Originally Processed With FOIA(s):
2005-0336-F

FOIA Number:
2005-0336-F

FOIA MARKER

This is not a textual record. This is used as an administrative marker by the George Bush Presidential Library Staff.

Record Group/Collection:	George H.W. Bush Presidential Records
Collection/Office of Origin:	Science and Technology Policy, Office of (OSTP)
Series:	Bromley, D. Allan, Files
Subseries:	General Science Files

OA/ID Number:	62045
Folder ID Number:	62045-002

Folder Title:
Physical Sciences: Space [1 of 3] [1991]

Stack:	Row:	Section:	Shelf:	Position:
	0	0	0	0

Howard A Schmidt
1652 Dryden Way
Crofton Md 21114

D Alan Bromley
White House Science Advisor to President Bush
C/o the White House
Washington DC.

Dear Mr Bromley.

In regards to an article by Douglas Birch in a morning Baltimore Sun newspaper.

Your recent attendance at the seminar in the Stouffer Harbourplace House you said, we, the United States, needs a new vast amount of Electric energy if we are to stay in first place in the world.

It is strange indeed that a few weeks ago my Congress man issued the same call asking for a new energy— Also in vast quantities.

I wrote to Mr MC Millen and I told him that I could give him just the energy he needs and it is not a secreat energy but good old Hydro Electric energy which I have been offering to the United States since 1987.

Mr McMillen never answered my letter and I know you will also not answer this letter.

First I should ask you if you know how to make Hydro Electric energy.

I know that you dont know how to make this energy because you dont know how.

All your knowledge was given to you by a teacher who also does not possess the knowledge of making it.

I can make this energy on and above and below the land and sea and also in a deep mine.

I will make it anywhere in the world and I will not need the river and the dam that all engineers say is necessary to make this energy.

I also will not need the transmission lines to carry the energy into Harry Homeowners home.

Should you care to talk to William Reilly our Environmental person you will find that he has recently discovered that the transmission lines do leak and cause cancer and leukemia.

He did say that he would go befor the Congress and demand that these transmisscon lines be removed all of them in every state.

This fact I have known for over 20 years and I have had to work around them to eliminate them.

Mr Reilly is right they should be removed But there is no Scientist in this world that can take the energy made in the generating plants and give it to Harry Home owner in his home.

So Mr Reilly will get no where with his plan to remove the transmisscon lines

Mr Bush in his talk with the Prime Minister of Canada said he knows the lines leak and he expects to loose some 50,000 lives a year to the Cancer and leukemia.

Yet when the Environment is discussed in Washington DC all that you hear is how many birds were Killed in the recent Exxon Valdez oil spill in Alaska.

You people put more value on some Animals than You do on Human lives.

Do not human lives Count over birds and seals and fish?

You well doubt me that I can make Hydro Electric energy without the use of the river and the dam

You also well doubt me on the fact that I do not need the transmission lines to put the energy in Harry Homeowners home.

I had to ask you first if it was possible for you to do it

I Know that you Cant do it but you also say that I cant do it but

I have made Hydro Electric energy before you were born.

I was in early Aviation 1926 And we decided, as we had the aircraft that we would be the ones to research the Universe but we knew the limitations of gasoline.

We needed a new energy source One that we could call on in outer space.

It was decided that in some way we must find a way to tap into the Electric magnetic force that exists in outer space

This is just what I did I found the way.

When I was confirmed into my Church my Bishop said:

The answer to All our problems in this world has allready been placed in the market place by our creator.

All one has to do is to be able to see it.

The Creator has blinded us in some way to make it hard to see the answers

No matter what your belief is the answers are there

That is where I found the answer to the problem to get the energy to help us research the world.

Plese let me explain what the Hydro Electric will do for the World.

1st it will give us clean air no having to wait till 2010 to get it. It will be immediate.

2nd it will be cost free as no one own it

It exists is such immence quantities you can take all you will ever need to supply the world and there will be plenty left

We will in less than 1 year pay the deficit and the debt we ow for years + years –

In short time it will save us the 30 Billion dollars we spend on fossil fuel to generate our present energy.

4

As for the transmission lines it will eliminate them and save us the Cost of having to repair them when they blow down by large snow storms

We will never loose any human lives to Cancer and leukemia.

It will replace Nuclear energy which is costly and dirty as it will Contaminate the earth with radio activity.

You scientists who urge the use of Nuclear energy have never looked back to see the damage caused by nuclear use.

Chernobyl will be with us forever we must find a way to put an end to the radio activity of Chernobyl

The Russian said there were only 32 people made Radio active Yet they took over 200,000 people to Siberia to die.

Have you seen the pictures of the mutation in the animals that were pregnant at the time of the desaster.

There are 2 headed cows - pigs horses with many extra legs.

As they took over 200,000 people out of the area

Some of the weomen must have been pregnant yet they showed no pictures of how the human child was mutaled.

The ground in all of east Europe is radio active

When the accident happened I told many of our Congressmen and senators that the USA and Canada would have to feed the world,

You can see that I was not wrong.

In my letters to Henry Waxman of LA I told him it would change the world I also said it would give his state of Ca-clean air and the cheap cost of the energy would make it possible for them to desalt the ocean waters and pump them inland into reservoirs and holding ponds for cultivation

I also sent my information to Governor Cuomo of New York State

Of course he wanted to know how I intended to do it.

I told him it was my secret and if he had a method to turn lead into gold would he give me a copy of his formula?

Now he does not answer my letters but I did offer him all the energy he wanted if he would give it to his people for no cost.

I know that he does not know how to make Hydro electric energy.

This also I told my Government that it can be used to make an electrical Car - One that also will take its energy from the electrical magnetic force that covers the Universe - a car that you will never have to replace the energy - will not have a million batteries that have to be recharged every 1½ hours

Here again you people listened to Thomas Edison who said you need a new type of battery before you can make an electric Car. Edison was so wrong.

What good is an electric car that has to be recharged every 1½ hours If you are able to tap into the electric magnetic field and get Constant supply of energy at no cost.

As Mr Bush is an advocate of fossil fuel we all are "shot down" by his decisions to stick with fossil fuel

If we have to develop a new energy as you tell it we dont need to look to far as Hydro Electric will do the job perfectly — "no polutants" clean air a simple cheap way to get clean water.

I am now corresponding with the Senator Daniel Moynihan from N.Y and he is in charge of many items and making clean water is one of them. He has sent my letters into the Dept of State

Of Course my letters are almost too hard to believe.

When the Human was Created the Creator gave only unto the human the ability to reason.

No other Creature on earth has this ability. Many Humans have not had the training to utilize this ability

But they have it anyway and your "Gung ho" love of Nuclear is what is holding you back.

If You forget Nuclear and its dirt put your reasoning to work you too will tell me that Hydro electric energy is the only answer to the problem as it will solve all the problems and not create more.

The changing of the temperature of the air "Global warming" is probably from the use of the shuttle that we have uses to return our Astronauts back to earth.

I studied many things when I went to aviation school. One is the zones of the air structure.

There never was any wind or air movement in the Stratosphere untill we had to have a vehicle to Return our astronauts back to land so they did not die is space from lack of oxygen.

This disturbance caused a mix up of all the gasses which had allready seperated and assumed their proper space in the stratosphere according to their specific gravity

The entrance of the shuttle acted like a big barn door and mixed up all the gasses thus causing the ozone layers to seperate.

When you stop useing the shuttle your air will again go back to what the creator made it to do and the ozone will heal itself and protect the people from the blindness that many farmers are suffering now in Chile and the countries in the Ant artic..

Please think it over. It will be cheap and it will be easy.

Thank You for reading my letter

Sincerely Howard A Schmidt

To Policy Planners:

Sirs:

I have seen on T.V. tonight Governor Anne Richards backing the use of Natural Gas powered vehicles.

I recognize that ideally natural gas is a cleaner fuel. However assuming that eventually there might in the future be more than one million gas powered vehicles: Probably 5% of the gas powered vehicles or more will have gas leaks. I expect that using compressed gas fuel on the large scale in America will screw up the atmosphere gradually because of the many small and large gas leaks that will occur.

Imagine the result of thousands of gas powered vehicles leaking gas and the environmental ~~re~~ long term results. ~~Gas released into the Natural Gas released into the~~

By altering synthesizing Natural Gas into an alcohol mixture by ~~inserting~~ catalytically adding an oxygen atom into a methane, ethane, propane or butane molecule an easily manageable liquid fuel is obtained which will also run an automobile motor.

By simply sending Natural Gas ~~mixt~~ mixed with enough water vapor over ~~palladium~~ hot palladium catalyst in a long enough tube, natural gas plus water goes in one end of the tube - alcohol vapor comes out the other end of the tube which can be condensed into a liquid fuel.

I'm not saying don't use Texas's Natural

Gas as a fuel, I'm saying catalytically process it as I've outlined in the interest of averting the inevitable disaster's that will occur over time from using a compressed combustible gas rather than a liquid fuel. Use of the liquid fuel is safer.

Synthetically produced alcohol is just as clean burning a fuel as the Raw Material Natural Gas that is used to produce the fuel.

Processing the Gas will create jobs.

The only Negative problem I see from turning Natural gas catalytically into Alcohol is the ~~Loss of~~ cost effectiveness problem.

Thanks for considering my Suggestion

MENSA MEMBERSHIP # 1108967

Wesley B. Perkins

January 10, 1991

A ~~modified~~ special carbureator will cause alcohol to evaporate good enough to run a vehicle in cold weather. Of course a modification of the power systems of vehicles would be required. But cutting the volume of petroleum imports is important.

I have been considering Working on the alternative fuels question for several years

"Document Control"

TYPE: INFORMATION DOCUMENT NUMBER: 9200026
ORIGINATOR: 02 STATUS C DIRECTORATE STATUS

****

FROM: MARK, Hans: THE UNIVERSITY OF TEXAS SYSTEM

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 12/27/91

SUBJECT: HE IS PROVIDING DR. BROMLEY WITH THE UPDATED VERSION OF THEIR PAPER ON LONG RANGE PLANNING FOR NASA.

****

DIRECTORATE
ASSIGNED:

STAFF
ASSIGNED:

ACTION
REQUIRED:

STAFF
ACTION:

****

SENDER'S DUE DATE:

OSTP DUE DATE:
DATE COMPLETED:

STAFF DUE DATE
DATE COMPLETED/DEPT:

****

COPIES TO: D. Allan Bromley
PHYSICAL SCIENCES

****

WHITE HOUSE TRACKING #:

CONTACT PERSON:
PHONE: EXT:

REMARKS:

OSTP RECEIVED: 01/06/92 DEPT RECEIVED:
FILE: P-PHYSICAL SCIENCES-SPACE

CENTRAL FILES:

Academic Component Institutions:
The University of Texas at Arlington
The University of Texas at Austin
The University of Texas at Brownsville
The University of Texas at Dallas
The University of Texas at El Paso
The University of Texas-Pan American
The University of Texas of the Permian Basin
The University of Texas at San Antonio
The University of Texas Institute of Texan Cultures at San Antonio
The University of Texas at Tyler

Health Component Institutions:
The University of Texas Southwestern Medical Center at Dallas
The University of Texas Medical Branch at Galveston
The University of Texas Health Science Center at Houston
The University of Texas Health Science Center at San Antonio
The University of Texas M.D. Anderson Cancer Center
The University of Texas Health Center at Tyler

THE UNIVERSITY OF TEXAS SYSTEM
601 COLORADO STREET AUSTIN, TEXAS 78701

December 27, 1991

Office of the Chancellor
(512) 499-4200

Dr. D. Allan Bromley
Office of Science and Technology Policy
Office of the President
Old Executive Office Building, Room 358
17th and Pennsylvania Avenue, N.W.
Washington, D.C. 20506

Dear Allan:

Ten years ago, Milt Silveira and I put together a short paper on long range planning for NASA. We thought that it might be a good idea to update the paper after a decade. The revised version is enclosed for your information. We hope that you find it useful.

With best wishes for a Happy New Year,

Sincerely,

Hans

Hans Mark
Chancellor and
Professor of Aerospace
Engineering and Engineering
Mechanics, The University
of Texas at Austin

HM:bb
Enclosure
xc: Dr. Milton A. Silveira

LONG RANGE PLANNING FOR NASA AND THE SPACE PROGRAM

by

Milton Silveira and Hans Mark

December 1991

I. INTRODUCTION

A decade ago, both authors were serving at NASA Headquarters in Washington, D.C. and were concerned about developing a long range plan for NASA and the American space program. In the summer of that year, we drafted a paper for submission to then Administrator, James M. Beggs, entitled "Notes on Long Range Planning" which outlined some of the things that we felt needed to be done in 1981.

Ten years later, it is obvious that a new effort must be made at developing a good long range plan for the American space program and for those institutions charged with implementing the plan. Since our purpose is to update our earlier plan, the 1981 memorandum is reproduced in its entirety in the next section of this paper.

II. "NOTES ON LONG RANGE PLANNING."

The development of long range planning for NASA should be based on Section 5 in the 1958 Space Act requiring "the preservation of the role of the United States as a leader in aeronautical and space science and technology..." This may be a difficult thing to do in view of limited funds that will be available to NASA in the coming years but the intent of the statement in the law is crystal clear and NASA must act accordingly.

1) FACILITIES

Fundamental to all that NASA does are the facilities that exist at NASA's research and development Centers. It is not always recognized but the NASA aeronautical facilities are vital, not only to aircraft design, but also to the development of our space technology. For example, the 40'x80' wind tunnel at the Ames Research Center which is justified solely as an aeronautical facility was used for testing the flying qualities of the Space Shuttle during the critical approach and landing phase. A one-third scale model was tested many hundreds of hours in the wind tunnel to insure performance, stability, and control characteristics. There are many other examples where wind tunnel and high temperature facilities are used to insure safe flight of a spacecraft as it passes through the atmospheric portion of its flight.

Broadly speaking, NASA's facilities fall into five separate categories:

1. Wind Tunnels
2. Flight and Operations Simulators
3. Propulsion Test Facilities
4. Experimental Airplanes
5. Computational Facilities

Recently, heavy investments have been made in required wind tunnel facilities. Approximately $250M have been spent, improving the Ames 40'x80' wind tunnel and building at Langley the High Reynolds Number Cryogenic Tunnel. Large investments have also been made in flight simulators, although more needs to be done in developing and building simulators to overcome current deficiencies. There is a need to develop more facilities for the simulation of operations and construction in space with a zero "g" environment and under demanding thermal conditions. The major aeronautical propulsion facility in the country is being developed by the United States Air Force at the Arnold Engineering Development Center. NASA must take advantage of this facility as best it can. NASA must also develop a policy toward the development of propulsion facilities at the Lewis Research Center. Particularly, NASA must also see to it that the rocket propulsion test stands are adequate for programs in launch vehicles that may be initiated following the completion of the Space Shuttle program. Experimental aircraft tend to be more specialized toward specific flight configurations. However, there are some programs such as the F-8 fly-by-wire aircraft and the Boeing 737 control configured vehicle in which the aircraft are used more-or-less as general purpose simulation facilities. Computers are not usually regarded as facilities but they should be viewed as such. The Numerical Aerodynamic Simulator now being proposed is particularly important in this regard since it may overcome certain limitations in the simulations of the other facilities now operated by NASA (wind tunnels, propulsion facilities and flight simulators) if the promise of computational methods in aerodynamics, chemically reacting flows, and dynamic structures can be realized. The maintenance and development of the necessary facilities to accomplish the mission stated in the law must, therefore, have the highest institutional priority in NASA.

2) AERONAUTICS

Work in aeronautics by NASA, and the NACA prior to 1958, has traditionally been oriented toward the support of military and civil aviation. Future interest in the military is likely to be centered on the development of a new long range combat aircraft (LRCA) by the United States Air Force having low radar, infrared, and visible observable (i.e., stealth technology), the creation of a new family of V/STOL aircraft for the Navy, and the continuing enhancement of the performance of rotor craft for the Army. To maintain a lead in civil aircraft sales, continual improvements must be made for greater economy. The technology suitable for third level carriers (i.e., commuter airlines) is likely to be the major civil requirement. The latter is especially important in view of the inroads being made by foreign competition in that field. Right now the Dehavilland Twin Otter, the DHC-7, and the Shorts Skyvan dominate that field in the United States. In addition to all of these things, a strong basic research program in fluid mechanics, materials and other topics related to aeronautics and space vehicles must be maintained.

3) THE SPACE SHUTTLE

The major technological development carried out by NASA in the last decade is the Space Shuttle vehicle. That basic development is now nearly complete and the next step is to turn it into an operational system. This effort must have the highest programmatic priority in NASA for the coming years to realize a return for this large investment. It should take about three years to make the Space Shuttle an operational transportation system. It is necessary to arrive at an agreed-upon definition of what is meant by "operational" and to determine whether NASA should be the agency that operates the Shuttle or whether some other institutional mechanism needs to be provided for that purpose. The organizational structure needs to be developed for Shuttle Operations. No matter how the matter of Shuttle Operations is finally decided, the Johnson Space Center should phase out of the operational mission during the next three years. It is very unlikely that it will be possible to control costs of operations if the developmental attitudes that prevail at the Johnson Space Center dominate after the Space Shuttle becomes operational. The operations of the Space Shuttle, both launch as well as mission control, should be handled by the Kennedy Space Center and by Vandenberg Air Force Base once the West Coast launch facility is complete.

4) THE SPACE STATION

While the Space Shuttle becomes operational, a project to establish a permanent presence in space (i.e., a Space Station) should be initiated. This should become the major new goal for NASA and, some time during the next two years, the President should be persuaded to issue a statement proclaiming a national commitment to that effect. The necessary arguments that justify this step must be carefully developed now, and these arguments range from national security (i.e., arms control verification, military surveillance) to the improvement of space operations (i.e., satellite maintenance on orbit and other things of this kind). The necessary committees of the National Academy of Engineering, the National Academy of Sciences, and other bodies of this kind should be established to set up now the technical baselines for this new enterprise.

5) UNMANNED LAUNCH VEHICLES

The Shuttle program has led to the creation of a new propulsion technology which should be further exploited. It is now generally agreed that unmanned launch vehicles will not be phased out completely once the Shuttle is operational. They will always be necessary to supplement the Shuttle launch capability. The current launch vehicles, (Atlas, Titan, Delta) are based on technology that is now thirty years old and should be replaced by more efficient and economical vehicles. New unmanned launch vehicles based on the Shuttle technology using solid rocket boosters and the Shuttle's main engine system should be developed. The solid rocket booster itself is an excellent rocket with a sea level thrust of the order of 2.5M lbs. Several solid rocket boosters strapped together could provide a formidable launch vehicle in terms of payload capacities. Such a vehicle with three solid rocket boosters could put into low earth orbit a payload weighing something like 100,000 lbs. and perhaps up to 20,000 lbs. into geosynchronous orbit with an appropriate upper stage. An important feature of the solid rocket boosters is that they are recoverable which means that the cost advantages inherent in that property could be important. This new generation of launch vehicles would not be "expendable" although it would be unmanned.

