percentage of sales, it is revealed that: DoD percentage of sales dropped 5.1 percent, NASA and other federal agencies fell 4.1 percent, commercial sales 1 percent while percentage of total sales of non-aerospace products increased 10.2 percent.

Aerospace Product Sales

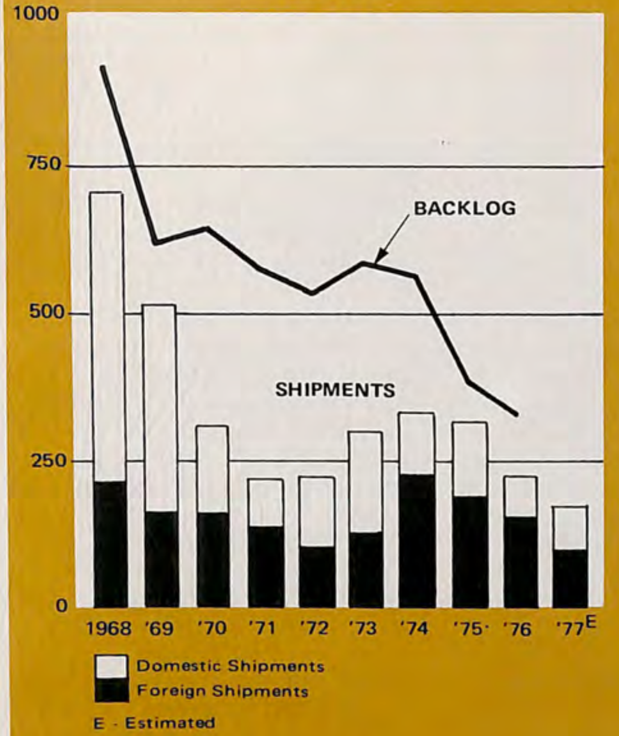
The breakout of the percentage of aerospace industry sales by product (aircraft, missiles, space activities and non-aerospace) reveals that aircraft sales, although the dominant factor, have slipped in recent years from a high of 57.2 percent in 1968 to an estimated 50.2 percent for 1977. Missiles, as a percentage of product sales, have moved from a low of 16.3 percent in 1968 to a high of 22.9 percent in 1972 then to an estimated 19 percent in 1977. Space activities have declined each year from a high of 17.7 percent of the total in 1968 to 13.5 percent in 1972, and to an estimated 11.8 percent in 1977.





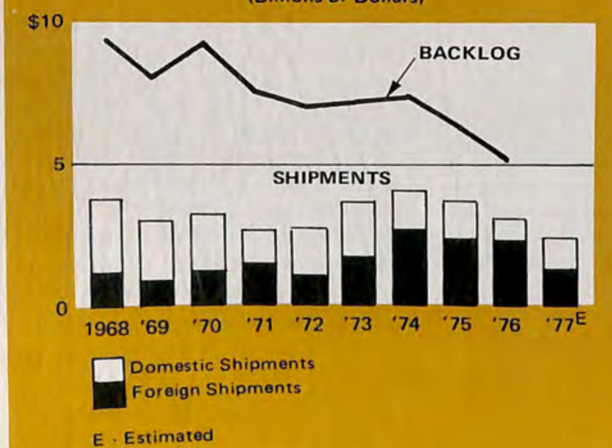
COMMERCIAL TRANSPORT SHIPMENTS AND YEAR-END BACKLOG

UNITS



VALUE

(Billions of Dollars)



Transport Aircraft Sales

Transport aircraft unit shipments have sustained a sharp and, except for the years 1973, 1974 and 1975, continuing decline. This is accounted for by inadequate airline earnings, a slow economic recovery since 1973, and soaring fuel prices, which have precluded purchases of new aircraft to replace transports in their aging jet fleets or to generate capital for new models of airliners for the 1980s and beyond.

In 1968, unit shipments reached 702 (481 domestic; 221 foreign) with a value of \$3.8 billion, and a backlog of 914 units valued at \$9.5 billion. By 1969, this record had dropped to 514 units (349 domestic; 165 foreign) with a total value of \$2.9 billion, and a backlog of 608 units valued at \$8.2 billion.

Further decreases occurred, with the notable exception of 1974, when a total of 332 aircraft were shipped (227 foreign; 105 domestic) with a value of \$4.0 billion. Backlog for that year was \$7.6 billion.

Today, it is predicted that total unit shipments for 1977 will amount to 170 (98 foreign; 72 domestic) with a total value of \$2.4 billion.

The earning level of U.S. scheduled air carriers is the major reason that orders for new aircraft have declined. Following losses in 1975, the airlines earned between \$325 and \$375 million in 1976. However, Dr. George W. James, Vice President-Economics and Finance, Air Transport Association, puts the problem of new transport procurement in focus: "Acquiring the new aircraft that airlines should be introducing into their fleets from now through the end of the 1980s will require a capital investment in the neighborhood of \$65 billion," he stated recently. "To meet capital needs of this magnitude, the airlines must realize—consistently, year after year—an average annual return of at least 5½ cents on each dollar of revenue. That means annual earnings at levels of \$800 million."

Employment

Aerospace employment is directly affected by all of the customer and sales records reported earlier.

From a 1968 high of 1.476,000 employees, including 782,000 production workers, employment slumped in 1972 to 944,000 (473,000 in production) and in 1976 to 893,000 (421,000 in production). Outlook for 1977 is a slight increase—a total of 898,000 (424,000 in production).

Payroll of this employment force underscores the effects of inflation. In 1968, 1,476,000 workers earned about \$14.4 billion, in 1977, 898,000 workers (578,000 *fewer* than in 1968) are expected to earn \$1,272,000 *more*.

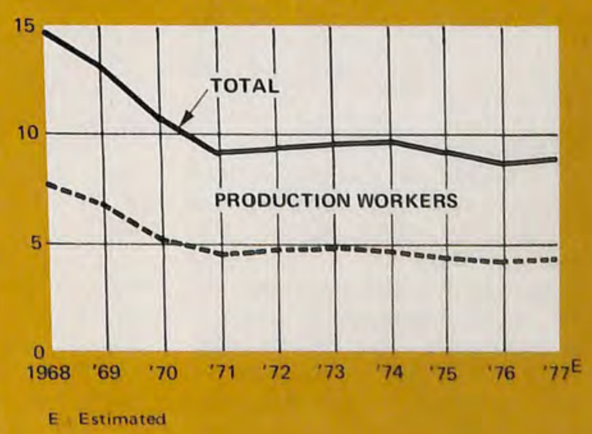
Industry profits, subjected to close scrutiny in contract negotiations, reviews during contract compliance and review after completion, historically fail to approximate profits earned by all manufacturing corporations.