6) SCIENTIFIC EXPLORATION

NASA has a fundamental responsibility to continue with the scientific exploration of objects in space and conditions in space. In the coming decade, scientific investigations conducted in earth obit will be the most important because these take the best advantage of the unique properties of the Shuttle. Specifically, this means that astronomy, experiments involving certain cosmological things such as general relativity and experiments in zero gravity using Spacelab will be the dominant trend in scientific space research. An extremely important aspect of this are the medical and biological experiments to be done using the Shuttle to establish what must be done to permit people, animals, and plants to live in zero gravity conditions for lengthy periods. It is probable that planetary exploration will be de-emphasized somewhat until we have a Space Station that can serve as a base for the launching of a new generation of planetary exploration spacecraft. It is apparent that the return of samples from various bodies in the solar system will be given highest priority once that time arrives.

7) SPACE APPLICATIONS

The applications program should emphasize the scientific part of the earth observations, specifically oceanography, geodesy, and things of this kind. In view of the Administration's policies with respect to technical demonstration programs, NASA should de-emphasize efforts to commercialize various applications projects. The applications program should also emphasize technology development and should cooperate closely with the national security community in these efforts. It is likely that the nation's surveillance satellites will move to geosynchronous orbit in the next two decades. This means that large space structures will be required, mirrors, antennas, and other systems of this type. NASA should be extremely active in the development of this technology and should establish the closest possible support of the national security community in achieving these objectives.

A few thoughts regarding future directions for NASA have been outlined in this paper. Obviously, much more detail needs to be done to develop some of these ideas. It is very important to begin now by setting up the proper procedural methods within NASA as well as the NASA advisory structure to make certain that these ideas are properly considered and developed into a coherent long range plan for the nation's aeronautical and space programs.

Hans Mark

Milton Silveira

August 1981

III. NOTES ON LONG RANGE PLANNING FOR THE 1990s.

In updating our 1981 plan, we will follow the same format that we used ten years ago and deal with the individual subjects in the same order.

1) FACILITIES AND PEOPLE

The NASA institution is still the most important base on which everything else depends. We have little to add to what we said in 1981 on the subject of facilities. Facilities are still the most important element in keeping NASA's in-house technical capabilities alive, therefore, upgrading of facilities continues to be the highest priority effort. We notice that several of the things that we proposed in 1981, such as the Numerical Aerodynamics Simulator (NAS), have now been constructed. This is all to the good. Since we have both been away from NASA for some years, it would not be appropriate for us to make detailed suggestions at this time, except to draw attention to the importance of facility programs.

In 1981, we did not mention the subject of people. We had the good fortune during our term of service at NASA Headquarters to be able to bring aboard upwards of a thousand new, young engineers and scientists. This group of people is now beginning to mature and will become the backbone of NASA as time goes on. It is appropriate here to reiterate the importance of continuing efforts to bring in the very best people available. The space program is an exciting enterprise and it is not difficult to recruit the very best young people to work on space related projects. These efforts must continue.

2) AERONAUTICS

The NASA aeronautics program is a major success story. It is still the best thing that NASA has going for it in terms of support from its most important constituency, the aerospace industry. For some years now, airplanes and aviation products have been the largest single U.S. export item, amounting to some $20 Billion a year in the last fiscal year. This fortunate result has been due to a strong "industrial policy" in aviation. We have enjoyed stable R&D funding, good technology transfer from NASA to the aviation industry and no adversarial relationships between the industry and the government.

All of this has had the consequence that we are now on the threshold of being able to exploit several new aeronautical developments that began with NASA research. The technology of tilt-rotor aircraft is one example. In spite of the move by the Defense Department to cancel the V-22 tilt-rotor "Osprey" program, it has been kept alive by the Congress. There is general recognition that both the military and civilian applications of this technology are promising enough to warrant this step. The war in the Persian Gulf provided numerous examples of the important applications of the technology base provided by NASA. One of us (HM), during a term of service as Director of NASA-Ames Research Center (1969 to 1977) supervised the wind tunnel tests of models that later became the "Stealth" aircraft that were so decisive in that conflict.

Several aeronautical developments are on the horizon for which more research and engineering development is required before judgments can be made as to their broader applications. One is in the area of cargo airplanes. Civil cargo aircraft today are all converted passenger airplanes. Air cargo is likely to be the fastest growing sector in air transportation in the coming years. An example of this trend is the recent completion of the construction of Alliance Airport north of Fort Worth, Texas. This facility is intended solely for air cargo. There is a question then as to whether a civilian cargo aircraft designed from the ground up for that purpose might be useful. This would be the equivalent of the containership in ocean transportation.

A second area is the application of composite primary structures. These have already been applied in small aircraft and the B-2 is the first airplane in which synthetic composite materials are employed on a large scale in the primary structure of the aircraft.

A good argument can be made that the time has come to revisit the question of an efficient and cost effective supersonic transport. The Concorde has operated for over a decade but its limits are now well understood. The range is too short and the payload is too small for economical performance. There have been advances in technology, such as the large variable geometry aircraft represented by the B-1-B, that could be applied to the development of a new civil supersonic transport that might have economic viability.

Finally, there is the National Aerospace Plane (NASP). This is an important long range future development but in our view somewhat premature for full scale expenditures at the present time.

3) THE SPACE SHUTTLE AND OTHER SPACE LAUNCH VEHICLES

In 1981, we recommended that the operation of the Space Shuttle be moved from the Johnson Space Center to the Kennedy Space Center. In our view, this move is more important now than it was ten years ago. The Shuttle is now a mature vehicle and the time has come to separate the operational responsibilities from those that have to do with the development of new space systems. We recommend that the Space Shuttle management be moved to the Kennedy Space Center. This recommendation is consistent with the one recently made by the outgoing Deputy Administrator of NASA, Dr. J. R. Thompson. We believe the Mission Control Center for Space Shuttle Flights should be moved to the Kennedy Space Center. The Astronaut Office should be kept at the Johnson Space Center, because Space

Station requirements will eventually dominate the use of people in space. The Mission Control Center for the Space Station should also be established at the Johnson Space Center. Currently existing facilities both at the Kennedy Space Center and the Johnson Space Center can be used to accomplish the purposes that we have just outlined.

In the 1981 paper, we predicted that unmanned launch vehicles would not be phased out, even though at the time, it was the policy of the federal government to do just that. It is for this reason, of course, that we have elected to combine the Shuttle and unmanned launch vehicles in one section in this updated paper. We now have retained Delta, Atlas and Titan as large operational unmanned launch vehicles. The Titan program is essentially military in nature and it should remain that way. If there is a civilian or NASA requirement for a Titan launch, then the appropriate agency should contract with the Air Force to execute it. The Delta and Atlas programs are supervised by NASA even though there are now commercially available launches in both cases. We would recommend that the current relationships be retained.

In the longer term, we believe that a new organization should be established to run all civilian launch vehicles, including the Space Shuttle. This new organization should be a quasi-public corporation on the COMSAT model which was instituted for communication satellites in 1962. This new organization would contract with General Dynamics in the case of Atlas and McDonald-Douglas in the case of Delta to operate these launch vehicles. This new entity would not be purely commercial in its initial phase but then neither was COMSAT. It took seven or eight years for communication satellites to demonstrate their commercial viability and even after that period, government subsidies were still necessary in terms of launch services to make communication satellites a good commercial proposition. The same would be true for the proposal we are making here. There is nothing wrong with subsidizing new transportation systems. In the 19th Century, the federal government subsidized the railroads through land grants because it then was in the public interest to do so. The government subsidized the early airlines with mail carrying contracts for the same reason. And, of course, the automobile industry is heavily subsidized through a large and extensive road building program. The same arguments should apply in the case of space transportation.

In our paper ten years ago, we suggested that a heavy lift launch vehicle be developed that was based on the new propulsion technology created in the Space Shuttle program. We still believe that this is a good idea because it would be much more expensive to do anything else and still provide the same weight lifting capability. The real problem with heavy lift launch vehicles is that there is no compelling requirement to develop one at this time. Neither the civilian sector -- even if a trip to Mars is included -- nor the military sector through the Strategic Defense Initiative absolutely require a new heavy lift launch vehicle. There is no doubt that it would be useful to have a heavy lift launch vehicle but the fact is that it is not absolutely necessary.

The suggestion has been made to use Russian heavy lift launch vehicles such as the Proton or the new Energia. The Proton is a good vehicle with a capability similar to that of the Titan IV and might eventually turn out to be useful. The Energia has just been completed and has yet to be successfully tested. There have been two launches and both had major failures. If the Energia launch vehicle turns out to be successful, then adopting it might be a good policy. The problem is, unfortunately, political instability in the former Soviet Union makes the use of Energia a very uncertain proposition.

In addition to the launch vehicles that we have mentioned, there are some small vehicles, and some orbital transfer vehicles and upper stages, that have been developed. Some of these are commercial enterprises. We would recommend that the current activities in these areas be continued.

4) THE SPACE STATION

In our 1981 paper, we recommended that the development and deployment of a Space Station to achieve a "permanent presence in space" be undertaken. In 1984, President Reagan included this program in his State of the Union Message. The Space Station program has now evolved to Space Station "Freedom" which we believe is, unfortunately, in some trouble. During the last congressional session, NASA was put on notice that the project is too expensive and that the management structure is too complex. There are too many approval levels and the abandonment of the "Lead Center" concept by NASA has led to very complicated interfaces among the various NASA institutions that are responsible for developing the Space Station "Freedom." After almost eight years and $5 Billion there is still not any flight hardware.

We believe that the Space Station project survived the last congressional debate only because the opposition was not well organized and because of the heavy international participation in the project. It is probable that international participation was the strongest reason for maintaining the Space Station program as it is currently configured. If this is indeed the case, then we have no choice but to go ahead with the current project in a technical sense because we have chosen not to disappoint our international partners. However, there are a number of management changes that can and should be made. First, we believe it is important to reestablish the Lead Center concept for the Space Station "Freedom" program. Specifically, the Johnson Space Center should be given the Lead Center responsibility for the management of the program. (This is consistent with a recommendation recently made by outgoing NASA Deputy Administrator J. R. Thompson.) Second, we recommend that the Space Station management organization located in Reston, Virginia be disbanded. In terms of contractor arrangements, the relationship between the Johnson Space Center and McDonnell-Douglas, between the Marshall Space Flight Center and Boeing, and between the Lewis Research Center and Rocketdyne, should be maintained. Since the Johnson Space Center under our recommendation would become the lead development center, McDonnell-Douglas would become the lead contractor. The general idea of this recommendation is to collapse the management organization and to focus responsibility at one center with one contractor for the execution of the Space Station "Freedom" program.

In view of the difficulties that have been encountered by the Space Station "Freedom" program, it is important to have a backup plan. In spite of the international arrangements that have been made, Congress may elect to kill the program. If that happens, we would recommend that the Industrial Space Facility (ISF) be used as a substitute. It is most important not to abandon the concept of the space station. The ISF would be an excellent way to keep the Space Station concept going and to eventually provide the "permanent presence in space" that we have in mind. The ISF program as currently formulated also has the great advantage that it can be implemented in an incremental manner. In managing this program, a "skunk works" approach should be used and the Johnson Space Center should still be used as the lead center for this backup program.

It has also been suggested in this connection that we consider the purchase of a MIR Space Station from the Soviets. This proposition is technically more attractive than using the Energia launch vehicle since MIR is a flight tested piece of hardware. One might even think of visiting the MIR Space Station currently in orbit for the conduct of research that bears on the deployment of Space Station "Freedom." The only caution here would be the same one that we have made with respect to the use of Soviet launch vehicles. Political instability in what was once the Soviet Union is probably the biggest hindrance to progress in this area.

5) SCIENTIFIC EXPLORATION

In its report on the nation's space program submitted late in 1990, the Committee headed by Norman Augustine put scientific research and exploration at the highest level of priority. The Committee also recommended that scientific exploration take up approximately twenty percent of NASA's total budget. We believe that this recommendation is a reasonable one and we concur with the approach adopted by the Augustine Committee. The term "highest priority" in our judgment, means not that the twenty percent is the biggest item in NASA's budget, but that it is protected. As we said in our 1981 paper, space science and exploration is exceedingly important to the fundamental mission of NASA.

In the past few years, there have been significant problems in scientific missions. We are speaking here of the Space Telescope and Galileo. The common thread here is that both of these spacecraft spent much time on the ground in storage for years waiting for a flight opportunity. Very little testing on either of these spacecraft was performed during these long quiescent periods. An appropriate and not very extensive test program would probably have eliminated both problems. It is necessary to tighten up the management of large space science programs and to provide for continuing test programs. It should also be recognized, however, that in the case both of the Space Telescope and Galileo the problems might be fixed. The Space Telescope was designed from the beginning to be man-tended and plans are now under development to visit the telescope and fix the problem with the mirror focus. In the case of Galileo, the mission may be rescued through the launch of a relay satellite that could take the signals from the defective antenna on Galileo and relay them to Earth with an appropriate high gain antenna. However, this is a costly proposition. Therefore, even though there are problems, both can probably be repaired provided that the necessary resources are available.

6) SPACE APPLICATIONS

In the case of space applications, our comments in the 1981 paper still apply. The aversion to the conduct of demonstration programs is still with us in the current administration. However, environmental measurements seem to be more important now in the public eye than they were ten years ago. It is this circumstance that has given rise to the so-called EOS program or "Mission to Planet Earth." The use of satellites for environmental measurements must, in our view, be traded off against the use of airplanes for the same purpose in each case. Airplanes are now extensively used both for earth observations and for environmental monitoring. Many of these airplane based programs are run by commercial enterprises on a profit making basis. It is our view that satellites have an important but relatively limited role to play in earth observations. This role is related to the unique capabilities of satellites that have to do first with synergistic views of the entire Earth and second with the measurement of long range trends.

The most useful contribution that NASA can probably make to environmental monitoring is instrument development. There have been some genuine successes along this line already and there is every reason to expect more in the future.

In addition to environmental monitoring, NASA should also do technology for new communication satellites. High frequency links with more data carrying capacity and laser communication systems are on the horizon. These should be developed to maintain what is today an American lead position in space communications.

7) THE SPACE EXPLORATION INITIATIVE

On July 20, 1989, the twentieth anniversary of the landing of Neil Armstrong and Buzz Aldrin on the moon, President Bush spoke about the American space program. He recognized the anniversary and then laid out the plan for the future. This plan consisted of three separate steps:

First, finish Space Station "Freedom" to establish the "permanent presence in space."

Second, go back to the Moon "this time to stay."

Third, mount a journey to Mars to explore that planet.

The President gave no time table in his speech but he did ask NASA to develop a plan to implement what he had in mind. NASA performed the so-called "Ninety Day Study" in which a program plan was submitted that called for a return to the moon sometime after the year 2000 and a flight to Mars sometime between the year 2014 and 2019. This time schedule is so lengthy that the Congress has been very reluctant to fund the program. In our view, it is not surprising that something which comes to fruition thirty years hence is of little political interest today.

We believe that it is possible to conduct the President's program, which has come to be called the "Space Exploration Initiative" (SEI), on a much shorter time scale. We believe that it is possible to return to the moon by 1996 or 1997 and to reach Mars in the year 2003 or 2004. It is most important in our view to mount a program to achieve these objectives. There is no doubt in our minds that NASA has the capability to execute this plan. One of us (HM) has been active in working out this plan and the details are described in the following publications: Aerospace America, August 1991, "Fast Track to Mars"; Paper Number IAF-91-462 presented in October 1991 at the 42nd Congress of the International Astronautical Federation, "The Human Exploration of the Solar System"; and Luft und Raumfahrt, Juli/August 1991, September/October 1991 and November/Dezember 1991 "Mission Zum Mond und Mars."

As in 1981, this paper is meant to be only an outline. Much more detailed work needs to be done to develop some of the ideas that have been described. A decade ago, we urged that the plan we had developed be executed as soon as possible. We urge the same today.

Hans Mark was Director of the NASA Ames Research Center from 1969 to 1977 and Deputy Administrator of NASA from 1981 to 1984. He is currently Professor of Aerospace Engineering and Engineering Mechanics at The University of Texas at Austin and Chancellor of The University of Texas System. He resides in Austin, Texas.

Milton A. Silveira worked on the Apollo Program and was Deputy Manager of the Space Shuttle Orbiter Program from 1972 to 1981 at the Johnson Space Center and Chief Engineer of NASA from 1983 to 1986. He is currently a consultant to the Aerospace Industry residing in Washington, D.C.

"Document Control"

TYPE: ACTION DOCUMENT NUMBER: 9125033
ORIGINATOR: 02 STATUS I DIRECTORATE STATUS

****

FROM: PRICE, Norman and CASH, David: AMHERST REGIONAL JUNIOR HIGH SCHOOL

TO: DR. D.A. BROMLEY

DEC 10 1991

DATE OF CORRESPONDENCE: 11/27/91

SUBJECT: THEY REQUEST INFORMATION REGARDING THE FUNDING PRIORITIES OF THE U.S., AND HOW DR. BROMLEY VIEWS THE FUNDING OF SPACE SCIENCE AND THE PROPOSED SPACE STATION IN PARTICULAR.

****

DIRECTORATE ASSIGNED: PHYSICAL SCIENCES

STAFF ASSIGNED: Doug Beason (2/2/91) (over your signature)

ACTION REQUIRED: DIRECT REPLY

STAFF ACTION:

****

SENDER'S DUE DATE:

OSTP DUE DATE: 12/18/91

DATE COMPLETED:

STAFF DUE DATE

DATE COMPLETED/DEPT: 3/16/92

****

COPIES TO: D. Allan Bromley
PCAST

****

WHITE HOUSE TRACKING #:

CONTACT PERSON:
PHONE: EXT:

REMARKS: DB responded.

OSTP RECEIVED: 12/04/91 DEPT RECEIVED:
FILE: P-PHYSICAL SCIENCES-SPACE

CENTRAL FILES:

"Document Control"

TYPE: ACTION
DOCUMENT NUMBER: 9125033
ORIGINATOR: 02
STATUS I
DIRECTORATE STATUS

****

FROM: PRICE, Norman and CASH, David: AMHERST REGIONAL JUNIOR HIGH SCHOOL

TO: DR. D.A. BROMLEY

DATE OF CORRESPONDENCE: 11/27/91

SUBJECT: THEY REQUEST INFORMATION REGARDING THE FUNDING PRIORITIES OF THE U.S., AND HOW DR. BROMLEY VIEWS THE FUNDING OF SPACE SCIENCE AND THE PROPOSED SPACE STATION IN PARTICULAR.