For example, in 1968 all manufacturing corporations earned 5.1 percent after taxes. The aerospace industry earned 3.2 percent. In 1971, the ratio was 4.1 percent (after taxes) for all manufacturing firms. Aerospace companies earned 1.8 percent.

The 1976 estimate is 5.0 percent for all manufacturing corporations. Aerospace: 3.0 percent.

AEROSPACE EMPLOYMENT

(Millions of Employees)



AEROSPACE IMPACT

New Budget Look

The Carter Administration's amended budget, submitted to the Congress on February 22, proposes little immediate impact on aerospace industry workload. The new defense budget contemplates major increases over the current fiscal year, although the degree of increase is substantially below that recommended in the Ford Administration defense plan. Funding for the industry's other major government customer, the National Aeronautics and Space Administration, is slightly higher than the Ford proposal.

Defense Budget

The revised defense plan for the fiscal year beginning next October 1 calls for total obligational authority of $120.4 billion, which represents an increase of $10.2 billion over FY 1977, or three percent in terms of constant dollars. Outlays for FY 1978—expenditures during the year—would amount to $109.7 billion, up $11.4 billion or five percent in inflation-adjusted terms.

The Carter amendments propose reductions from the Ford budget of $2.7 billion in total obligational authority, but only $400 million less in actual outlays during FY 1978. The reductions were achieved, according to a Department of Defense statement, by "eliminating those programs that contribute marginally to security or deferring them where a question exists as to how much value they have."

The amended budget, if adopted intact, would not appreciably change the aerospace forecast detailed in preceding pages. The forecast covers the calendar year 1977 and only the final quarter of the year is affected by the FY 1978 defense budget.

However, the revisions could have more significant impact on the aerospace industry's workload in future years. The amendments involve deferrals of some major aerospace programs which could be terminated or stretched out further, depending on the outcome of additional studies and arms limitation negotiations. Also, the revised budget proposes elimination or cutback of certain current production programs.

Strategic Programs

Although overall funding for strategic programs would increase by $800 million over FY 1977, the new budget plan imposes reductions and schedule deferrals in several aerospace programs.

Under the Ford Administration budget, engineering development of the new generation MX intercontinental ballistic missile had been planned, offering an option for deployment in the 1980s of an advanced ICBM with improved accuracy and a greater payload of multiple warheads. The Carter budget reduces funding by $160 million and defers full-scale development until FY 1979. Research and development of the MX will continue through FY 1978, but not on the accelerated basis earlier envisioned.

A Ford budget plan to buy 60 additional Air Force/Boeing Minuteman III ICBMs was dropped, but the production line will remain open on a component basis. DoD said the funds allocated in the original budget will be used to purchase components and equipment to upgrade the existing Minuteman III force and to maintain a degree of production capability without further procurement of complete missiles.

The revised budget cuts the planned FY 1978 buy of Air Force/Rockwell B-1 bombers from eight to five aircraft, "pending further evaluation of the system requirements." A final decision as to whether the B-1 program will be continued, or whether the number of aircraft should be reduced below the 244 currently projected, is expected by mid-year. In a related cut, production of the Boeing SRAM AGM-69A air-launched missile would be "rephased consistent with the B-1 schedule."

A Ford Administration plan to start pre-production work on an interceptor version of the Air Force/McDonnell Douglas F-15 fighter was temporarily shelved. The original budget provided advance procurement funding in FY 1978 for a planned purchase in FY 1979 of the F-15 follow-on interceptor for continental air defense. The amended budget eliminates advance funding and delays the buy one year for further study.

Tactical Programs

In the area of tactical weapons procurement, two major aerospace programs would be terminated under the Carter defense budget.

The budget deletes an earlier plan to buy non-nuclear Lance Army battlefield missiles, built by Vought Corporation. The Ford Administration intent was to provide Lance battalions in Europe, now equipped with nuclear warheads, a conventional war capability as well. The revision eliminates $78 million from the FY 1978 budget, which would have bought 360 of the non-nuclear weapons, and also diverts current-year non-nuclear Lance money to purchase of spares for the nuclear version of the missile.

The other terminated tactical program is the Navy's A-7E light attack aircraft, also built by Vought Corporation. DoD stated that the earlier planned purchase of six A-7Es was "not required to equip approved forces" and the $24 million allocated for the buy was deleted.

Production of the Air Force's primary operational tactical fighter, the McDonnell Douglas F-15, would be slowed under the terms of the revised budget pending a further review of USAF tactical aircraft requirements. The Carter plan pegs the F-15 production rate at 78 aircraft a year, down from the previously budgeted 108.

DEPARTMENT OF DEFENSE BUDGET
($ IN BILLIONS)

	FY 1976 Actual	FY 1977 Estimate	FY 1978 Estimate	Increase FY 1977-78
January 1977 (Ford Budget)				
Total Obligational Authority (TOA)*	$ 97.5	$110.2	$123.1	$13.0
Budget Authority (BA)*	102.2	106.6	120.5	13.8
Outlays	88.5	98.3	110.1	11.8
February 1977 (Carter Amendments)				
Total Obligational Authority (TOA)	$ 97.5	$110.2	$120.4	$10.2
Budget Authority (BA)	102.2	106.6	117.7	11.1
Outlays	85.5	98.3	109.7	11.4

* TOA — Total Obligational Authority — the sum of budget authority granted or requested from the Congress in a given year, plus unused Budget Authority from prior years.

* BA — Budget Authority — authority provided by the Congress, mainly in the form of Appropriations, which allows Federal agencies to incur obligations to spend or lend money.

DEPARTMENT OF DEFENSE BUDGET
MAJOR AEROSPACE PROCUREMENT ITEM QUANTITIES

	FY 1976 Program	FY 1977 Program	FY 1978 Program
Aircraft			
Army	72	117	139
Navy and Marine Corps	263	214	169
Air Force	181	217	335
Total — Aircraft	516	548	643
Helicopters	81	142	147
Fixed Wing Aircraft	435	406	496
Missiles			
Army	43,633	18,114	17,072
Navy and Marine Corps	11,795	15,844	22,463
Air Force	8,500	3,215	4,600
Total — Missiles	63,928	37,173	44,135

Other adjustments to tactical procurement and development programs include:

• Deferral of one year the planned procurement of the Air Force's Advanced Tanker/Cargo Aircraft (ATCA), a modified version of a still-undesignated commercial wide body jetliner. DoD said, "further study is required of future tanker and airlift requirements and the most cost-effective ways to meet them."

• A slowdown in development of the Army's Advanced Attack Helicopter. The Hughes YAH-64 was selected last September as the Advanced Attack Helicopter and ordered into full-scale development with the aim of procuring more than 500 of the craft as the Army's principal anti-armor helicopter. The revision, intended "to reduce risk and provide for a more thorough evaluation of options," halves developmental funding to $100 million.

• A delay of one year in procurement of the Navy/Marine Corps CH-53E, built by Sikorsky Aircraft Division of United Technologies. The CH-53E would be used by the Marine Corps for moving heavy equipment and by the Navy as a vertical on-board delivery (VOD) vehicle for carrier operations. The revised budget cuts CH-53E money by $62 million but provides funds for continuing development to prepare the helicopter for later procurement.

• A reduction from six to three Boeing-built Air Force E-3A Airborne Warning and Control System (AWACS) aircraft in the FY 1978 procurement plan. The reduction, DoD stated, stemmed from "uncertainties which bear on the ultimate number of AWACS aircraft to be acquired, particularly the question of the number of AWACS needed for continental air defense. The production line remains open to accommodate the NATO requirement, which the Administration fully supports."

• Elimination of FY 1978 funding for six battery sets of the Army's Raytheon Hawk surface-to-air missile. The procurement was cancelled "pending further evaluation of alternative ways to improve readiness."

Aerospace-related Ship Programs

A review of the Navy's shipbuilding program led to a decision to cancel—on cost-effectiveness grounds — a planned nuclear-powered cruiser which was to have been equipped with the AEGIS area defense weapon system. Some $187 million, for funding of long lead time items, was deleted from the FY 1978 budget.

The new budget also scraps plans for two Polaris submarine overhauls. Initial funding in FY 1978 was deleted "while the future use and disposition of the submarines is restudied."

NASA Budget

The Carter Administration review left NASA's $4 billion budget request unchanged except for slight but important increases in two categories. The increases total $15 million in new obligational authority and since most of the money will be spent in FY 1978 the changes entail an increase in outlays of $12 million.

The Lunar/Planetary Programs category gains an additional $10 million. The money will go for studies of Mars follow-on missions to be directed by Jet Propulsion Laboratory. Included are studies of program definition, preliminary system design and technology associated with the Rover, a mobile Mars surface laboratory planned for 1984 launch. Also included is a study of a mission in which a Mars-landing spacecraft would return a surface sample to earth. The mission is targeted for 1988.

The other $5 million of the NASA increase will provide initial funding for a back-up Landsat D earth resources spacecraft, to be used in case the primary spacecraft fails on its 1979 launch. Total cost of the back-up is estimated at $60 million. Principal Landsat contractor is General Electric Company.

The Carter revision also proposed an increase in NASA's current (FY 1977) budget. The change involves an additional outlay of $27 million for the Space Shuttle.

AEROSPACE HIGHLIGHTS: 1976

By James J. Haggerty
Associate Editor, Aerospace Magazine

Twin landings of robot spacecraft on Mars, the public debut of NASA's Space Shuttle Orbiter, a variety of milestone events in military aircraft and missile developments, a financial turnaround for the nation's airlines and introduction of supersonic passenger flight to the United States . . . these are among the highlights of the aerospace year 1976.

Space

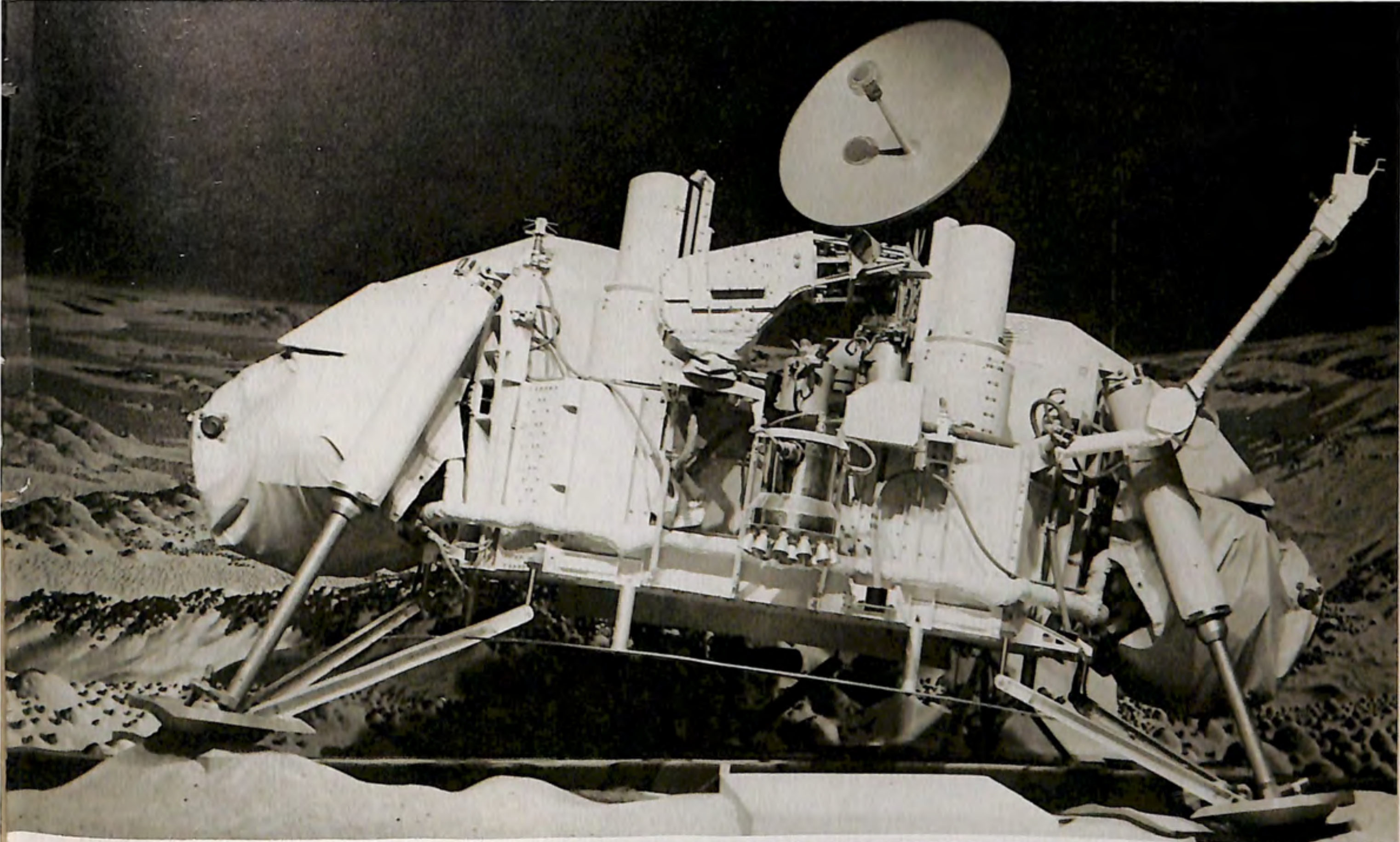
On July 20, 1976, a parachute blossomed in the atmosphere of Mars and lowered to the surface a 1,300-pound robot spacecraft built by Martin Marietta Corp. and known as Viking Lander 1. It was a historic touchdown, the first successful soft-landing of an instrumented spacecraft on the Red Planet. It made possible the most comprehensive scientific investigation of another planet ever undertaken, including a search for extraterrestrial life.