****

DIRECTORATE ASSIGNED: PHYSICAL SCIENCES

STAFF ASSIGNED:

This is a form letter!

ACTION REQUIRED: DIRECT REPLY

STAFF ACTION:

Forget it! DAB.

****

SENDER'S DUE DATE:

OSTP DUE DATE: 12/18/91

STAFF DUE DATE:

DATE COMPLETED:

DATE COMPLETED/DEPT:

****

COPIES TO: D. Allan Bromley
PCAST

****

WHITE HOUSE TRACKING #:

CONTACT PERSON:

PHONE:

EXT:

REMARKS:

CLOSED

OSTP RECEIVED: 12/04/91

DEPT RECEIVED:

FILE: P-PHYSICAL SCIENCES-SPACE

CENTRAL FILES:

Damar –

DAB got the same post card 2 wks. ago. I sent them his Post article on the Space Station. ~~And~~ Perhaps they need a more in-depth response.

Lisa

5033

Dear Sir or Madam,

We are doing research on the funding priorities of the United States and would like your perspective. We are interested in how you view the funding of space science in general and the proposed space station project (Space Station Freedom) in particular. It would be helpful to know:
1) whether you think these areas should receive increased, level, or decreased funding,
2) your reasons for favoring these or different funding priorities,
3)any suggestions about additional organizations (governmental or private) that have a strong opinion about this issue.
Thanks in advance for your help.

Sincerely,
Norman Price and David Cash
Science Department
Amherst Regional Junior High School
Amherst, MA 01002

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

March 18, 1992

Dear Mr. Price and Mr. Cash:

Thank you for your letter inquiring about Space Station Freedom. This program, the largest international R&D project ever undertaken, will enable the performance of life sciences and materials research in a premier space laboratory for extended periods. Specific experiments during the initial operation of Freedom will lead to new knowledge in semiconductor and biotechnology fields, and may lead to eventual production of unique commercial products from space. When Freedom's crew is aboard full time, emphasis will shift to life sciences research, necessary for the long-term space flights of the next century.

The President's fiscal year 1993 budget request provides $2.25 billion for space station. This includes an increase of 10% over the 1992 enacted level of development, and initial funding for Space Station operations. This amount will support finalization of detailed designs, and allow fabrication, qualification, and assembly tests of various critical components in preparation for first element launch in 1996, the attainment of a man-tended capability in 1997, and a permanently manned capability in late 2000.

The President remains firmly committed to his long-term goal, articulated in 1989, of manned and unmanned exploration of the solar system. Space Station Freedom will play a major part in that exploration.

If you require any additional information, please feel free to contact the Space Station Freedom Office at 600 Independence SW, Washington DC 20546. Thank you for your time.

Sincerely,

Dr. J. Douglas Beason
Senior Policy Analyst

Mr. Norman Price and David Cash
Science Department
Amherst Regional Junior High School
Amherst, MA 01002

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION DOCUMENT NUMBER: 9124193

ORIGINATOR: 02 STATUS C DIRECTORATE STATUS

****

FROM: TRULY, Richard H.: NASA

TO: DR. D.A. BROMLEY

DATE OF CORRESPONDENCE: 09/23/91

SUBJECT: A COPY OF THE, "REPORT OF THE EARTH OBSERVING SYSTEM, ENGINEERING REVIEW COMMITTEE, SEPTEMBER 1991" AND AN OFFER TO ARRANGE A BRIEFING BY DR. FRIEMAN AND A BRIEFING ON NASA'S EOS ACTIVITIES.

****

DIRECTORATE ASSIGNED:

STAFF ASSIGNED:

ACTION REQUIRED:

STAFF ACTION:

****

SENDER'S DUE DATE:

OSTP DUE DATE:

STAFF DUE DATE

DATE COMPLETED:

DATE COMPLETED/DEPT:

****

COPIES TO: D. Allan Bromley
PHYSICAL SCIENCES

****

WHITE HOUSE TRACKING #:

CONTACT PERSON:

PHONE: EXT:

REMARKS:

OSTP RECEIVED: 09/25/91

FILE: P B-PHYSCIAL SCIENCES-SPACE

DEPT RECEIVED:

4193

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

September 23, 1991

The Honorable D. Allan Bromley
Assistant to the President
for Science and Technology and
Director, Office of Science and
Technology Policy
Executive Office of the President
Washington, DC 20506

Dear Dr. ~~Bromley~~ Allan:

Concurrent with the FY 1992 budget deliberation process, an engineering review was initiated to examine possible alternative approaches to flying NASA's Earth Observing System (EOS) remote sensing instruments. A prestigious group of scientists and engineers, led by Dr. Edward Frieman, was established by NASA to conduct this review. The Committee conducted its review this summer and has submitted its findings to NASA in the form of the "Report of the Earth Observing System (EOS) Engineering Review Committee." In accordance with the Terms of Reference for this review, I am pleased to forward you a copy of the Report.

The Report provides important inputs to the restructuring of the EOS program. It also makes recommendations regarding the broader United States Global Change Research Program involving agencies other than NASA. For its part, NASA has been in the process of restructuring the EOS program, and the Committee Report endorses these actions. The restructuring will provide greater flexibility and robustness, and also will accommodate current and anticipated fiscal realities.

I would be pleased to arrange a briefing for you by Dr. Frieman and other members of his Committee at your convenience, if you so desire. I would also like to offer you a briefing on NASA's EOS activities. We are confident that our actions to restructure the EOS program will lead to a robust global change research effort which will permit environmental policymakers to make wise choices in the future.

Sincerely,

Richard H. Truly
Richard H. Truly
Administrator

Enclosure

Report of the Earth Observing System (EOS) Engineering Review Committee

September 1991

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION DOCUMENT NUMBER: 9123996

ORIGINATOR: 02 STATUS C DIRECTORATE STATUS

****

FROM: DON FUQUA, AEROSPACE INDUSTRIES ASSOCIATIONS

TO: DR. D.A. BROMLEY

DATE OF CORRESPONDENCE: 09/10/91

SUBJECT: AEROSPACE INDUSTRIES ASSOCIATION'S REPORT, "THE U.S. AEROSPACE INDUSTRY IN THE 1990s: A GLOBAL PERSPECTIVE"

****

DIRECTORATE ASSIGNED:

STAFF ASSIGNED:

ACTION REQUIRED:

STAFF ACTION:

****

SENDER'S DUE DATE:

OSTP DUE DATE:

STAFF DUE DATE

DATE COMPLETED:

DATE COMPLETED/DEPT:

****

COPIES TO: D. Allan Bromley
Michelle Van Cleave
Dr. Phillips
Dr. Wong

****

WHITE HOUSE TRACKING #:

CONTACT PERSON:

PHONE: EXT:

REMARKS: DAB HAS THE REPORT

OSTP RECEIVED: 09/11/91 FILE: P-PHYSICAL SCIENCES-SPACE

DEPT RECEIVED:

9123956

Aerospace Industries Association

Don Fuqua
President

September 10, 1991

The Honorable D. Allan Bromley
Assistant to the President for Science & Technology
Office of Science & Technology Policy
Old Executive Office Bldg., #358
17th St. & Pennsylvania Avenue, N.W.
Washington, DC 20500

Dear Dr. Bromley: Allan

The aerospace marketplace of the 1990s is highly competitive, complex and global. Long the dominant player in this market, the U.S. aerospace industry is more dependent on export sales than ever in order to maintain its position. U.S. aerospace firms are therefore more exposed to the competitive practices of other countries. Foreign firms are expanding their sales base through international alliances. They are also working closely with their governments to position themselves for market share growth. As a result, advantages that the U.S. aerospace industry has long enjoyed--e.g., the economies of scale that result from a large domestic market--will not be so easily realized in the future.

The Aerospace Industries Association has just published a report that looks closely at the global aerospace market--and at the U.S. industry's advantages and disadvantages. "The U.S. Aerospace Industry in the 1990s: A Global Perspective" also discusses how major regional and product markets are developing, and explores a key market issue: technology development and transfer.

From my perspective, an important conclusion to be drawn from the report is that the traditional adversarial relationship between Government and industry works against maintaining a strong U.S. aerospace industry.

I sincerely hope that the strategies AIA proposes can form the basis of a positive dialogue between the industry and government policy-makers. The global aerospace market of the 1990s strongly challenges U.S. aerospace firms. The industry will not maintain as dominant a position in all market segments as it has in the past. However, I believe that Government and industry--in partnership--can ensure that the U.S. continues to lead the world in aerospace capabilities and sales.

Don

Don Fuqua

DF: vcl
Enclosures (2)

Aerospace Industries Association of America, Inc.
1250 Eye Street, N.W., Washington, D.C. 20005 (202) 371-8400

THE WHITE HOUSE

WASHINGTON

September 20, 1991

Dear Don:

Many thanks for sending me a copy of your latest report "The U.S. Aerospace Industry in the 1990s - A Global Perspective." This, as are all your previous reports, is an excellent piece of work and I have enjoyed reading those parts of it that I have had time to focus on. I can assure you that my staff considers these documents from the AIA to be models of the kind of road map that I can only wish other private sector organizations would produce for technologies of major interest to them.

You will be interested in knowing that we have decided that it is time for us to bring together a group to update the so-called **Bird Books** on the status of the U.S. position in aeronautics. Obviously, we will want to work closely with you and your associates in this activity and some of my people will be in touch with you shortly.

With warmest best wishes,

Sincerely yours,

Allan

D. Allan Bromley
The Assistant to the President
for
Science and Technology

Mr. Don Fuqua
President
Aerospace Industries Association
of America, Incorporated
1250 Eye Street, N.W.
Washington, D.C. 20005

SUMMARY & HIGHLIGHTS

The U.S. Aerospace Industry in the 1990s A Global Perspective

The United States is the world leader in aerospace design and manufacturing but other countries are strong competitors. In a new report, "The U.S. Aerospace Industry in the 1990s: A Global Perspective " the Aerospace Industries Association takes a hard look at where it stands and how it can maintain or increase its market position.

The aerospace industry of the 1990s is global, dynamic, and complex—driven by fast-paced technological change and heavily influenced by national government support. The aerospace market is also characterized by numerous international partnerships of every sort. In this environment, the traditional "modus operandi" of many U.S. firms and the U.S. Government may be inappropriate for continuing success.

The U.S. Aerospace Industry in 1991

Since AIA published its 1988 report on *The U.S. Aerospace Industry and the Trend Toward Internationalization*, the U.S. industry has increased its international activities. As a result, both exports and imports continue to rise, but export growth has been considerable enough to ensure a continuing string of record trade surpluses. Aerospace has the largest positive trade balance of any U.S. manufacturing sector. Still, the U.S. world market share in aerospace is declining. Despite growing demand for aerospace products, there are an increasing number of market competitors.

In a changing world, where market access is often on a *quid pro quo* basis, U.S. companies cannot depend only on direct sales abroad of U.S. products manufactured in the United States. Other avenues of trade must be pursued. Consequently, the number of U.S./foreign partnerships is rising and U.S. companies are exploring new roles in these relationships.

U.S. aerospace manufacturers are producing for two very different markets, although strong foreign competition and international cooperation—to one degree or another—are characteristic of both.

Defense Aerospace Market With the end of the Cold War, and despite lingering concern over a Soviet threat, the United States and its allies are more concentrated on regional threats to global peace. A lesson of the Persian Gulf War is that a strong defense is still necessary; at the same time, that lesson will not prevent the decline of the defense budgets of the United States and its allies. Instead, there will be increased emphasis on tactical systems, and on force mobility and deployment.

The U.S. defense industry is entering this new era from a weakened financial position resulting from government policies that limited profits and reduced the cash flow needed to meet increased operating capital requirements. Defense exports can offset some of the lost sales as the U.S. Government cuts defense spending. However, any number of sales are politically problematic for the United States, and with enormous excess defense production capacity in the world, American companies can easily be supplanted as suppliers. The loss of key defense markets could mean loss of national influence in certain regions of the world.

The issue of economic competitiveness has grown in importance relative to purely defense-related concerns in the United States. Worries about the industrial/technology base have heightened discussion over foreign sourcing for defense system components, foreign investment in the United States, offset sales arrangements, and technology export through international defense cooperation. While many would have the United States pull back from cooperative relationships, other countries, particularly in Europe, are forging closer ties; this could limit U.S. participation in those markets. European countries are also strong competitors for defense sales around the globe.

Civil Aerospace Market The market for civil aerospace products is more promising than the defense market. Commercial production is the growing share of total U.S. industry output and commercial products have long dominated U.S. aerospace exports. With world airline capacity expected to double by 2005, prospects for the commercial transport sector are particularly bright.

Problems confronting U.S. producers include economic recession and airport congestion, which could limit expected expansion of this market. Another concern is the need to harmonize airworthiness requirements to prevent additional costs to U.S. manufacturers, and to preclude these requirements becoming technical barriers to trade between nations. Probably the most serious threat to all U.S. civil aircraft and space vehicle manufacturers is foreign government support of their aerospace companies.

The U.S. civil helicopter industry is not faring as well as the commercial transport sector. Strong foreign competition, often subsidized, has made substantial market inroads. Rotorcraft manufacturers have suffered from recession in the oil industry. Today, they are pinning hopes on the need to replace aging fleets, a rebound in energy markets and the economy, and new technology models under development. Long-term, expansion of this market depends on development of an infrastructure to support regularly scheduled rotorcraft operations.

American general aviation manufacturers have experienced serious decline in the piston-powered aircraft market, due to excessive product liability claims and the resulting high cost of insurance. Higher-value commuter and business turboprops and business jets are selling well and exports are rising. New technology aircraft and sizable military contracts should lead to stronger sales.

The space vehicles and launch services sector is expanding steadily. Military requirements for space systems will continue to grow. The commercial space market will develop more slowly and require substantial government support and encouragement.

Two regional markets are particularly important to the U.S. aerospace industry in the 1990s — Western Europe and the Asia-Pacific Rim.

Western European Aerospace Market

The market landscape is being altered for U.S. manufacturers by the emergence of a unified Western European economy, parallel efforts to integrate the European defense market (which already has significant cross-border relationships), the unification of East and West Germany, and the opening of other Eastern European countries. The U.S. relationship with Europe through NATO has been a cornerstone of the American defense market. Events in Eastern Europe and the Soviet Union may mean that the NATO alliance will take on a more political than military cast — with considerable effect on European defense purchases and U.S./European manufacturing arrangements.

Western countries will continue to need defense equipment such as deep strike, theater ballistic missile defense, air defense, chemical/biological warfare protection, command and control, surveillance and verification, early warning and reconnaissance, and long-range targeting systems. These needs should provide opportunities for joint U.S.-European cooperation. However, joint programs have not occurred on any significant scale. Instead, European countries are cooperating among themselves—as are American companies—to a greater degree.

Cross-border relationships have been central to European strategic planning for years, and they have been a key element in keeping the European aerospace sector viable. Meanwhile, U.S. defense manufacturers were able to be successful by concentrating on the large U.S. domestic market, and competing against each other.

Exports have been extremely important to European aerospace manufacturers for years, and—as the U.S. defense market shrinks—their importance to U.S. companies is growing. Both U.S. and European aerospace companies lean heavily on direct exports and on licensing to achieve foreign sales objectives. In addition, European manufacturers are pursuing international joint ventures and mergers at a pace unparalleled in the industry. While most of these efforts are aimed at consolidating their regional position, European manufacturers are also making inroads in the U.S. and Asian markets. The emergence of these larger corporate entities and interfirm alliances is spearheading a global change in the industry.

Factors that figure prominently in the European embrace of a transnational strategy, and the development of larger companies, include: the rising price of advanced technology, the increasing risk of undertaking aerospace programs, regional overcapacity, and the need to balance the United States' competitive advantages in terms of a greater sales base and strong R&D funding.

European governments have fostered international aerospace alliances by:

- Allowing companies to participate in transnational partnerships—particularly those involving defense contracts and nationalized firms. European governments have not overburdened partnerships with oversight and technology-transfer restrictions.

- Continuing to fund joint venture projects which, in many cases, would have been impossible without government assistance.

- Supporting European economic unification, joint aeronautical R&D, and the efforts of the Independent European Program Group, which has called for cooperative R&D and greater regional competition to strengthen Europe's defense industrial base.

Nine of the 12 European Community members can produce some form of aircraft and several have the capability to design and assemble state-of-the-art products. Depending on the extent of their current capabilities, these countries use international collaboration to supplement their domestic programs, build their credentials in the world aerospace market or, in the case of new market entrants—Greece, Portugal and Turkey—to build their industrial base.

Japan and the Asia-Pacific Rim Aerospace Market

Twenty-three countries comprise the Asia-Pacific Rim region and the robust economic growth of this region will continue to create demand for aerospace products. Commercial air traffic is in a growth mode. Defense spending is also on the increase, with annual regional increases of 6 percent. The region is an important market for U.S. aerospace manufacturers and commercial sales, particularly, have shown growth. European manufacturers have also gained a share of this market—once totally dominated by U.S. industry. European firms are currently engineering a more aggressive marketing campaign in the region.

Many nations in the Asia-Pacific Rim are launching their own aerospace programs. Japan has ambitions to be a major player in the world aerospace market. While its efforts have not always met with success, Japan continues to move forward and is currently involved in several important aerospace projects. China is another active regional aerospace market participant, although with more limited capabilities. Taiwan and South Korea both have programs underway, which they hope will provide the start necessary to build at least some aerospace capacity within their countries. While these nations will not be able to challenge U.S. "big-ticket" programs such as the manufacture of commercial transports, they will increase competition in other segments of the market—e.g., in the production of components and parts. Because a large national commitment will be needed for success, government support of aerospace programs in the Asia-Pacific Rim will be substantial and long-term.

Japan is the economic power in the region and its actions may be a guide to its neighbors. In the defense sector, the Japanese aerospace industry has used its strong position as a buyer to obtain technology and manufacturing skills from foreign companies, particularly those in the United States. The Japanese domestic market alone is not of sufficient size to allow Japan to sustain a large commercial aircraft manufacturing effort. Instead, the Japanese have concentrated on niche markets, such as parts and subassembly production, and have targeted export demand.

The Japanese government has been strongly behind the development of its aerospace industry. It has identified projects, solicited foreign collaboration, set up and coordinated domestic consortia, and arranged financing and R&D funding. Japan considers cooperation between government and industry in developing market capabilities not only desirable, but necessary. The government sees aerospace as a strategic industry, and the key to advancing high-technology development generally.