Viking 1 had departed earth 11 months earlier. It had flown a 460-million-mile parabolic path to a rendezvous with Mars, then separated into two spacecraft: an Orbiter, which was to revolve around the planet, conducting its own experiments and acting as communications go-between; and the Lander, which touched down on a rocky Martian plain called Chryse and immediately went to work. Minutes after landing, the spacecraft's cameras began taking the first close-up photos of the Martian surface. A miniature weather station began sampling the thin Martian air while other instruments recorded data on magnetism and radiation, reported on the planet's seismic activity, and conducted a variety of other investigations. Eight days after the landing, Viking's 10-foot arm scooped up soil samples for analysis by the spacecraft's miniature biology laboratory, which contained instruments designed to recognize microbial life within the soil.

Seven weeks later, Viking Lander 2 dropped onto the Martian surface at a place called Utopia, about a thousand miles nearer to Mars' polar cap than Chryse. The second spacecraft began a series of experiments similar to those of Viking 1.

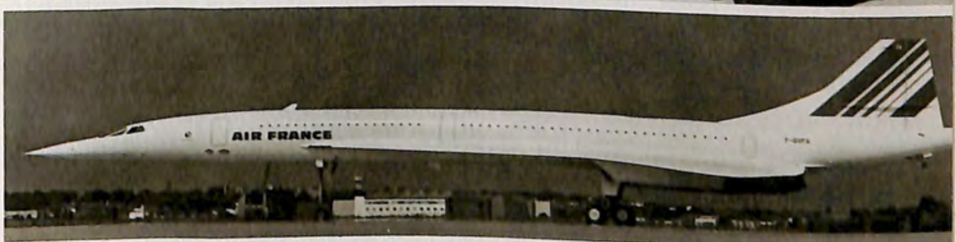
At year-end, the question of life on Mars remained inconclusive. Data obtained by instruments in both spacecraft indicated the presence of compounds that were conceivably of biological origin. However, other instruments showed no evidence of organic molecules, the building blocks of life—or at least of Earth-like life.

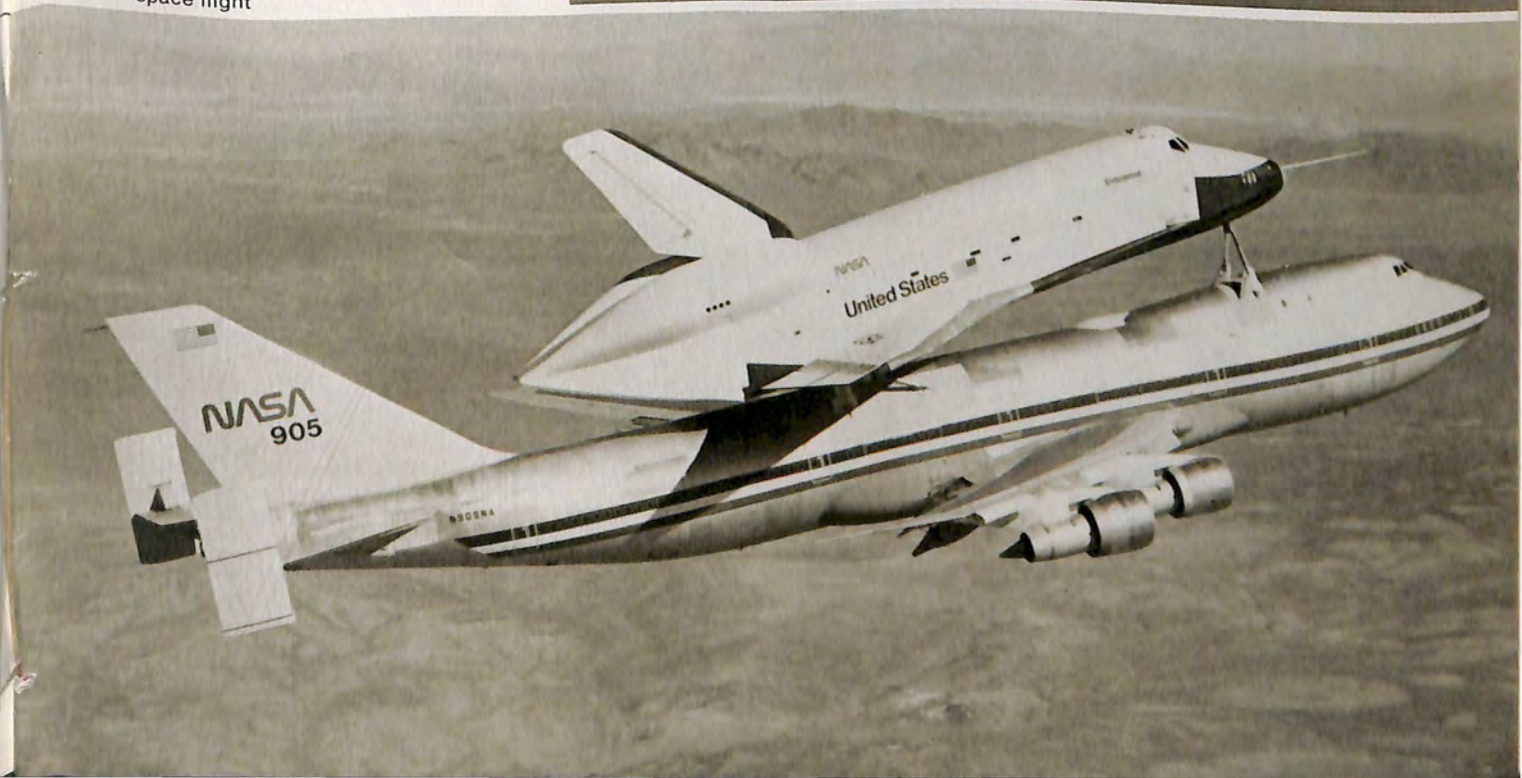
After a month of inactivity starting in mid-November—because the Sun's position between earth and Mars blocked communications — the four-spacecraft team (two Orbiters and two Landers) resumed work late in the year. Plans for 1977 included more photographs of the



1. Highlight of the space year was the Mars landing of a Viking spacecraft
2. The Anglo-French Concorde inaugurated supersonic commercial service to the U.S. in May
3. The September rollout of NASA's Space Shuttle Orbiter heralded a new era of space flight

2





Martian surface, continued monitoring of seismic events, observation of daily and seasonal weather changes and further life-detection tests of soil samples. It was hoped that the Vikings would remain active throughout an entire Martian year of 25 months.

The Viking landings highlighted the National Aeronautics and Space Administration's operational effort in 1976. During the year, NASA had 16 spacecraft launches, all of them officially rated as successful. The perfect launch record was the second in the agency's 19-year history. Only two of the launches involved NASA payloads: Gravitational Probe I and Lageos I, the latter an earth-orbiting satellite designed to study continental drift and the processes that create earthquakes. Two others were cooperative projects: Helios II, second of two probes investigating space close to the Sun, jointly developed with the Federal Republic of Germany, and the Communications Technology Satellite, a U.S./Canada program for further development of direct broadcast techniques. The CTS transmitter, 10 times as powerful as those of commercial comsats, makes possible communications relay to simple, low-cost antennas in remote areas where population and usage are insufficient to justify the expensive complex of ground stations, antennas, amplifiers and land lines required by the commercial comsat network.

The other 12 launches of 1976 were in the reimbursable category, wherein the payload sponsors—Intelsat, NATO and individual foreign governments, for example—paid NASA for the costs of the launch.

Highlight of NASA's developmental effort in 1976 was the September 17 rollout of the Rockwell International-built Shuttle Orbiter, the manned segment of the Space Shuttle Transportation System, which also includes a huge external fuel tank and two recoverable solid rocket boosters. For launch from earth, power is supplied by the boosters and by Orbiter's three main rocket engines, which draw their fuel from the external tank. The five propulsion units collectively produce 6.8 million pounds of thrust for the boost phase after which the solid rockets separate to descend by parachute for recovery and reuse. The non-recoverable fuel tank is jettisoned just before the spacecraft attains orbital altitude. The Orbiter, using internal fuel for course corrections, operates as a maneuverable spacecraft, then returns after its mission in space to land on earth like an airplane.

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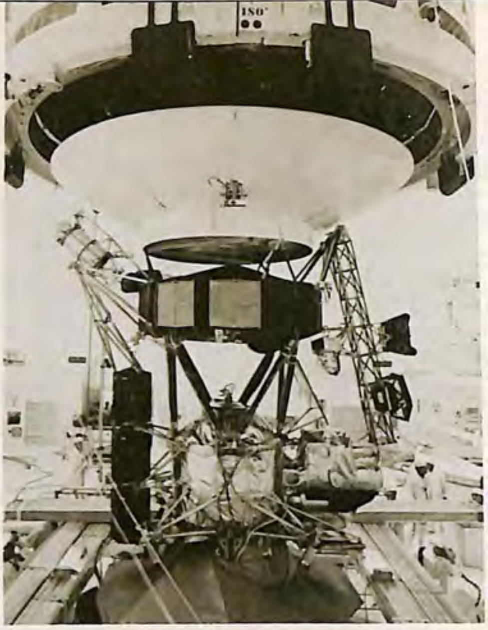

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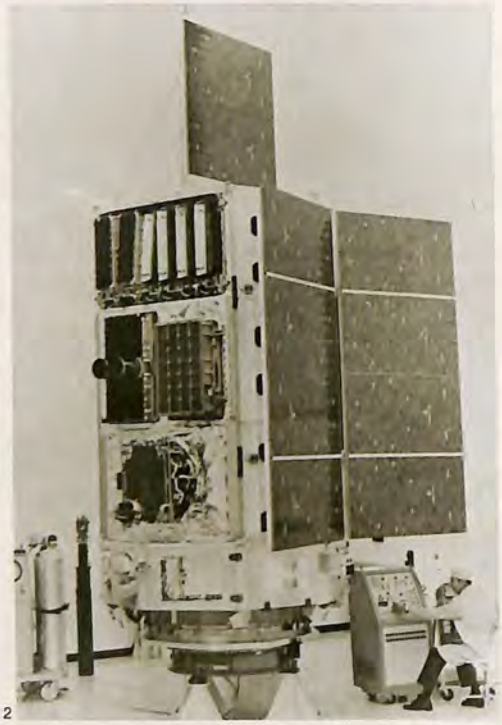


3


1. In advanced development during 1976 was the Mariner Jupiter/Saturn spacecraft, scheduled for 1977 launch

2. Ground tests were conducted on the High Energy Astronomy Observatory in preparation for launch in April 1977

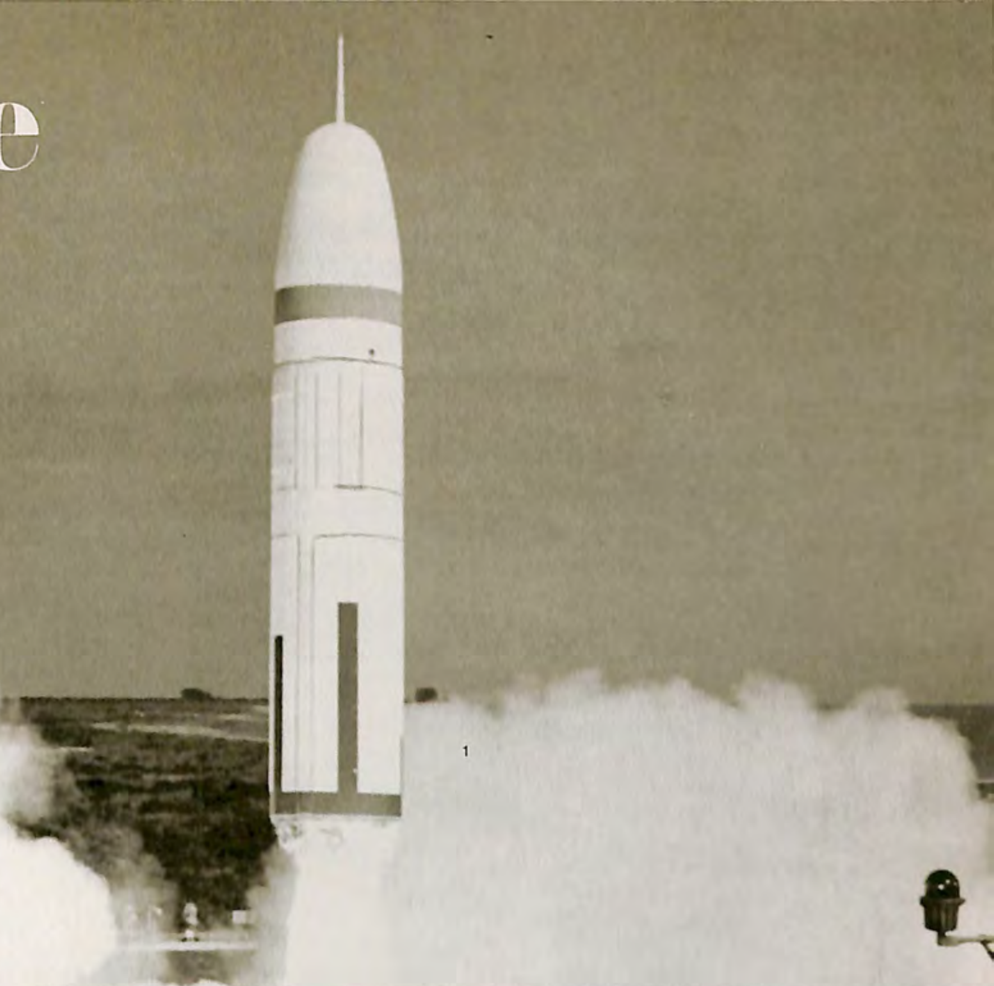
3. Launched in 1976 was Helios II, second of two U.S.-West Germany probes investigating space near the sun