Japan is pursuing an aerospace development strategy centered on:

• Continuing R&D aimed at enabling Japanese manufacturers to shoulder a larger role in development and production of future or next-generation technology (e.g., high speed civil transport). Japan will seek an equal partner role in such an effort.

• Attempting to launch a regional aircraft program with foreign partners.

• Improving design and production processes by remaining a high-quality reliable supplier of aircraft parts and sections, particularly fuselage subassemblies and wing parts.

• Becoming a world leader in aerospace systems and components production. Japanese industry is looking for joint development opportunities in this area.

• Developing high technology space systems, including unmanned launch vehicles and manned space systems.

At the subcontractor level, Japanese firms compete against each other and foreign companies for business. For large projects, which require high levels of R&D funding, national competition is limited; major Japanese aerospace firms form domestic consortia and negotiate workshares. Consortia enable Japan to present a stronger position on the international market.

Changing U.S. Role in International Space Activities

For years, the United States dominated free world space efforts, cooperating with other nations to establish worldwide satellite communications capabilities, but continuing to develop guidance systems, electronics, computer software, new materials, propulsion equipment, and so forth, in the United States—and almost solely for government needs. Today many nations have space capabilities and any nation with the ability to pay for a launch can have access to space. At least seven nations offer launch facilities and vehicles. Space is on the way to becoming a business, not simply a function of national prestige or dominance driven by political and military considerations.

Worldwide, it is estimated, nearly $80 billion a year is being spent on space-related activities. Of that $80 billion, the United States accounts for about 42 percent, the Soviet Union 45 percent, and the rest of the world 13 percent. Of that 13 percent, Europe predominates followed by China and Japan. Many newcomers to space have piggybacked on American technology.

In a world of tighter space transportation and R&D budgets, the United States must make decisions about its investment. Billions of dollars have been spent to support a serious space program. However, large near-term outlays for long-range, visionary programs may be in doubt in light of program setbacks and budget deficits. The United States will maintain a broad capability in space—in part, for national security reasons. But it must better position itself to capture the benefits of space in the commercial sector.

Over the next few years, it will be important to maintain confidence in the U.S. space program, and to sustain an appropriate level of funding. In addition, space programs need stronger coordination and focus within the government. With a spotty history of success in international cooperative programs, the nation also needs to recognize that international partnerships will be necessary for many new space endeavors—and operate accordingly. Finally, there are some tough trade issues to be faced including how to ensure that U.S. private companies can compete against the space products and services of nonmarket economies.

Aerospace Technology - Trends and Strategies

Technology development and technology export are priority concerns for the aerospace industry. Technology is a key issue in either creating or impeding international partnerships. The high cost and risk of new technology, access to technology advantages of partners, and market entry are reasons favoring cooperation. But technology leaders such as the United States also face the possible loss of a key element of business advantage. It is important to ask: What must be held back to protect future competitive advantage? What can be shared to achieve today's sales, today's market access, today's mutual benefit?

Nations are collaborating more to develop and apply new aerospace technology, and the capabilities of U.S. competitors are growing. An additional complication is that some technology being applied in aerospace is "dual-use," with both military and civil applications. This has led to a situation where some U.S. products are—or may be—restricted from export, while similar products of competitors are not.

The issue of technology transfer was at the heart of the controversy over the FSX fighter project with Japan. The issue has also caused problems between Europe and the United States. If the United States is not willing, or U.S. companies not allowed, to pursue cooperative efforts—sometimes from initial R&D on—companies from other nations will not hesitate to fill the void. The agreement between Germany's Daimler-Benz and Mitsubishi of Japan to discuss a range of collaborative efforts is a striking example.

What can be lost in discussions about cooperation between the United States and other countries is the fact that technology flows both ways. Other countries have made advances from which the United States can benefit. Agreements can be structured to protect critical, proprietary information while taking advantage of the market potential cooperative arrangements provide.

The United States has no strategy to foster technology development and satisfactorily address technology-sharing questions. Its approach is an *ad hoc* blend of government and private industry initiatives, offensive and defensive. Defensive initiatives include Buy American legislation, offset restrictions, anti-foreign direct investment measures, and export controls. Unfortunately, export controls are not coordinated, delays in issuing export licenses can be extreme and American manufacturers are often prevented from making, or must report at length, special arrangements needed to secure foreign sales.

Strategies that place the United States on the offensive include research and development incentives, teaming domestically for research and development, and targeted spending on critical technologies. The Aerospace Industries Association has launched a Key Technologies initiative to keep the United States aerospace industry in the forefront. AIA identified important enabling technologies, and is developing technology roadmaps and development plans, and working cooperatively with the government and universities to focus funding and research.

Government policy makers and industry continue to debate what a national technology strategy should be, and the issue is often contentious. Technology strategy is frequently cast, and negatively, in terms of "industrial policy"—the choosing of winners and losers. The question is: what middle ground can be found between a government-directed and supported approach to business and leaving things as they are? Meanwhile, U.S. companies compete in a marketplace where other nations' resolve to subsidize and otherwise assist their industries is influencing the outcome of sales.

Conclusions

The World Aerospace Market

The aerospace market is a global market that will strongly challenge U.S. aerospace firms in the 1990s.

The aerospace market is characterized by numerous international business partnerships—from joint ventures through subcontracting relationships. In this environment, the traditional *modus operandi* of many U.S. firms and the U.S. Government may be inappropriate for achieving success.

The U.S. aerospace industry will continue as the world leader in aerospace for the foreseeable future—given the right balance of policy and programs. It will not maintain as dominant a position as in the past in all segments of the market.

The prescription for market success calls for maintaining the industry's scientific and technical strengths and enhancing them with greater manufacturing capability. Success depends upon the industry's ability to export, its access to affordable investment capital—and to well-educated workers.

New market opportunities are available for U.S. aerospace firms.

With sales and exports at record levels, the U.S. aerospace industry is in a strong position to capitalize on the market opportunities of the next decade. The world's defense market will continue to be an important source of sales. However, the commercial sector is now the area of market growth.

U.S. aerospace producers face greater competition.

Every national market will be more competitive. Manufacturers from the Soviet Union and Eastern Europe will be moving into Western markets for the first time. Aerospace firms in Western Europe will be stronger and more capable than ever. Countries in the Asia-Pacific Rim are intent on developing their own aerospace industries.

Trends In International Aerospace Cooperation

Foreign firms will continue to seek out U.S. companies for collaborative efforts, particularly on commercial projects.

Aerospace companies are cooperating internationally in order to compete. The size of the U.S. military and commercial markets makes U.S. companies attractive partners. At the same time, foreign companies—particularly European firms—are competing with the United States for key roles in international partnerships

Defense cooperation between the United States and other nations will not live up to recent expectations.

The decline in defense funding and the changing threat will reduce defense cooperation between the United States and other countries from expectations of several years ago. Paradoxically, these same trends and events will highlight the usefulness of cooperation as a means of spreading costs, sharing risk, and increasing market access.

In Western Europe and Japan, cooperation is viewed as a fundamental part of the defense industrial strategy. In general, in the United States, cooperation is not seen as essential to building an effective defense.

Cooperation among U.S. defense contractors is increasing.

American companies are beginning to work together, as are the Europeans, to rationalize their defense technology resources.

International collaboration will often take different forms than in the past.

The competitive pressure on the United States for more genuine collaboration is resulting in new types of partnerships and new, sometimes subordinate, roles for U.S. manufacturers. But critical U.S. technologies will be more closely guarded by both companies and the government for competitive reasons.

The Space Market

The United States will continue to be a leader in space but will face increasing competition in commercial markets.

U.S. space leadership will continue thanks to the large investment in space-related research and the significant space infrastructure the United States has created. However, the trend is towards sharing of a larger space market and away from the dominance of the United States and the Soviet Union.

In the years just ahead, it will be difficult for NASA to do ambitious "big ticket" projects.

Political consensus is necessary to fund ambitious large-scale space projects and, at a time of budget restraints, that will be difficult for the United States to achieve. A new attitude of long-term commitment by the government is necessary in order to accomplish the goals of large-scale programs. It will be necessary to establish discrete short-term goals, concentrated on enabling technologies.

U.S. commercial space business prospects could be enhanced by more centralized decision-making.

Programs that could lead to competitive products and services suffer from a lack of focused, business-oriented management. The diffusion of responsibility and lack of focus make funding decisions difficult for Congress.

U.S. government help will be needed to get the commercial space sector established.

The U.S. Government should support space-oriented commercial business—as other governments are doing.

International space consortia are proceeding without U.S. participation.

The United States will be excluded from some international arrangements because of its reputation as an unreliable partner and its restrictive technology transfer policies.

Technology Trends and Strategies

The United States needs a national technology strategy and commitment to a strong industrial/technology base.

The United States does not yet have a coherent strategy to support industry on high technology issues. A strong case is building for a strategy of nurturing generic, enabling technologies—technologies that encompass both civil and military applications and are vital to worldwide competitiveness.

The United States needs to step up its investment in manufacturing capability.

While maintaining the vitality of science and technology, the United States cannot afford to underinvest in manufacturing technology. The true cutting edge in world competition is how fast, how well and how cost-effectively products are manufactured.

The prospects of the U.S. aerospace industry will be affected by tighter R&D budgets and the debate over how technology dollars should be spent.

Technology demonstration will become more important than ever in order to shorten the time from concept to application and to learn how various advanced technologies work together.

Validation of generic technology—to reduce the risk of application for manufacturers—is as important in the civil as in the military sector. Over the long term, lack of validation funding will inhibit technological preeminence in civil aeronautics.

More codevelopment and coproduction among American companies will strengthen the competitive position of the United States.

Coproduction ventures among U.S. firms will help companies build upon joint research, and create profits they can reinvest in the technology base.

Trying to stop the international flow of advanced technology through excessive restrictions on products or on cooperative programs is nonproductive.

Company proprietary know-how and technologies critical for national security must be protected. Beyond that, restrictions on technology are less productive than working to continually advance the state-of-the-art, improve manufacturing technology, and speed up the cycle of concept to application.

An educated, motivated work force is one of the most important components of competitive success for aerospace.

The aerospace industry will be challenged to meet its future work force needs. Other countries are doing a better job of preparing workers who can meet the requirements of high technology industries.

Recommendations

Create Better, Lower-cost Products Faster Than Competitors

Industry

• Give technology planning and development as much priority in business planning as profits.

• Expand the use of concurrent engineering whereby engineering designers and manufacturing planners work hand in hand from the first stages of product development.

• Pursue the aerospace industry's Key Technologies for the Year 2000 program.

• Commit to a strong, continuing investment in manufacturing capability.

• Emphasize use of Total Quality programs to motivate employees and improve the productivity of the aerospace work force.

• Put more effort into building better working teams, both in domestic partnerships, and with foreign companies.

Government

• Support industry-led Key Technologies program and work with industry to develop consensus technology development plans.

• Provide sustained, strong, balanced funding of the technology base and technology demonstration/validation.

• Provide incentives for private R&D investment.

• Enact legislation supporting formation of U.S. production-based consortia.

• Support major space initiatives such as Space Station Freedom, the Missions to and from Planet Earth, and the Space Exploration Initiative within the context of a strong overall U.S. space program and the incremental development of technology.

• Pursue bilateral or multilateral cooperative efforts in space.

• Support a competitive commercial space industry in the United States through a strong public-private partnership.

• Increase IMIP funding within the DoD budget, set unified policy for management of programs across services, and streamline IMIP contract implementation.

• Support development of the National Defense Manufacturing Technology Plan.

• Foster use of management concepts for continuous productivity improvement.

Establish An Investment Climate That Supports A Strong Industrial/Technology Base

Industry

• Build partnerships with U.S. suppliers and promote productivity through assistance with employee training, R&D, manufacturing investment.

• Develop international partnerships that provide a strong flowback of financial and technology resources.

Government

• Pursue fiscal and spending policies that will make capital available and affordable for business investment.

• Place greater effort into improving the dialogue between government and industry, and involving industry in the development of program requirements.

• Encourage industry's investment in technology and innovation by allowing full recovery of the costs of IR&D/B&P.

• Increase progress payments to defense contractors.

• Reorient the defense budget cycle to allow more multi-year procurements.

• Rescind the current DoD policy on recoupment of RDT&E costs and apply recoupment surcharges only to major defense equipment sold to foreign countries.

Educate, Attract, And Develop A High-calibre Work Force

Industry

• Continue and strengthen support of the public education system, particularly science, math and language programs from K-12 through university level.

• Expand enhanced in-house education programs for those with specialized and critical skills, and to increase productivity and competitiveness of the work force as a whole.

• Expand in-house remedial education for workers, stressing fundamentals such as English, communications, and computations.

• Expand recruitment and training of women and minorities.

• Continue to pursue and develop ties with the university community in support of research objectives and development of an educated work force.

• Continue to provide Key Technologies information to universities to help guide curriculum changes.

Government

• Provide strong support nationwide for the study of science, math and languages.

• Provide financial incentives to develop university-industry partnerships.

Academia

• Work with industry to develop and integrate curricula that respond to the needs of knowledge-intensive production.

• Work with industry and government to develop sound Key Technology development plans, coordinate with them on university-based research efforts and relate curriculum where possible to important generic technologies.

Remove Barriers To Trade

Government

• Work toward a free and open climate for international trade and investment including greater harmonization of country practices on R&D and production subsidies, and elimination of non-tariff barriers and technical barriers such as some standards, testing and certification requirements.

• Take aggressive action against violators of international trade agreements.

• Continue to support the Uruguay Round of the GATT and work to strengthen the multilateral trading system.

• Effectively regulate the entry of space launch systems developed in nonmarket economies into the limited commercial market.

Establish Pro-trade Policies

Government

• Seek active FAA role in promotion of U. S. aviation interests worldwide, including strong efforts to maintain the integrity of U.S. federal airworthiness regulations (FARs).

• Work toward speedy harmonization of product liability laws in the international arena, and reform present U.S. product liability law and penalties.

• Affirm an Administration policy on defense exports and international cooperative programs.

• Work toward a multilateral framework on offset understandings and take no unilateral action to limit offsets.

• Ensure adequate financing for all exports.

Implement Technology Export Policies That Make National Security And Market Sense

Industry

• Foster discussion of industrial/technology base issues from a global perspective.

• Focus internal activities on key company strengths—critical product and process technology—while cooperating internationally to enhance U.S. market opportunities.

• Structure cooperative agreements for strategic acquisition—as well as sharing—of technology.

Government

• More clearly define products and technologies to be controlled rather than imposing broad, generalized prohibitions.

• Provide a single DoD policy guidance on defense exports, technology transfer, the industrial base, and arms cooperation.

• Clarify jurisdiction between Departments of State and Commerce with respect to "dual-use" commodities, with final appeal to the President.

• Conform U.S. Munitions List to COCOM International List to put U.S. suppliers on equal footing with foreign competitors.

• More narrowly define "defense articles and services."

• Streamline export controls administration.

• Pursue technology developed abroad through government to government efforts.

The Aerospace Industries Association (AIA) is the non-profit trade association representing the nation's manufacturers of commercial, military, and business aircraft, helicopters, aircraft engines, missiles, spacecraft, and related components and equipment.

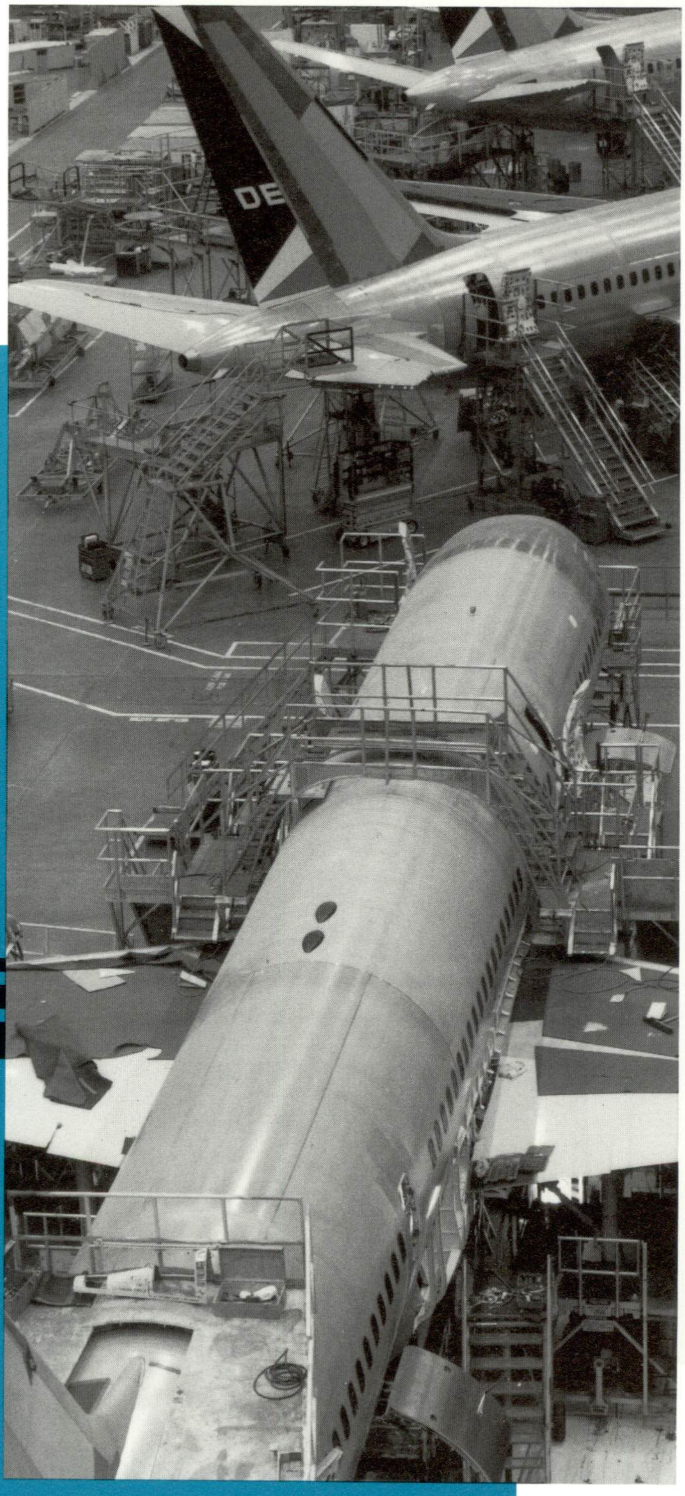
The full report on *The U.S. Aerospace Industry: A Global Perspective* is available to AIA nonmembers for $20. Contact AIA at 202/371-8561.