The reusable Shuttle represents a major advance in space capability in that it eliminates the need for costly one-shot launch vehicles and allows routine and economical access to space for a variety of purposes: delivery of payloads to orbit, several at a time; servicing payloads in space or retrieving them for return to earth for rework; serving as a transportation link between earth and manned orbiting stations; or duty as a construction vehicle for erecting large structures in orbit. All that, however, will come after 1980, the date targeted for operational use of the Shuttle. In 1976, Shuttle effort focused on checkout of the first Orbiter preparatory to atmospheric test flights in 1977. On these flights, to begin in July at Dryden Flight Research Center, Calif., the Orbiter will be carried piggyback to high altitude, then released to glide to earth landings, the initial phase of a three-year flight test program.

Two of NASA's most important space science projects progressed during 1976 to final development status; both were slated for 1977 launch. The first, to be launched in April, is NASA's heaviest unmanned spacecraft, the two-ton High Energy Astronomical Observatory (HEAO). HEAO-A, to be redesignated HEAO-I after launch, will return information on some of the most intriguing mysteries of the universe—pulsars, quasars and "black holes" in space.

The other major project is known as Mariner Jupiter/Saturn. Two 1,600-pound Mariner interplanetary spacecraft are to be launched in August and September on multi-year flights past Jupiter and Saturn to conduct extensive investigations of the two planets and the interplanetary medium between them. Primary emphasis will be on a comparative study of the two planetary systems, including their satellites and the rings of Saturn. The Mariners will photograph the planets and explore such matters of scientific interest as mass and density, atmospheres, magnetic fields and exposure to solar radiation. The spacecraft will encounter Jupiter in 1979 and Saturn in 1981.

Defense



1

The principal aerospace-related forces of the Department of Defense remained, during 1976, at more or less constant strength levels, but modernization progressed in a number of areas.

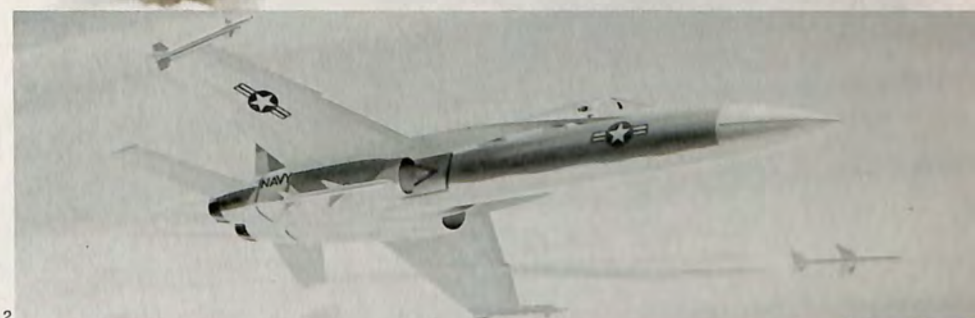
The land-based strategic missile force numbered, as in previous years, 1,054 ICBMs, including 54 Martin Marietta Titan IIs and a mix of 1,000 Boeing Minuteman II and Minuteman III weapons. At year-end, the Navy's ballistic missile submarine force included 10 boats equipped with Lockheed-built Polaris missiles and 26 armed with the advanced Poseidon weapon produced by the same company. Five additional submarines were in process of conversion from Polaris to Poseidon and were expected to join the fleet by the end of 1977.

The number of Air Force Boeing B-52 and General Dynamics FB-111 squadrons remained at 24. During the year, structural modifications to 80 B-52Ds, designed to extend their service lives into the 1980s, were completed.

The Air Force continued to operate 26 tactical air wings but moved further toward bringing the active force up to full strength. In 1976, a program was initiated to improve the capabilities of five squadrons equipped with older aircraft by replacing them with McDonnell Douglas F-15 fighters and Fairchild A-10 close support aircraft. The Navy was operating 13 attack carriers and 12 air wings, the Marine Corps three air wings. Army strength remained at 16 active and four reserve divisions.

The two principle Department of Defense development programs of an aerospace nature were the Air Force's Rockwell B-1 bomber and the Navy's Lockheed Trident submarine-launched strategic missile.

2



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1. A principle development program in 1976 was the Navy's Lockheed Trident submarine-launched strategic missile
2. The Navy's F-18 air combat fighter was ordered into full-scale development early in 1976
3. The first of eight development models of the Air Force F-16 rolled off the production line in October

1


5


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3


1. The Bell Model 222 mid-size commercial twin-turbine helicopter made its first flight in August
2. Ground tests of the NASA/Army XV-15 Tilt-Rotor Research Aircraft began late in the year
3. Winner of the Army's Advanced Attack Helicopter competition was the YAH-64
4. By year-end 1976 three development models of the Air Force B-1 bomber had accumulated 440 hours of flight test time
5. The YC-14 twin-engine STOL aircraft successfully flew for the first time in August
6. In flight test status during 1976 was the Air Force's YC-15, competitor of the YC-14 in the Advanced Medium STOL Transport competition
7. Ordered into initial production was the Army's UH-60A Utility Tactical Transport Aircraft System
8. First prototype of the Sikorsky S-76 twin-turbine commercial helicopter was completed in 1976