Aerospace Industries Association

Aerospace Industries Association of America, Inc.
1250 Eye Street, NW
Washington, D.C. 20005

The U.S. Aerospace Industry in the 1990s

A GLOBAL PERSPECTIVE



The U.S. Aerospace Industry in the 1990s
A Global Perspective

by
Virginia C. Lopez
David H. Vadas

Consultant/Space
Henry R. Hertzfeld

A Publication of
THE AEROSPACE RESEARCH CENTER
Virginia C. Lopez, Executive Director

AEROSPACE INDUSTRIES
ASSOCIATION OF AMERICA, INC.
1250 Eye Street, N.W.
Washington, D.C. 20005

September 1991

The Aerospace Research Center engages in research, analyses and advanced studies designed to bring perspective to the issues, problems and policies which affect the industry and, due to its broad involvement in our society, affect the nation itself. The objectives of the Center's studies are to improve understanding of complex subject matter, to contribute to the search for more effective government-industry relationships, and to expand knowledge of aerospace capabilities that contribute to the social, technological and economic well-being of the nation.

Table of Contents

The U.S. Aerospace Industry in the 1990s
A Global Perspective

Introduction

In 1988, the Aerospace Industries Association published a report, *The U.S. Aerospace Industry and the Trend Toward Internationalization,* that described growing foreign competition and the steps American companies were taking to adjust to global realities. The marketplace was being transformed into a network of global, cooperative business relationships.

The View From 1988

The 1988 report concluded that internationalization of the aerospace industry would continue. Cooperation in civil aerospace was already well established. Cooperation in defense programs was growing, too, as many nations developed aerospace capabilities. This would make it more difficult for U.S. companies to market "off the shelf" military products, and would promote their participation in international programs. U.S. defense contractors were sometimes handicapped from deeper involvement in collaborative efforts by government technology transfer policies. If the United States were to continue as the leader in both defense and civil aerospace products, the industry would have to be in sound financial health and maintain its technological vitality.

Trends Since 1988

Events have moved faster and farther than expected just a few years ago. General trends were for the most part anticipated but some of the events speeding them along could not be foreseen. Some of the changes:

- Commercial aerospace business replaced the defense sector as the greatest source of industry growth.

- U.S. defense contractors, already feeling the pinch of government policies that make it difficult to raise operating capital, now face severe defense budget cuts.

- The Soviet bloc fragmented—unexpectedly—heightening the pressure to reduce defense spending.

- The Persian Gulf War demonstrated that regional conflicts—including matters of technology transfer and arms control—will take center-stage in U.S. strategic thinking. The war also demonstrated the value of the U.S. investment in high technology weaponry, and increased the attractiveness of battle-proven U.S. systems. However, export restrictions for many of these products are unlikely to be relaxed in the near future.

- The role of the North Atlantic Treaty Organization (NATO) alliance is changing, hastened by the opening of Eastern Europe, improved but uncertain relations with the Soviet Union, and the reuniting of the two Germanies. It is unclear how efforts to maintain "rationalization, standardization and interoperability" or "RSI" of defense systems among the United States and other NATO members will fare; however, the new multinational, crisis-reaction force structure and the experiences of the Persian Gulf War reinforce the importance of RSI.

- Europe continues as the leading regional market for U.S. aerospace products (defense and commercial combined). But as the Soviet threat diminishes, the U.S. market in Europe will shrink. Economic unification is strengthening European aerospace firms, and presenting the United States with stiff competition.

- The U.S. aerospace industry's ties to Asia/Pacific Rim nations have grown in importance. The balance of trade is overwhelmingly in favor of U.S. companies and the future market in that region, especially for commercial products, is considerable. At the same time, the aerospace industries of countries in that region are growing rapidly.

- Dozens of nations are developing market niches in the space business, while the United States—which still dominates that sector—struggles to fund a broad range of programs.

- There is growing concern in the U.S. political arena that international cooperation will build competition and erode the industrial base. This concern is the basis for a stronger government hand in establishing requirements in matters such as trade, export finance, offsets, and foreign direct investment.

- There is also growing friction among western trading partners as the threat provided by the Soviet bloc diminishes, as trade relationships between Europe, Japan and the United States become more competitive, and as economic systems and strategies clash.

- International leasing companies exercise growing influence over competition in the commercial transport sector. Their ability to place major orders creates fierce competition among producers and can have a significant effect on prices. American jet transport manufacturers, who do not have the benefit of the government support available to competitors, are at a disadvantage.

- Technology life cycles are shorter and shorter and U.S. companies must quickly exploit technological advantage. Advancements must be incorporated into products before they are duplicated by competitors—or before the technology becomes obsolete.

These trends provide some context for this report and are all factors shaping the markets for U.S. aerospace products. It is readily apparent that market success or failure depends heavily on maintaining a global view.

This Report

Specifically, this report addresses these questions:

- What advantages and disadvantages does the U.S. aerospace industry possess as it faces the global marketplace of the 1990s? What are its challenges?

- What developments are shaping two major regional markets: Europe and the Pacific Rim?

- What forces are shaping the space market as other countries step up efforts in areas once dominated by the United States and the Soviet Union?

- What will be the effects of the exponential dispersal of technology around the globe, and what effects will U.S. technology policies—or lack thereof—have on the market viability of U.S. companies?

- What strategies should U.S. companies and the U.S. Government follow to keep the American aerospace industry strong and innovative?

Conclusions

The internationalization of the aerospace market is continuing at a rapid pace.

The U.S. aerospace industry is well positioned for continuing success in the marketplace but must take steps to insure that this remains the case.

The government has an important role to play in the continuing health of the U.S. aerospace industry.

The World Aerospace Market

The aerospace market is a global market that will strongly challenge U.S. aerospace firms in the 1990s.

The aerospace market is characterized by numerous international business partnerships of every sort and at every level—from subcontracting relationships through joint ventures. In this environment, the traditional *modus operandi* of many U.S. firms and the U.S. Government may be inappropriate for achieving success. The U.S. industry has capable competition in many countries—firms that offer outstanding technology and a wide range of product offerings. The advantages U.S. firms once achieved from economies of scale—based on a large domestic market—may be more difficult to realize as foreign firms expand their sales base through international networking. The U.S. Government, for its part, is used to functioning in a period when the United States was the undisputed economic leader. Foreign government practices of support for their industries including subsidies and various nontariff barriers to free trade were generally overlooked or worked around because the cost to U.S. manufacturers did not appear to be great. In addition, the government/business relationship in the United States continues to be strongly adversarial, while such relationships in other countries have a long history of cooperation and mutual respect. With greater reliance on and exposure to the international market, past U.S. advantages may not be enough to keep the U.S. aerospace industry in its current leadership position.

The U.S. aerospace industry will continue as the world leader in aerospace for the foreseeable future—given the right balance of policy and programs. It will not maintain as dominant a position as in the past in all segments of the market.

The prescription for market success calls for maintaining the industry's scientific and technical strengths and enhancing them with greater manufacturing capability. Success depends upon the industry's having access to affordable investment capital—and to well-educated workers. In the marketplace of the 1990s, success is a blend of staying ahead in key technical areas, restricting access for a reasonable time to important new knowledge, and developing the manufacturing skills to translate knowledge quickly into world-class products. Success also depends on the ability to export—to enter the market at the right time with quality products at a competitive price.

Technology is not static, development cycles are getting shorter, and the United States cannot maintain dominance in every technology, and every sector. The goal should not be to hoard technology but to outrun competitors by picking up the pace.

New market opportunities are available for U.S. aerospace firms.

With sales and exports at record levels, the U.S. aerospace industry is in a strong position to capitalize on the market opportunities of the next decade. The world's defense market will continue to be an important source of sales. However, the commercial sector is now the area of market growth. Eastern Europe, the Asia-Pacific Rim region, and possibly the Soviet Union, represent areas of new and expanding demand. Western Europe will continue to be a market for U.S. defense and civil aerospace products although conventional force agreements could dampen some growth in this market.

U.S. aerospace producers face greater competition.

Every national market will be more competitive. Manufacturers from the Soviet Union and Eastern Europe will be moving into Western markets for the first time. Most will probably seek joint venture arrangements with western firms. Also, aerospace firms in Western Europe will be stronger and more capable than ever. Countries in the Asia-Pacific Rim are intent as well on developing their aerospace industries.

With more nations producing defense systems, nations will tend to purchase more from domestic and regional sources. Strong competition will allow purchasing nations to drive hard bargains with nondomestic suppliers. While the huge cost and risk of commercial aircraft and engine programs limits entry into the civil market as original equipment manufacturers, companies around the world are developing as suppliers in the lucrative commercial market. Even in the United States, U.S. companies will be competing more fiercely as imports rise and foreign direct investment in America grows. U.S. aerospace suppliers at the sub-tier levels will be the most directly affected, and many will leave the aerospace industry. Partnerships built on long-term commitments to productivity and quality enhancement between U.S. prime equipment manufacturers and suppliers can help reduce this attrition.

Trends In International Aerospace Cooperation

Foreign firms will continue to seek out U.S. companies for collaborative efforts, particularly on commercial projects.

Aerospace companies are cooperating internationally in order to compete. The global network of relationships continues to expand and at an accelerating rate. The size of the U.S. military and commercial markets makes U.S. companies attractive partners—and investment in the United States an attractive option. Access to U.S. technology is also an incentive for foreign companies to seek partnerships with the United States. At the same time, foreign companies—particularly European firms—are competing with the United States for key roles in international partnerships.

In the civil aerospace market, cooperation has deep roots. The major western manufacturers of large commercial transport aircraft have well-established, worldwide networks of suppliers; some programs involve coproduction or equity sharing partnerships. New market opportunities in Asia and Eastern Europe will increase the number of cooperative relationships in civil aerospace.

Just as foreign firms will seek out partnerships with U.S. companies, American firms will actively seek to collaborate internationally.

Defense cooperation between the United States and other nations will not live up to recent expectations.

The decline in defense funding and the changing threat will reduce international defense cooperation from expectations of several years ago. However, these same trends and events will highlight the usefulness of cooperation as a means of spreading costs, sharing risk, and increasing market access—important concerns for both industry and government.

Among the nations of Western Europe, cooperation on defense programs will be spurred by cross-country mergers and acquisitions and shrinking defense budgets. With the opening of Eastern Europe, these relationships will multiply. Important cooperative relationships will also continue among the three major power blocs—Europe, the United States and Asia, particularly Japan. However, in the United States, lack of emphasis on defense trade, poor coordination of cooperative efforts, little support among the military services, and weak political support have worked against the success of international defense cooperative programs. U.S. technology transfer restrictions are the primary obstacle to cooperation. In Western Europe and Japan, cooperation is viewed as a fundamental part of the defense industrial strategy. In general, in the United States, cooperation is not seen as essential to building an effective defense. However, this may change. Because U.S. defense spending is declining, there should be greater urgency and increased motivation within the U.S. Government and industry to participate in collaborative efforts.

Despite efforts to harmonize U.S. and European national acquisition processes, critical differences will remain for some time. Governments will have to provide industry with the flexibility to operate more effectively within the differing acquisition processes of the United States and the European nations, if they want cooperation to flourish.

Cooperation among U.S. defense contractors is increasing.

American companies are beginning to work together, as are the Europeans, to rationalize their defense technology resources. In several recent military programs where investment costs are high and financial and technological risks considerable, U.S. manufacturers have teamed—with the blessing and encouragement of the government. To some extent, this will offset the need to team with firms in other countries, and will also protect critical U.S. technology.

International collaboration will often take different forms than in the past.

The competitive pressure on the United States for more genuine collaboration is resulting in new types of partnerships and new, sometimes subordinate, roles for U.S. manufacturers; in the past, U.S. firms were generally project leaders. There is also a trend toward more long-term and risk-sharing arrangements, and more cooperation that begins with research and development, rather than production.

Critical U.S. technologies will be more closely guarded by both companies and the government for competitive reasons. Collaborations with foreign partners will involve greater equity in technology transfers. There will be less ambiguity regarding technology transfer in future agreements.

For the most part, U.S. firms have not been as aggressive in pursuing international ties as their foreign counterparts. As a technology leader, the United States has more to lose from cooperation —but it still has much to gain. For one thing, access to markets may be slanted to favor companies that have a presence there based on cooperative relationships. But other countries also have technology that the United States can use. U.S. firms can come out ahead if they emphasize assimilating and adapting knowledge and experience from cooperative relationships and structure them where possible for technology flowback.

Company to company ties may prove a stronger element of U.S./European cooperation than government to government relationships. American and European companies are forming alliances to bid on work in each other's market, to sell each other's products in home markets, or to develop and sell a project jointly in third countries. They are taking equity stakes in each other's companies. Few U.S. companies have set up manufacturing plants abroad but they are upgrading their presence in other countries, finding partners for specific projects or products, and sometimes establishing agreements which may develop into broader, more permanent relationships.

The Space Market

The United States will continue to be a leader in space but will face increasing competition in commercial markets.

U.S. space leadership will continue thanks to the large investment in space-related research and the significant U.S. space infrastructure. However, in some space fields the barriers to entry have fallen and U.S. leadership and cooperation is no longer essential to other nations. The trend is towards sharing of a larger space market and away from the dominance of the United States and the Soviet Union. Still, there is ample room for growth in the U.S. industry and for vigorous U.S. commercial space leadership.

The U.S. Government approach to space has been more geo-political than economic and has focused on a full-service space capability. Most other nations are investing in targeted, specialized areas with a view to present and future market opportunities. They will use their combined government and industry muscle to compete for a part of major programs, such as the Space Station. They will focus on developing strategic technology or hardware in support of the program (e.g., terrestrial electronics or receiving equipment). Then, in more strictly commercial competition—against private American companies that do not have the same government support system—foreign companies may well have an economic advantage.

In the years just ahead, it will be difficult for NASA to do ambitious "big ticket" projects.

Political consensus is necessary to fund ambitious large-scale space projects and, at a time of budget restraints, that will be difficult for the United States to achieve. A new attitude of long-term commitment by the government is necessary in order to accomplish the goals of large-scale programs such as the Missions to and from Planet Earth. There must be a commitment beyond the normal election cycles of an administration—a commitment that is sustained through the attainment of the goal. To achieve long-range goals, it will be necessary to establish discrete short-term goals, concentrated on enabling technologies. A building block approach will lay the groundwork to accomplish long-range program objectives while living within NASA budget constraints. It will also be essential for both government and industry to explore and participate in international teaming on major projects.

U.S. commercial space business prospects could be enhanced by more centralized decision-making.

U.S. space research and development and space operations and commerce are commingled within several U.S. Government agencies, and thus in the budgets that are reviewed by several different Congressional oversight committees. Programs that could lead to competitive products and services suffer from a lack of focused, business-oriented management.

The diffusion of responsibility and lack of focus make funding decisions difficult for Congress.

U.S. government help will be needed to get the commercial space sector established.

With the exception of government contract work and communication satellites, there is a noticeable lack of commercial interest in investing in space. The payoff from space lies beyond the financial planning horizon of most of today's business executives. Since this is not likely to change soon, the U.S. Government should support space-oriented commercial business—as other governments are doing.

International space consortia are proceeding without U.S. participation.

Consortia of nations that do not include U.S. participation are forging ahead with state-of-the-art space programs. The United States will be excluded from some international arrangements because of its reputation as an unreliable partner and its restrictive technology transfer policies.

Technology Trends and Strategies

The United States needs a national technology strategy and commitment to a strong industrial/technology base.

While the Bush administration has issued a National Technology Policy statement, the United States does not yet have a coherent strategy to support industry on high technology issues. A strong case is building for a strategy of nurturing generic, enabling technologies—technologies that encompass both civil and military applications and are vital to worldwide competitiveness. The case for a national technology strategy is strengthened by the increasing speed with which technology is being developed and transferred globally.

The United States needs to step up its investment in manufacturing capability.

While maintaining the vitality of science and technology, the United States cannot afford to underinvest in manufacturing technology. Strong government commitment to state-of-the-art manufacturing technology, and to incentives for industry investment—such as the Industrial Modernization Incentives Program (IMIP)—is needed. The true cutting edge in world competition is how fast, how well and how cost-effectively products are manufactured. The Japanese have amply demonstrated this. They have used their manufacturing capability to rise to the top in several industry sectors.

The prospects of the U.S. aerospace industry will be affected by tighter R&D budgets and the debate over how technology dollars should be spent.

In the future, U.S. Government R&D funding will focus more on dual-use technology, and on obtaining a commercial payoff from defense technology, than it has in the past. Greater integration of the defense and civil technology bases makes sense. Some advanced requirements of defense systems can be met with commercial products; thus, it makes sense for the Department of Defense to buy commercially, where possible. However, there continue to be areas where defense technology needs diverge from those of the commercial sector. Performance and endurance requirements of materials, parts and systems for military purposes often go beyond anything required for the commercial market.

In an era of tight defense budgets and changing threat, there has been much discussion of open-ended technology development—of developing technology and putting it "on the shelf" until needed. Technology that is not tied to specific products and programs, and that has possibly never been field tested, will not adequately support a strong defense technology base. Technology demonstration will actually become more important than ever in order to shorten the time from concept to application and to learn how various advanced technologies work together.

Validation of generic technology—to reduce the risk of application for manufacturers—is an important part of aerospace technology development and is as important in the civil as in the military sector. Funding for technology and technology validation within the National Aeronautics and Space Administration has declined, and although funding is now being increased to some extent, it is still insufficient. Over the long term, this will inhibit technological preeminence in civil aeronautics.

More codevelopment and coproduction among American companies will strengthen the competitive position of the United States.

Legislation enacted in 1984 made it easier for U.S. companies to cooperate on research and development ventures. Later legislation permitted government laboratories to join these R&D consortia. A natural follow-on would be legislation that removes antitrust inhibitions against certain coproduction joint ventures. Coproduction ventures among U.S. firms will help companies build upon joint research, and create profits they can reinvest in the technology base.

The U.S. Government is already encouraging U.S. aerospace company teaming on major programs—in much the way that companies in other countries have been working together for decades. The comparative ease with which American companies can form joint ventures abroad, but not at home, probably prepared the way for this level of cooperation. Without teaming, U.S. defense contractors will not be able to take part in some future projects that require a considerable investment on their part. Years of poor return on investment—the result of a combination of government regulatory policies—have increased debt and reduced company funds for R&D and plant and equipment.

Trying to stop the international flow of advanced technology through excessive restrictions on products or on cooperative programs is nonproductive.

In the global marketplace, one company or nation will not be likely to maintain all of the technological advantages indefinitely. Already, there are competitive products for many of the products restricted from export by the U.S. Government. In addition, collaboration with foreign companies provides opportunities for the U.S. aerospace industry to expand its knowledge base; increasingly, technology is flowing back into the United States.

International aerospace partnership arrangements vary considerably in nature and can be structured for mutual advantage without the loss of critical company-proprietary knowledge. An advantage of the complex, modular nature of aircraft is that systems and parts can be produced independently without transferring knowledge of the other parts, or about the integration of the whole.

Company proprietary know-how and technologies critical for national security must be protected. Beyond that, restrictions on technology are less productive than working to continually advance the state-of-the-art, improve manufacturing technology, and speed up the cycle of concept to application. Meanwhile, "yesterday's" technology is an asset that can be shared or traded for market advantage.

An educated, motivated work force is one of the most important components of competitive success for aerospace.

The aerospace industry will be challenged to meet its future work force needs in view of the inadequacies of the U.S. education system. Other countries are doing a better job of preparing workers that can meet the requirements of high technology industries—judging by the scholastic scores of young Americans vis a vis their foreign counterparts. American youths are also less interested in pursuing scientific and technical careers than are those in other countries. The aerospace industry is investing heavily in education and needs to work even more closely with government and academia to develop a globally competitive work force. Yet money alone will not be sufficient. Industry must provide new ideas and direction to the educational process.

Recommendations

Create Better, Lower-cost Products Faster than Competitors
Establish an Investment Climate That Supports a Strong Industrial/Technology Base
Educate, Attract and Develop a High-calibre Work Force
Remove Barriers to Trade
Establish Pro-trade Policies
Implement Technology Export Policies that Make National Security and Market Sense

Create Better, Lower-Cost Products Faster Than Competitors

Industry

- Give technology planning and development as much priority in business planning as profits.
  - Include acquisition of foreign-developed technology as a key element of international strategic alliances.

- Expand the use of concurrent engineering whereby engineering designers and manufacturing planners work hand in hand from the first stages of product development.

- Pursue the aerospace industry's Key Technologies for the Year 2000 program.
  - Work to develop national consensus technology plans and program priorities.
  - Pursue establishment of industry/government/university cooperative endeavors.
  - Take the lead in identifying the most promising areas for cooperative development.

- Commit to a strong, continuing investment in manufacturing capability.

- Emphasize use of Total Quality programs to motivate employees and improve the productivity of the aerospace work force.

- Put more effort into building better working teams, both in domestic partnerships, and with foreign companies.

Government

- Support industry-led Key Technologies program and work with industry to develop consensus technology development plans.

- Provide sustained, strong, balanced funding of the technology base and technology demonstration/validation.
  - Increase funding for DoD technology integration demonstration programs.
  - Increase National Aeronautics and Space Administration (NASA) funding for technology development/validation.
  - Seek industry input on program priorities.
  - Establish closer cooperation on aeronautical research and development (R&D) between NASA and the Federal Aviation Administration.

- Provide incentives for private R&D investment.
  - Make the R&D tax credit permanent to permit long-term planning.
  - Foster cooperation between industry and academia.
  - Accelerate depreciation of test facilities and equipment.

- Enact legislation supporting formation of U.S. production-based consortia

.

- Support major space initiatives such as Space Station Freedom, the Missions to and from Planet Earth, and the Space Exploration Initiative within the context of a strong overall U.S. space program and the incremental development of technology.
  - Identify enabling technologies and begin funding shorter-term projects that will provide the basis for future major programs.

- Pursue bilateral or multilateral cooperative efforts in space.
  - Establish policy that reflects the existence of new technological and market challengers and accepts the role of other nations as full partners—in areas where cooperation will benefit all parties.
  - Strive to change the image of Americans as unreliable partners in space projects.
  - Pick partners carefully, where economic interests are at stake, and negotiate agreements to provide for a fair and equitable sharing of results.

- Support a competitive commercial space industry in the United States through a strong public-private partnership.
  - Take steps to reduce the differences between the United States and other countries in the way we do business in space.
  - Separate space research and development and space operations and commerce responsibilities within government to strengthen management, provide a better focus on market opportunities, and clarify funding decisions.
  - Focus NASA and the DoD on space research and technology, sharing capabilities where feasible.
  - Increase private access to government facilities and technology.
  - Promote uniformity in the way countries do business in space.

- Increase IMIP funding within the DoD budget, set unified policy for management of programs across services, and streamline IMIP contract implementation.

- Support development of the National Defense Manufacturing Technology Plan.

- Foster use of management concepts for continuous productivity improvement.

Establish An Investment Climate That Supports A Strong Industrial/ Technology Base

Industry

- Build partnerships with U.S. suppliers and promote productivity through assistance with employee training, R&D, and manufacturing investment.

- Develop international partnerships that provide a strong flowback of financial and technology resources.

Government

- Pursue fiscal and spending policies that will make capital available and affordable for business investment.
  - Expand the economic objective of full-employment and price stability to encompass promotion of a climate that fosters long-term capital formation.
  - Develop tax policies that make long-term investments in productive assets more financially attractive.

- Place greater effort into improving the dialogue between government and industry and involving industry in the development of program requirements.

- Encourage industry's investment in technology and innovation by allowing full recovery of the costs of IR&D/B&P.

- Increase progress payments to defense contractors.

- Reorient the defense budget cycle to allow more multi-year procurements.
  - Continue implementation of two-year budgeting.
  - Initiate project termination protection measures for companies.

- Rescind the current DoD policy on recoupment of RDT&E costs and apply recoupment surcharges only to major defense equipment sold to foreign countries.

Educate, Attract, And Develop A High-calibre Work Force

Industry

- Continue and strengthen support of the public education system, particularly science, math and language programs from K-1 through university level.

- Expand enhanced in-house education programs for those with specialized and critical skills, and to increase productivity and competitiveness of the work force as a whole.

- Expand in-house remedial education for workers, stressing fundamentals such as English, communications, and computations.

- Expand recruitment and training of women and minorities.

- Continue to pursue and develop ties with the university community in support of both research objectives and the development of an educated work force.

- Continue to provide Key Technologies information to universities to help guide curriculum changes.

Government
- Provide strong support nationwide for the study of science, math and languages from K-12 through the university level.

- Provide financial incentives to develop university-industry partnerships and to foster and enhance, for example:
  - University-based R&D activities,
  - Training of new scientists, engineers and technically-oriented managers, and
  - Continued education for university-based and industry-based holders of advanced degrees.

Academia
- Work with industry to develop and integrate curricula that respond to the needs of knowledge-intensive production.

- Work with industry and government to develop sound Key Technology development plans, coordinate with them on university-based research efforts and relate curriculum where possible to important generic, enabling technologies.

Remove Barriers To Trade

Government
- Work toward a free and open climate for international trade and investment including greater harmonization of country practices on R&D and production subsidies, and elimination of non-tariff barriers and technical barriers such as some standards, testing and certification requirements.

- Take aggressive action against violators of international trade agreements.

- Continue to support the Uruguay Round of the GATT and pursue measures to strengthen the multilateral trading system.

- Effectively regulate the entry of space launch systems developed in nonmarket economies (e.g., China and the Soviet Union) into the limited commercial market.

Establish Pro-trade Policies

Government
- Seek active FAA role in promotion of U. S. aviation interests worldwide, including strong efforts to maintain the integrity of U.S. federal airworthiness regulations (FARs).

- Work toward speedy harmonization of product liability laws in the international arena, and reform present U.S. product liability law and penalties in light of a rapidly changing economic environment.

- Affirm an Administration policy on defense exports and international cooperative programs.
  - Establish implementation guidance.
  - Provide a single point of contact within DoD on arms sales and cooperation.
  - Consider export design requirements during the product design phase.
  - Support American products and concepts at trade shows.
  - Remove or limit recoupment of development costs by DoD on non-major defense items.

- Work toward a multilateral framework on offset understandings and take no unilateral action to limit offsets.
  - Limit offset reporting requirements to basic and essential facts.

- Ensure adequate financing for all exports.
  - Maintain sufficient Eximbank program authority to enable complete fulfillment of its mandate to facilitate civil sales.
  - Increase use of asset-based financing for civil exports through financial guarantees or political risk insurance.
  - Extend allowable repayment term under Large Aircraft Sector Understanding to 18 years.
  - Establish government guarantees for commercial bank financing of defense exports to credit-worthy countries.
  - Work with foreign export credit agencies and private lending institutions to encourage financing of international collaborative programs.

Implement Technology Export Policies That Make National Security <u>And</u> Market Sense

Industry

- Foster discussion of industrial/technology base issues from a global perspective.
  - Promote understanding of the dangers of a "protectionist" approach in the face of strong world market competition.

- Focus internal activities on key company strengths—critical product and process technology—while cooperating internationally to enhance U.S. market opportunities.

- Structure cooperative agreements for strategic acquisition—as well as sharing—of technology.

Government

- More clearly define products and technologies to be controlled rather than imposing broad, generalized prohibitions.

- Provide a single DoD policy guidance on defense exports, technology transfer, the industrial base, and arms cooperation.

- Clarify jurisdiction between Departments of State and Commerce with respect to "dual-use" commodities, with final appeal to the President.

- Conform U.S. Munitions List to COCOM International List to put U.S. suppliers on equal footing with foreign competitors.
  - Better define items that belong on the Militarily-Critical Technologies List.

- More narrowly define "defense articles and services."

- Streamline export controls administration.

- Pursue technology developed abroad through government to government efforts.

The U.S. Aerospace Industry in 1991

The United States achieved—and maintains—world leadership in aerospace by capitalizing on U.S. long-term macroeconomic growth, the largest defense market in the free world, and the highest aerospace R&D spending of any national aerospace sector. —

The U.S. industry's international business has increased, but so has its exposure to the pressures of the marketplace. World market share figures indicate the industry faces some serious challenges. —

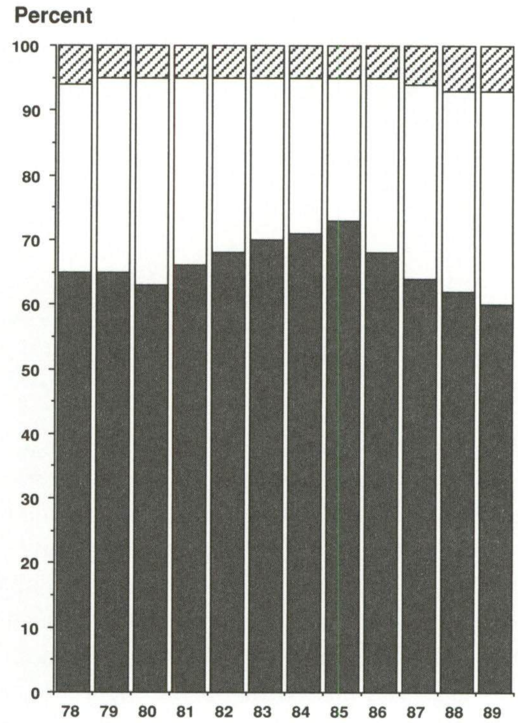
The U.S. aerospace industry is one of the fundamental sources of America's economic strength and world leadership. American aerospace products enable the nation to project a military presence that is second to none. U.S.-manufactured air transports dominate world cargo and passenger traffic, facilitating business and tourism.[1] The U.S. space program is responsible for a long list of achievements that have improved the quality of life—from advances in medicine, to global satellite networks that speed the exchange of communications.

Even though the U.S. industry dominates the world aerospace market, there is growing pressure from other foreign companies attempting to gain a larger portion of the increasing global demand. In 1970, U.S. market share of total free-world aerospace production stood at 79 percent. Market share declined in the 1970s, until increased U.S. defense spending and commercial aircraft sales growth during the 1980s pushed the U.S. share up to 73 percent in 1985. Since then, U.S. market share has fallen to 60 percent even as U.S. aerospace sales continued to increase, particularly in the commercial sector. In contrast, European market share has improved since 1985 from 21 to 33 percent.[2] Part of the recent U.S. decline in market share comes from a reduction in domestic military sales: in real terms, U.S. defense outlays turned downward after 1986. But also contributing to the general decline is the increasing European aggressiveness in pursuing commercial sales. See Figures 1 and 2 for market share and aerospace sales trends over time. A more accurate barometer of U.S. aerospace competitiveness is to eliminate the bias of domestic spending programs and calculate world market share in terms of export deliveries only. Using this measure, the trend is still the same. The U.S. share of complete aircraft and aircraft parts exports drifted downward from 65 percent in 1974 to 50 percent in 1986. The U.S. share of aircraft and parts imports increased from 12 to 26 percent over that same period. The European share of aircraft and parts exports rose from 25 percent in 1974 to 40 percent in 1986.[3]

These market share figures underscore the challenge that U.S. manufacturers face when competing in the international arena. This challenge is significant, because the industry is taking on a greater global orientation. To compete in this environment one must understand the forces motivating industry and governments and the actions they are taking to position themselves for economic growth in the aerospace field into the next century.

To shed light on this process, the next three sections of this report will look at the aerospace sectors in the United States, Western Europe, and Japan and the Asia-Pacific Rim. This first section will focus on the U.S. industry. Since a 1988 AIA study, *The U.S. Aerospace Industry and the Trend Toward Internationalization*, supplied background on the U.S. industry, detailing its characteristics and motivations, that material will not be repeated. Instead, this first section will concentrate on U.S. foreign trade and investment activities since 1986, updating data presented in the first report. The sections that follow—on Western Europe and Asia-Pacific Rim—will cover more ground, including information on industry structure and government/industry relationships. The focus of all three sections will be on how aerospace companies respond to overseas demand through licensing, trade, foreign direct investment, and joint ventures. Although international business arrangements are complex and frequently incorporate a combination of these approaches, to simplify this review and maintain continuity with the previous AIA study, these approaches will be discussed as discrete activities.

Figure1
World Aerospace Market Share 1978 - 1989



Source: European Commission, The European Aerospace Industry Trading Position and Figures 1991, Brussels.

*U.S. Aerospace Market Overview**

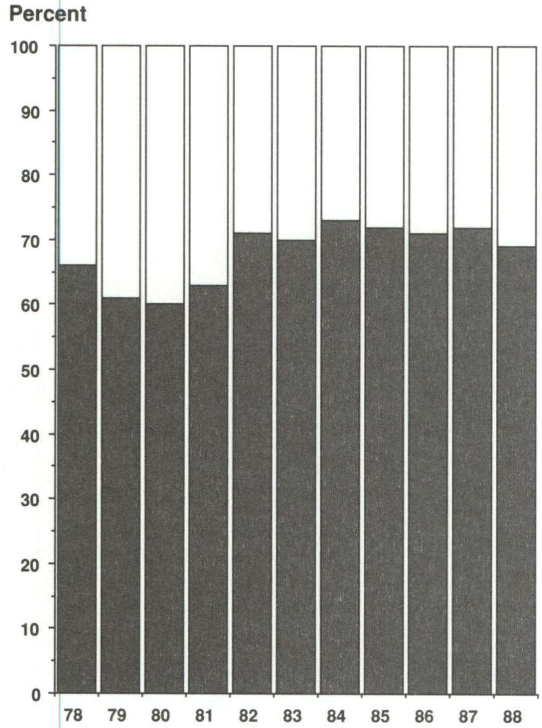
Underpinning the achievements of the U.S. aerospace industry is a large domestic market, reinforced by years of economic growth and U.S. Government defense spending, which together have provided the means for building the most dynamic and competitive national aerospace sector in the world. In recent years, an increasing share of U.S. aerospace sales has come from the civil sector, but government contracts still account for 56 percent of total aerospace sales (Figure 3).[4] U.S. aerospace sales have improved annually since 1971 and reached an estimated $131 billion in 1990.[5] No other nation comes close to achieving sales of this magnitude.

See pages 30-33 for more on the U.S. in the global marketplace.

The industry has also demonstrated a commitment to maintaining the highest level of aerospace research and development (R&D) in the world. This effort is strongly supported by U.S. Government funding for military projects, as well as for basic research in civil aeronautics. U.S. aerospace R&D averaged over $22 billion annually between 1987 and 1989.[6]

The U.S. aerospace sector is composed of privately-held companies. Some are dedicated solely to aerospace manufacture, while others are more diversified. In general, U.S. manufacturers are larger than their foreign competitors (Figure 4). Seven U.S. companies are capable of assembling large-scale aircraft, two can produce high-performance jet engines, and a vast number of specialized suppliers also exist.

Figure 2
World Aerospace Sales 1978 - 1988



Source: European Commission, The European Aerospace Industry Trading Position and Figures 1991, Brussels.

U.S. Aerospace International Relationships

Licensing

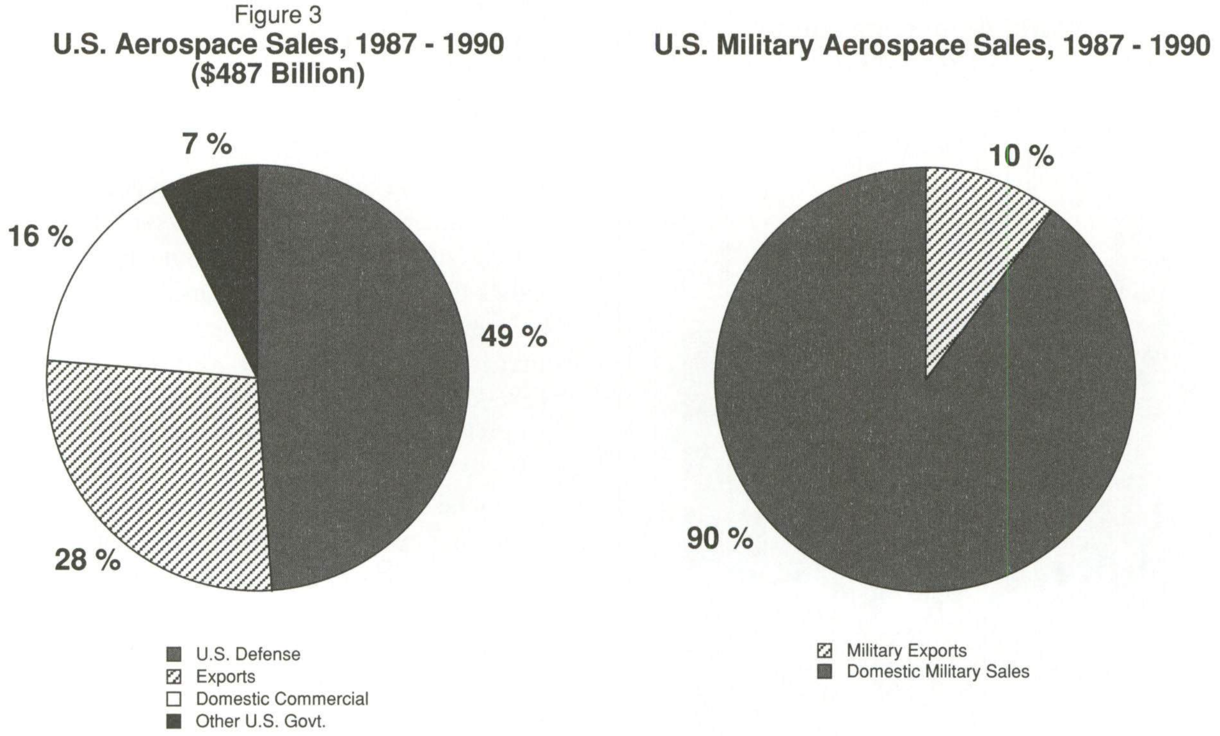
Licensing involves the transfer of know-how, patents, or trademarks from one company to another in return for some level of licensing fee or royalty.[7] In the international aerospace arena, U.S. firms have licensed technology more frequently in the defense sector than in the commercial marketplace. Licensing has helped U.S. defense manufacturers tap foreign demand. Licensing has been encouraged by the U.S. Government to enhance the defense capabilities of allies, thus furthering national security. Given the United States' position as a technology leader in aerospace, technology has tended to flow from U.S. firms to foreign companies. This is still generally the pattern today, although increasingly there is technology flowback to U.S. firms.