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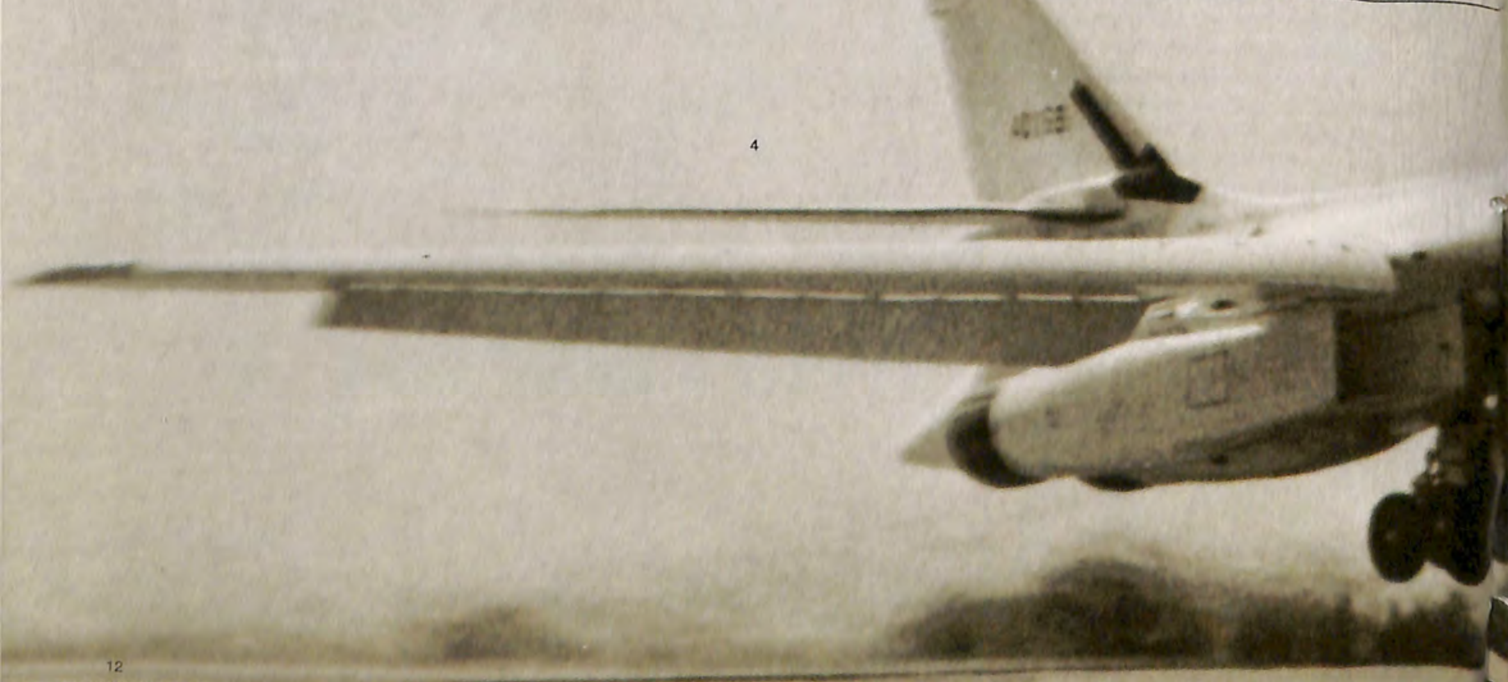

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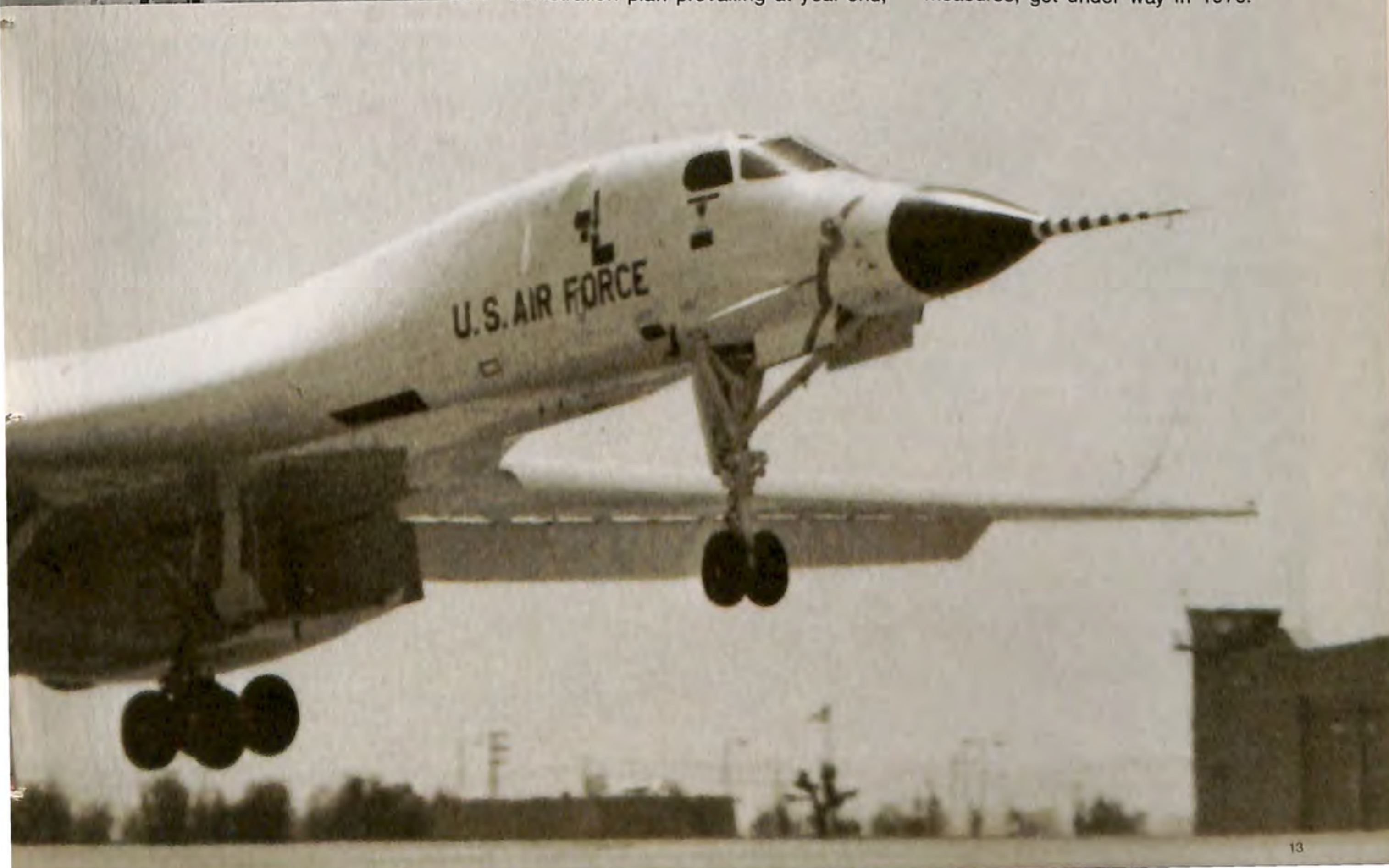
During 1976, flight testing of the B-1 continued and by year-end three development aircraft had accumulated more than 440 hours of flying time. The test program, according to the Department of Defense, "fully demonstrated the B-1's operational capability." Decision as to B-1 production plans, originally expected before year-end, was deferred because of the change in Administrations.