The U.S. Government does not routinely collect data on licensing in individual industry sectors. To get an approximation of licensing activity, one must use a broader measure which encompasses all manufacturing activities. This "All Manufacturing" indicator shows that royalties and licensing fees received by U.S. manufacturing companies from their foreign direct investment activities rose from $4.1 billion in 1986 to $6.5 billion in 1988. This increase is significant when compared to earlier years.[8]

In the context of aerospace production, licensing results in more than the receipt of royalties and fees. Most of the content of products produced abroad under U.S. license—e.g., components, avionics—comes from U.S. manufacturers, which boosts exports. Over the life of the project, U.S. content usually declines. Recent international agreements involving licensed technology indicate that U.S. aerospace companies still consider licensing to be an important part of their overseas marketing strategy.

In 1988, the United States and Japan signed a agreement to produce an advanced support fighter called the FSX for Japan's defense forces.[9] The arrangement is based upon the transfer of U.S. F-16 airframe technology from General Dynamics through license to Mitsubishi Heavy Industries; however, it goes beyond earlier aircraft coproduction agreements with Japan to include joint development of new technology. The United States placed limitations on the transfer of technology in several areas including technology related to airfoils, carbon-carbon and other high-temperature components, very-high-speed integrated circuitry, and source codes for the digital flight control computer.[10] General Dynamics will receive all new technologies emerging from the project, although limitations will be placed on phased-array radar, inertial navigation, electronics warfare and fire control computer technology. Of particular importance to General Dynamics are techniques related to the pro-

Figure 3

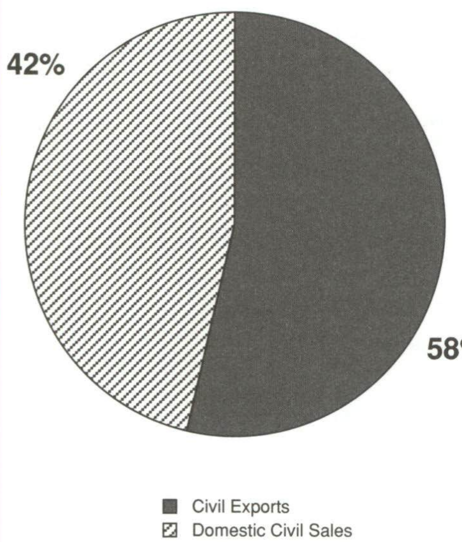


Source: Aerospace Industries Association, Year-End Review and Forecast 1990, and supplemental trade data.

duction of a new composite wing. A U.S. engine manufacturer, General Electric, was selected to provide the engine for the new fighter. Almost from the start, the FSX program was mired in controversy and various technology-related issues surfaced: what U.S. technology should be transferred to Japan; the type of Japanese technology that should be transferred to the United States and at what cost; and whether transferred Japanese technology can be reexported by the United States.

Another project, being negotiated in the Spring of 1991, is the licensed production by South Korean manufacturer Samsung of F-16 fighters. The resulting Korean fighter will be called the KFP. This agreement is significantly different from the FSX arrangement with Japan because it involves no codevelopment. The Korean industry will receive production assembly technology from General Dynamics, and as the program progresses, will produce up to 50 percent of the aircraft. South Korea will also buy U.S.-manufactured enhanced-performance engines to power the aircraft. Samsung, the lead contractor, will eventually manufacture many of the engine parts, although no engine control systems or hot section parts, which incorporate the most advanced engine technology, will be coproduced.[11] This program has also been criticized by some members of the U.S. Congress who are concerned that the United States may be giving away technology to a potential competitor.

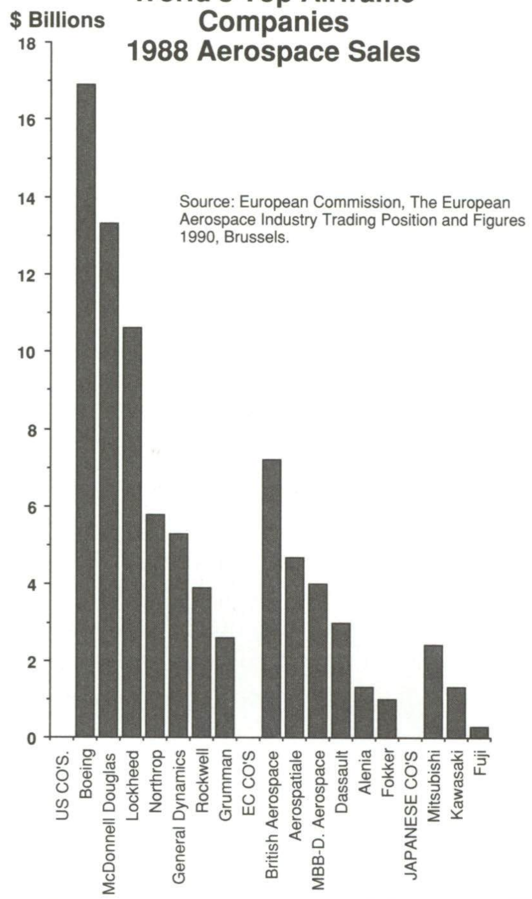
U.S. Civil Aerospace Sales, 1987 - 1990



Both projects highlight an attitude that has evolved in the United States concerning technology transfer. At one time, licensing agreements for defense programs were a commonly accepted practice. Recently it has become controversial, particularly with regard to Japan (see *Aerospace Technology Trends and Strategies.*) Notwithstanding, licensed production to foreign companies will continue because foreign governments will demand it. When governments spend large amounts of public funds to purchase aerospace products, they need to demonstrate to their citizens that immediate and direct public benefits derive from those expenditures. The U.S. Government is no exception to this practice—as demonstrated by the AV-8B and T-45 aircraft programs in which purchases from the United Kingdom required coproduction in the United States.

The opening of markets in Eastern Europe and the Soviet Union should further increase the demand for licensing arrangements, since companies in both regions need western technology. However, the outgrowth of the debate over technology licensing will be greater safeguards placed on technology and agreements that are more specific as to the type and extent of technology transfer permitted.

Figure 4
World's Top Airframe Companies 1988 Aerospace Sales



Aerospace Trade

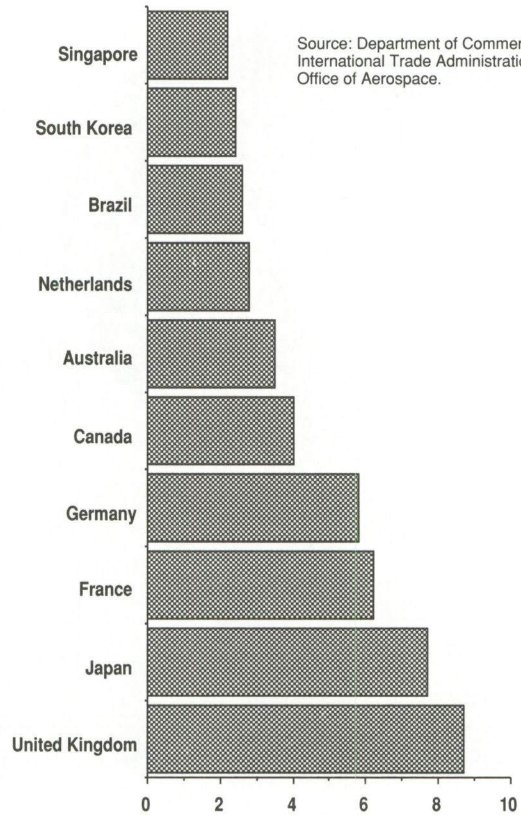
Growing U.S. aerospace trade reflects the attractiveness of U.S. products abroad, as well as the increased vitality of foreign producers who are entering the U.S. market. Both U.S. exports and imports of aerospace products have continued to grow since 1986.[12] Aerospace trade has not grown in isolation: total U.S. trade also continues to rise. Yet, while U.S. merchandise trade has recorded deficits since 1986, the U.S. aerospace trade balance has reflected a surplus for the past 30 years, rising to a high of $27 billion in 1990.[13] (Also see Figure 1, chapter on Asia-Pacific Rim aerospace industry.) Exporting has been a viable strategy for U.S. aerospace companies. Because of economies of scale and advanced R&D efforts, most U.S. manufacturers are capable of producing the highest-quality, state-of-the-art products possible at the lowest market price.

Exports: Exports have become increasingly important to U.S. aerospace manufacturers. Exports equalled $20 billion in 1986 and climbed to $39 billion in 1990—an annual increase of 18 percent. During the early 1980s, exports rose by only 5 percent annually. Exports have also risen as a percent of aerospace sales, from 19 percent in 1986 to approximately 30 percent in 1990.[14] (See Figure 3.) During the 1960s, exports accounted for less than 10 percent of total U.S. aerospace sales.[15]

Between 1986 and 1990, civil aerospace products constituted 79 percent of the industry's exports. Commercial transports accounted for most of the foreign civil sales, while aircraft engines and parts were the largest share of military exports.[16] The size of these follow-on orders to earlier military aircraft exports are indicative of the importance—over a considerable period of time—of overseas sales (Table 1, Appendix A).

The top four markets for U.S. aerospace exports since 1986 in descending order have been: the United Kingdom, Japan, France, and Germany (Figure 5).

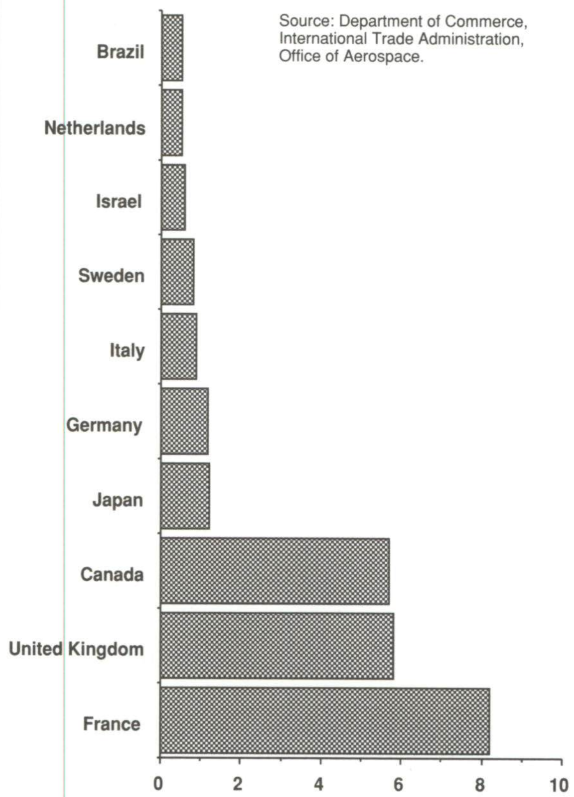
Figure 5
U.S. Aerospace Exports by Country 1987 - 1990 ($ Billions)



Source: Department of Commerce, International Trade Administration, Office of Aerospace.

Imports: The value of aerospace products imported by the United States has also climbed since 1986, although the rate of increase has been less than that for exports. In 1986, imports totaled $8 billion, while in 1990 they reached $12 billion.[17] These figures represent an 11 percent annual growth rate. The U.S. aerospace industry has historically had a low import penetration ratio compared to other U.S. sectors. This ratio has risen from 9 to 11 percent between 1986 and 1990.[18] The majority of imports are aircraft and engine parts which are incorporated into final products by U.S. manufacturers. Between 1986 and

Figure 6
U.S. Aerospace Imports by Country 1987 - 1990 ($ Billions)



1990, civil products were 77 percent of aerospace imports (Table 2, Appendix A).

The four leading sources of U.S. aerospace imports since 1986 in descending order have been: France, the United Kingdom, Canada, and Japan (Figure 6).

Foreign Direct Investment

The 1988 AIA study on internationalization concluded that foreign direct investment was not particularly prevalent in the industry.[19] The events that have since taken place in Europe have led to a flurry of European cross-border investment activities. (See *Western European Aerospace Market* section on Direct Investment.) Investment has been stimulated by the possibilities of accessing foreign technology, markets, or market experience.

Foreign market access by means other than direct investment still appears to offer greater opportunity at less cost to U.S. companies. U.S. firms are generally more cautious about direct investments in Europe than European firms are about investing in America. U.S. investment in Europe tends to generate far greater anxiety among Europeans than does intra-European investment and this acts to discourage U.S. investment efforts. In addition, the U.S. market remains the largest in the world for aerospace products and U.S. companies tend to put their capital into improving their domestic base. U.S. aerospace companies are more comfortable operating out of their home market and have traditionally shied away from establishing permanent manufacturing outlets overseas. In addition, the changes occurring in the European market are still unsettled, and consequently, investments there involve greater risk for U.S. firms.

U.S. Government statistics do not specifically track changes in aerospace-related assets. Instead, such investments are captured in a broader statistical category called "Other Transportation." Within this category, aerospace-related assets account for an estimated 75 percent of the category value. Between 1986 and 1989, U.S. overseas investments in "Other Transportation" assets did not grow, remaining at $1.1 billion. In comparison, U.S. investments abroad in the "Motor Vehicles" and "Electric and Electronic" sector both rose about 70 percent to $22.3 billion and $11.9 billion, respectively.[20] The number of foreign aerospace firms owned by U.S. companies totals 14, according to one U.S. Government source.[21]

Total foreign direct investment in U.S. assets grouped as "Other Transportation" increased 100 percent to $916 million between 1986 to 1989. For the same period, foreign investment in the U.S. "Electric and Electronic Equipment" industry rose 126 percent to $16.3 billion and investment in the "Motor Vehicles" sector climbed 106 percent to $3.9 billion).[22] The number of aerospace-related firms or divisions now owned by foreign investors in the United States is 38.[23]

Joint Ventures and Other Partnerships

International joint ventures and a range of other cross-border relationships are increasingly prevalent in the global aerospace industry. The primary reasons for pursuing these linkages include: sharing the large development costs and the high degree of risk inherent in aerospace projects, access to advanced technology, and the ability to penetrate foreign markets. The recent surge in such alliances, and the shrinkage in defense spending, have prompted U.S. companies to take a closer look at establishing additional relationships abroad. (See *Western European Aerospace Industry* section on Joint Ventures.)

Traditional joint ventures involve a separate business entity to which companies contribute resources and many U.S. international agreements follow this form. In addition, U.S. companies are engaged in various other partnerships—e.g., some are open-ended commitments, others are exclusively marketing arrangements. (A U.S. Department of Commerce study indicates that 40 percent of U.S./Japanese business agreements in aerospace are marketing arrangements.[24]) The following are a sampling of relationships between U.S. companies and international partners: General Electric (U.S.) and Pratt and Whitney (U.S.) are both negotiating arrangements with foreign firms to design and produce powerful turbojet engines—the General Electric GE90 and the Pratt and Whitney PW4000; Rockwell International (U.S.) has been working with Messerschmitt-Boelkow-Blohm (MBB) (Germany) to design an experimental fighter aircraft based on MBB technology called the X-31; Motorola (U.S.) and Selenia Spazio (Italy) will jointly develop a transponder capable of relaying information from satellites to ground stations. MBB also joined Boeing and Sikorsky (U.S.) in competing for the development and production of the U.S. Army's next light attack helicopter. McDonnell Douglas (U.S.) and Matra (France) concluded an agreement to market the French firm's missiles in the United States. General Dynamics (U.S.) and British Aerospace (U.K.), as well as Lockheed (U.S.) and Aerospatiale (France), agreed to cooperate on a range of future projects.

U.S. aerospace firms are involved in more international partnerships than ever before. Compared to European international cooperative efforts, the number of U.S. foreign business alliances is still small—nevertheless, more U.S. collaborations appear to be on the horizon. Table 1 underscores this point. It displays the programs of the world's three primary commercial jet engine companies in the various engine thrust categories. International alliances are evident throughout the chart.

The opportunities for—and benefits of—cooperative programs between U.S. and Western European firms will continue as both industries proceed simultaneously to further develop and apply command and control, surveillance and verification, early warning and reconnaissance, and long-range targeting systems. The Persian Gulf War underscored the importance of these systems, and demonstrated the success of U.S. technology in these areas.

Notwithstanding the many partnerships in which U.S. firms are involved, there are still obstacles to U.S. participation in cooperative efforts:

- U.S. policy restrictions on technology transfer—for security and economic reasons—often prohibit U.S. firms from sharing their top-of-the-line technology with foreign companies. Foreign firms are more open about sharing technology between partners. This difference has limited the opportunities for U.S. companies to enter into joint ventures and it reduces the incentive of foreign companies to join U.S. efforts. Also, it makes the end

Table 1
Large Commercial Aircraft Engine Programs

	15,000 - 20,000 lbs. Thrust
Discussion stage	GE (US), Snecma (France)
Discussion stage	PW (US), MTU (Germany)
Discussion stage	RR (UK), BMW (Germany)
	13,850 - 36,000 lbs. Thrust
CFM56	GE (US), Snecma (France) - CFM International
V2500	PW (US), MTU (Germany), RR (UK), Fiat (Italy), JAEC (Japan) - International Aero Engines
JT8D	PW (US), MTU (Germany), MHI (Japan), Volvo (Sweden)
Tay	RR (UK), BMW (Germany), Volvo (Sweden), Alfa Romeo (Italy)
	36,000 - 45,000 lbs. Thrust
PW2037	PW (US), MTU (Germany), Fiat (Italy), Volvo (Sweden)
RB 211-535	RR (UK), IHI (Japan), KHI (Japan)
	46,000 - 70,000 lbs. Thrust
CF6	GE (US), Snecma (France)
PW4000	PW (US), FN (Belgium), Fiat (Italy), KHI (Japan), MHI (Japan), NJ (Norway), Samsung (S. Korea), Singapore Aircraft Industries (Singapore), Eldim (Netherlands)
RB211-52	RR (UK), IHI (Japan), KHI (Japan)
	+ 70,000 lbs. Thrust
GE90	GE (US), Snecma (France), IHI (Japan), Volvo (Sweden), Fiat (Italy)
PW4000 (Growth)	PW (US), MTU (Germany), Fiat (Italy), FN (Belgium), KHI (Japan), MHI (Japan), Samsung (S. Korea), Singapore Aircraft Industries (Singapore), Eldim (Netherlands)
Trent	RR (UK), BMW (Germany), IHI (Japan), KHI (DJapan), Hispano-Suiza (France)
	Supersonic
Study Mach 1 - 3.5	RR (UK), Snecma (France)
Study Mach 1 - 3.5	GE (US), PW (US)
Study Mach 3 - 5	Japanese Group,* GE (US), PW (US), RR (UK), Snecma (France)

*Primarily IHI, KHI, MHI

product of any combined effort less attractive to potential buyers, because such products are based on older technology. A related problem is that foreign governments are more willing than the U.S. Government to export high-technology products to third-country markets.