In advanced development during 1976, Trident I was being readied for its initial flight test at year-end. The subsequent flight—on January 18, 1977—was highly successful; the weapon impacted a target area some 4,000 miles down the Atlantic Missile Range from the launch point at Cape Canaveral, Florida. Trident I was slated for initial operational deployment in 1979, aboard new Trident-type submarines now in development. In study status was Trident II, a potential weapon system for the 1980s, which would offer a 7,000-mile range capability as compared with Trident I's 4,600 miles.

Another important missile project, in design status, was the Advanced ICBM, or MX. The MX project contemplates development of a larger, more accurate land-based ICBM with greater survivability, to be provided by concealing mobile weapons in underground trenches or hardened shelters. Under the Ford Administration plan prevailing at year-end, MX was to have progressed this year to engineering development status, with an option for deployment in the mid-1980s. Indications by the new Administration were that MX would be retained as a research project but that the developmental pace would be slowed.

Among other important missile development projects were DOD's cruise missiles, small, jet-powered pilotless bombers designed for high accuracy and penetrability and capable of carrying either conventional or nuclear warheads. Programs active in 1976 included the Air Force's Boeing Air-Launched Cruise Missile (ALCM) and the Navy's General Dynamics Tomahawk, which can be launched either from a submarine or a surface ship. Both were in flight test status during the year and scheduled for progression to full-scale engineering development toward operational capability in 1980. A third type of cruise missile, designed for launch from fixed or mobile ground positions, was under study.

Following successful completion of a series of "proof-of-principle" flight tests, the Army's Raytheon Patriot (formerly SAM-D) air defense system progressed to engineering development status during the year. An advanced flight test series, designed to evaluate the missile's ability to operate against electronic countermeasures, got under way in 1976.



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1. The Navy's Tomahawk cruise missile completed a successful series of tests in 1976
2. The Army's Patriot air defense missile began advanced flight testing in December

Heading the list of DOD aircraft in development during 1976 were the new air combat fighters, the Air Force's General Dynamics F-16 and the Navy's McDonnell Douglas F-18.

The F-16 is designed to meet a requirement for a low-cost, multi-purpose aircraft to complement the more sophisticated McDonnell Douglas F-15 in the air-to-air role and to serve additionally as an air-to-surface attack plane. In October 1976 the first of eight full scale development F-16s rolled off the General Dynamics line and it was delivered to the Air Force in December for the start of a comprehensive flight test program. Destined to be the bulwark of NATO air superiority forces as well as a primary Air Force craft, the F-16 schedule at year-end called for deliveries of first production aircraft in August 1978 and first operational service by 1980.

The companion F-18 was ordered into full scale development early in 1976 with an initial contract for 11 development flight test models. Planned for large scale procurement, with first production orders in the fiscal year 1979, the F-18 will team with the Grumman F-14 in Navy and Marine Corps operations as a carrier-based air superiority fighter in the 1980s. The Department of Defense also planned to develop an A-18 attack version.

Another key airplane in DOD's air modernization program, the Fairchild A-10 close support aircraft, joined the Air Force's operational inventory in March 1976. The A-10 completed its Initial Operational Test and Evaluation during the year and a follow-on test program involving a number of production airplanes was inaugurated later in the year. Year-end plans called for the first A-10 wing to be fully operational in fiscal year 1978.

The Boeing-built Air Force E-3A Airborne Warning and Control System (AWACS) essentially completed its development flight test program in 1976 and delivery of the first production model was expected early in 1977. Designed to overcome the limitations of ground-based radar by air deployment of long-range, jamming-resistant radars, AWACS offers the Air Force a significantly improved capability with regard to strategic force surveillance and early warning, together with command and control in support of both tactical and theater-level operations. Through the end of 1976, funding had been provided for 16 production AWACS aircraft in addition to the three development test planes. The Air Force projected initial operational capability, with five aircraft in service, by September 1977.

In the USAF's Advanced Medium STOL Transport (AMST) competition, Boeing's YC-14 twin-engine STOL made its initial flight in August 1976, joining in flight test status the competing McDonnell Douglas YC-15, which had started tests a year earlier. By year-end there were four AMST prototypes flying, two of each design. The Department of Defense planned a decision as to further development in 1977.

Foremost among Army aircraft developments of 1976 were decisions in two important helicopter competitions. In September, evaluation of two competing Advanced Attack Helicopter prototypes was completed and Hughes Helicopters Division of Summa Corp. was selected to continue development of the YAH-64 helicopter, slated to be the backbone of the Army's anti-armor helicopter force of the future. The year-end plan called for eventual procurement of 536 aircraft.

In December, Sikorsky Aircraft Division of United Technologies Inc. was named winner of the Army's Utility Tactical Transport Aircraft System (UTTAS) competition. Sikorsky was awarded an initial low-rate production contract for its UH-60A helicopter, a combat assault squad carrier which will also be used by aeromedical evacuation units. The total program, as envisioned at year-end, called for eventual production of more than 1,100 helicopters.

The Army was also participating—jointly with NASA—in two notable vertical lift research projects. In October 1976, the Sikorsky S-72 Rotor Systems Research Aircraft (RSRA) made its initial test flight. The S-72 is a heavily-instrumented flying laboratory designed to test a wide variety of rotor systems and, after later additon of wings and jet engines for forward propulsion, to investigate flight characteristics of the compound helicopter, a hybrid 'copter-airplane.

The other Army/NASA project in development status during the year was the Bell Helicopter Textron XV-15 Tilt-Rotor Research Aircraft, designed to explore further the tilt-rotor concept in which the blades provide helicopter-like vertical lift for take-off, then tilt forward to operate like propellers in conventional flight. The first of two XV-15 prototypes was rolled out late in the year and early in 1977 it was checked out in ground tie-down tests preparatory to first flight.