• U.S. firms are viewed overseas as unreliable partners, because the U.S. Government has not demonstrated a strong funding commitment over the long term to defense collaborative projects. It is perceived overseas that the U.S. Government does not see international cooperation as being vital to its operations and it functions accordingly. This represents a fundamental difference between the U.S. Government and European governments.

• Large U.S. Government contracts may be seen as too risky. Major programs require considerable time and investment, and the fierce competition between competing teams in the United States adds greater uncertainty to contract competition than European firms are accustomed to, when operating in their home markets. Foreign firms naturally want to ally themselves with the winner of a competition, and cannot easily decide which company or team to join.

• Joint projects require time and commitment to succeed. Foreign firms take a longer view regarding international relationships and their commitment is often supported by government assistance. U.S. companies are generally geared towards shorter-term results.

• U.S. firms have generally wanted to shape and control programs, causing potential partners to back away from U.S. companies. During the 1950s and 1960s, U.S. manufacturers dominated joint arrangements as U.S. technology flowed to foreign firms. Today, many foreign companies are more evenly matched with the United States technologically and they want greater respect in collaborative projects. Unfortunately, past U.S. attitudes persist.

• Some U.S. companies undertake international cooperative ventures with the attitude that there is nothing their partner company can teach them. Consequently, they have not gained the full benefits that these alliances can offer, because they have not worked hard enough to learn from their partners. U.S. companies need to place greater emphasis on assimilating as much knowledge and experience as possible from their partners and then adapting what is useful to their own operations. Asian companies have been particularly good at this.

Transatlantic defense cooperation seems to be working better on a company to company basis, than when it is initiated through government channels. The recent difficulties of cooperative R&D programs sponsored under the Nunn Amendment highlight this point. (See *Aerospace Technology Trends and Strategies*.) Company-initiated cooperation is based more on economic criteria than political considerations and partners are not subject to the changing priorities of governments. Also, fewer parties and less bureaucracy are involved in a company to company effort. Western European Government-initiated intra-European joint ventures also have their share of problems, but the pressure of U.S. competition is acting to keep many such efforts glued together.

U.S. participation in business ventures with foreign firms may have helped prepare the way for the recent teaming of U.S. defense contractors. During the past several years, the U.S. Government has allowed and encouraged codevelopment/coproduction teaming for the Advanced Tactical Fighter, the Light Helicopter Experimental, the Advanced Technical Bomber, the V-22 Osprey, and the Advanced (Space) Launch System. Although this represents a new step for U.S. policy makers, Japanese companies have been working together in domestic consortia for over thirty years. In Europe, national consolidations have taken the place of domestic teaming, but regional consortia have been actively pursued since the 1960s.

Footnotes

1 As of 1989, 82 percent of the turbojet aircraft in operation worldwide were manufactured by U.S. companies. Aerospace Industries Association (AIA), *Aerospace Facts & Figures 1990/91* (Washington, D.C.), p. 91.

2 These figures represent the best available figures on comparative aerospace sales. European Commission, *The European Aerospace Industry Trading Position and Figures 1991*. (Brussels, Belgium: 1991), p. 186 and AIA, "U.S. Aerospace Recovers Market Share," *Facts & Perspectives,* June 1988, p. 2.

3 Data provided by the National Science Foundation. A third source on export market share data is the United Nations *International Trade Statistics Yearbook*. UN data show that between 1977 and 1987, the U.S. share of complete aircraft declined from 58 percent (1977) to 55 percent (1987).

4 Aerospace Industries Association, *Year-End Review and Forecast 1990*, and supplemental trade data.

5 AIA, *Year-End Review and Forecast 1990.*

6 Battelle, *Probable Levels of R&D Expenditures in 1987*, also *1988, 1989* (Columbus, Ohio: December 1986, 1987, 1988).

7 Licensing is most prevalent when: a firm possesses a range of technological skills useful in a foreign market, the technology transfer costs are reasonable, the opportunity costs do not outweigh the benefits of licensing, and host country licensing requirements are considered reasonable. Aerospace Industries Association, *The U.S. Aerospace Industry and the Trend Towards Internationalization,* March 1988, p. 28.

8 Between 1980 and 1986 royalties and licensing fees stayed relatively flat. Bureau of Economic Analysis (BEA), U.S. Department of Commerce, *Survey of Current Business*, August 1985, 1988, 1989, pp. 34, 46, 66.

9 Although the agreement calls for codevelopment, this is not a true risk-sharing effort for two reasons: only Japan will be shouldering the development costs, and the Japanese Government will provide a guaranteed market for the finished product.

10 John D. Morrocco, "Revised FSX Pact Eases Trade, Technology Concerns," *Aviation Week and Space Technology,* May 8, 1989, p. 16.

11 As part of its proposal General Dynamics also offered to assist South Korea's aerospace industry. "F-16 Korea Deal Includes GD Aid to Build Indigenous Trainer," *Defense News,* February 1, 1991, p. 4.

12 Factors contributing to increased world aerospace trade include: product specialization, low transportation costs, and economies of scale. AIA, *Trend Towards Internationalization*, p. 22.

13 AIA, supplemental trade data.

14 AIA, *Year-End Review and Forecast 1990,* and supplemental trade data.

15 AIA, *Aerospace Facts & Figures 1981/82,* pp. 13, 113.

16 AIA, *Year-End Review and Forecast 1990,* Table 8, and supplemental trade data.

17 Ibid., Table 7, and supplemental trade data.

18 Ibid., Tables 2, 7 and 8, and supplemental trade data. Import penetration ratio here is defined as total sales, minus exports divided by imports.

19 Foreign direct investment is defined as occurring when one company purchases a controlling interest (10 percent) in another foreign company. AIA, *Trend Towards Internationalization,* p. 36.

20 *Survey of Current Business,* August 1990, p. 97.

21 U.S. Department of Commerce, *Foreign/U.S. Investments in the Aerospace Industry,* 1989.s

22 Department of Commerce, *Survey of Current Business,* August 1990, p. 55. It should be noted that the Department's Bureau of Economic Analysis (BEA) is currently revising its method for calculating International Investment to represent greater accuracy. Its past methods computed book value rather than current market value. Since U.S. investments are more mature than investments by foreign investors, the values given by BEA have understated U.S. company investment relative to foreign investor holdings.

23 Department of Commerce, *Foreign/U.S. Investments in the Aerospace Industry.*

24 Department of Commerce, *The Role of Corporate Linkages in U.S.-Japan Technology Transfer 1991.*

THE U.S. AEROSPACE INDUSTRY IN THE GLOBAL MARKETPLACE

DEFENSE AEROSPACE

The Persian Gulf War demonstrated the importance of a strong national defense and the value of high technology weaponry. However, the U.S. defense budget will continue to decline under pressure of the national budget deficit, and because of the reduced Soviet threat. The defense spending of NATO allies also faces deep budget cuts. The uncertain direction politically of the Soviet Union means that a threat from that quarter cannot be entirely ruled out. Nonetheless, the objective of deterring the Soviet Union from attacking Europe has been largely replaced by one of preserving the peace globally. So despite tighter defense budgets, over the next few years, America and its allies will have to prepare to defend against regional, primarily third world, threats. There will be increased emphasis on tactical standoff weaponry and defense systems like cruise missiles, smart bombs and anti-missile systems. Flexibility and mobility of defense forces will be paramount.

Despite the defense buildup of the first half of the eighties, and large new contracts, the ability of U.S. defense companies to earn a profit on those contracts declined over several years. (The debt/equity ratio of defense stocks as a group has deteriorated. The performance of aerospace stocks has not matched the Standard and Poor 500 stock index.) This resulted from government policies including: reductions in the rate at which the government reimbursed companies for expenses incurred (progress payments) in performing contracts, a change in the method of paying taxes to require payments before profits were realized, and a shift to fixed-cost development contracts. Declining financial health and declining U.S. defense business mean that exports will play a larger part in the viability of the U.S. aerospace defense industry. Exports currently account for about 10 percent of total U.S. military aerospace sales.

There are a substantial number of markets for defense exports including the Middle East and Southeast Asia regions. However, sales to the Middle East have become problematic. The United States is concerned about the possibly destabilizing effect of arms sales to the area. At the same time, U.S. influence in the region is heavily dependent on support of its allies there. Other nations from both East and West could easily fill the void if the United States withholds arms. From 1984-1988, Western European arms shipments to Africa, Latin America, the Middle East, and South Asia were greater than U.S. arms exports to those regions.

As the European nations forge economic and political bonds, they seek to integrate and strengthen their defense industrial base. The United States faces greater difficulty selling in Europe, and will often be competing with European countries for major defense sales elsewhere. Other arms exporters include France, the United Kingdom, and the Soviet Union which, with the demise of the Warsaw Pact, will more actively seek global markets. Although some of the smaller arms producers—e.g., N. Korea, Chile and Brazil—may not be able to offer the sophisticated weaponry of the United States and other major arms exporters, their products may well fit their own requirements and those of many Third World nations.

In general, economic competitiveness has replaced purely defense concerns in the American consciousness. Concerns about the health of the industrial base—the foundation for both economic leadership and national security—are heightening the political discussion over foreign sourcing for components of U.S. defense systems, foreign investment in the United States, offset arrangements imposed on the United States by buyers of its defense systems, and technology export through international defense cooperation.

Cooperation among nations in the development and production of weapons systems continues to increase, particularly in Europe. Defense cooperation between the United States and Europe, a political goal for years, is proceeding more slowly. There are sound economic reasons to cooperate—to prevent duplication and share costs—and security advantages to be gained from the rationalization of systems and industrial capabilities. However, greater European cooperation and technology export controls in the United States tend to work against transatlantic cooperation. Cooperation between the United States and potential buyers of U.S. defense systems in other regions of the world will nonetheless increase as countries tie purchases to benefits to their own economies.

CIVIL AEROSPACE

The market for civil aerospace products is more promising than the defense market. Civil aerospace products, particularly commercial jet passenger transports, have long dominated U.S. industry exports. Civil production is now the growing share of total industry output.

Commercial Transports: The prospects for growth of the commercial transport sector are particularly bright. The need to replace aging jets with newer, quieter, more fuel-efficient models, coupled with demand in the economically expanding Pacific Rim region, will keep the industry busy for years. The Boeing Corporation projects aircraft sales through 2005 will total $617 billion. U.S. manufacturers are working to fill $112 billion worth of orders for commercial transports—more than half of them from foreign customers.

Yet the industry faces a number of serious challenges including the financial problems of the world's airlines. The airlines have been buffeted by the high cost of fuel, and a downturn in passenger travel as a result of the Persian Gulf War and economic recession. U.S. airlines together experienced an operating loss in 1990. Even the healthiest airlines are having difficulty obtaining investment capital in today's economy. Airport congestion—in the United States and abroad—could act as a brake on traffic growth.

One of the most serious threats to U.S. civil aircraft and space vehicle manufacturers is foreign government subsidy support. The United States filed a case in early 1991 against the European Commission and Germany with the General Agreement on Tariffs and Trade (GATT) organization. The case is based on German financial support to Deutsche Aerospace that offsets the company's exposure to currency exchange rate fluctuations. Deutsche Aerospace is a member of the Airbus Industrie consortium, the major competitor for U.S. commercial transport manufacturers. The U.S. Government will be challenged to maintain a free and fair trading system in civil aircraft as other nations increase their participation in the market. The development of aerospace industries in nonmarket economies such as China and the Soviet Union, or those making the transition from communist to free market as in Eastern Europe, will pose new problems.

Other developments will increase the competitiveness of the market for commercial transports. Several airlines in the United States continue to decline in the aftermath of deregulation and under myriad financial pressures; deregulation is proceeding in Europe; and the United States has decided to permit foreign investment in U.S. airlines. Over time, the result will doubtless be fewer airlines worldwide. Of these, many will reflect international, rather than strictly national, financial interests. Some airlines are forming groups to more effectively negotiate aircraft purchases of similar models of aircraft, a practice which increases their leverage with airframe and engine manufacturers. At the same time, international leasing companies are purchasing large numbers of aircraft which they lease to airlines anywhere in the world. These trends mean there will be fewer, but larger and more significant, sales campaigns. The manufacturers of large jet transports and the major engine producers will continue to be pitted against each other in fiercely price-competitive sales negotiations. The financial support afforded manufacturers by foreign governments could profoundly influence the outcome of particular sales, and the financial survival of U.S. manufacturers.

U.S. airworthiness standards and certification procedures were preeminent in the civil aviation marketplace for years. Today, the Federal Aviation Requirements (FARs) are in danger of being displaced by European Joint Airworthiness Requirements (JARs). This would impose additional costs on U.S. aircraft manufacturers. Standards significantly different from those of the FARs could also pose technical barriers to trade for U.S. companies **(see page 128.)** The harmonization of standards for civil aircraft manufacture certification and operation is vital to free and open trade in this sector.

Helicopters: The U.S. helicopter industry has suffered from strong foreign competition as well as recession in the oil industry and a general economic downturn, which affects corporate sales. Exports have followed a downward trend since 1986. For the five-year period from 1986 to 1990, France's Aerospatiale outsold Bell Helicopter Textron, America's leading producer of civil turbine helicopters and number two in the market. Germany's MBB held third place. These two European companies are currently attempting to merge their helicopter operations into a single, stronger U.S. competitor called Eurocopter. At year-end 1990, U.S. unit shipments of helicopters reached a high of 570. Sales, however, declined to the lowest point in 16 years because the bulk of increased shipments were primarily lightweight single-engine models. Working against the industry is the divergence of military and civil requirements. In the past, military rotorcraft were more easily converted to civil missions and producers could gain advantage from developments in the military sector. Today, military helicopters are more sophisticated and costly and less suitable for civil applications. A less than booming market has made it difficult for manufacturers to invest in new commercial technology. New models are under development, however. Manufacturers expect the demand for intermediate-weight twin-engine helicopters to increase in the next several years because of low fleet inventories, aging models in the fleet, and regulatory pressure. A rebound in the economy and in the energy market should help sales. In the long-term, expansion of the civil helicopter market depends upon development of an infrastructure that can handle scheduled helicopter operations. Helicopter operations on a regular basis require air traffic control and flight approach procedures that are compatible with rotorcraft capabilities.

General Aviation: The U.S. general aviation industry delivered 1,144 aircraft worth $2 billion in 1990. This represented a 25 percent decline in unit shipments but an 11 percent increase in sales (up from $1.8 billion) due to increased shipments of high-value business aircraft. The commuter and business turboprop segments of the market also showed strength. The significant decline in shipments overall is attributable to the decline of the piston-powered general aviation aircraft market where product liability claims have taken a major toll. Insurance coverage for these smaller aircraft has depressed sales for years. Exports accounted for a record 39 percent of shipments in 1990 and for 42 percent of billings. Investment in new technology aircraft and sizable military contracts for training aircraft should lead to stronger sales in the future.

Space Vehicles/ Launch Services: The space vehicles and launch services sector has experienced steady growth through the 1980s. Despite restrained budgets, U.S. spending on space research and equipment was expected to grow 13 percent in 1990 to $29.1 billion. Non-DoD government agencies would contribute $12 billion of that amount. The U.S. military will continue to have a strong interest in space for surveillance and various defensive systems. The commercial space market, outside the communications satellites business, will develop more slowly and will require substantial government support and encouragement. Nonetheless, it is an area with significant growth possibilities for U.S. aerospace manufacturers. (See *The International Space Market—Increasing Cooperation and A Changing U.S. Role.*)

International cooperation—sourcing arrangements, subcontracting, coproduction arrangements and equity sharing—is well established in the civil aerospace sector. Cooperation enables aircraft and engine manufacturers to share the enormous costs of product development, manufacture and marketing. It enhances access to foreign markets. It also provides opportunity for suppliers to take advantage of the economies of scale and to participate in the market in specialized areas such as component or subassembly manufacture and product support. Cooperation and trade across national borders has brought the benefits of the industry's growth to countries around the world. The United States has benefited by a considerable expansion of trade and a continuing string of positive trade surpluses. The opening of market opportunities in Eastern Europe and the Soviet Union will lead to considerably more cooperation. Western aircraft and engine manufacturers are already establishing relationships with countries in that region as they work to develop their economies.

The Western European Aerospace Industry

Its Market, Structure, and International Relationships

Intra-European trade and business relationships are a key part of the European aerospace industry's growth strategy, and should place European firms in a stronger market position.

European manufacturers are aggressively seeking export markets and are the major competitors of U.S. aerospace firms. They are actively seeking a greater market share in the Asia-Pacific Rim.

Transatlantic partnerships will continue to be important—militarily and commercially—for both the U. S. and Europe.

Aerospace has become a global business connecting manufacturers in one country with suppliers in another, as well as linking buyers and sellers of differing nationalities. At one time, U.S. industry generally dominated this market in terms of sales, product offerings, and technical capabilities. This is no longer the case. Western European firms in particular have been expanding their foreign sales and restructuring their operations in ways that may influence the future direction of the aerospace industry.

To gain insight into the dynamics underlying these changes, it is important to understand the motivations and approaches used by Western European aerospace firms as they position themselves in the world market. Europe is home to some formidable aerospace companies who represent the U.S. industry's foremost competitors. Western Europe is also a useful study because it has been a significant source of demand for U.S. aerospace products—U.S. sales to Europe between 1986 and 1990 amounted to 42 percent of U.S. aerospace exports and 10 percent of the industry's total sales.[1]

This section will look at the Western European aerospace industry by first examining its general characteristics, using the U.S. aerospace sector as a point of reference. The primary factors that have contributed to Europe's transnational movement in aerospace will be discussed. Finally, licensing, trade, direct investment, and joint ventures will be explored in the context of European market objectives.

Western European Aerospace Industry

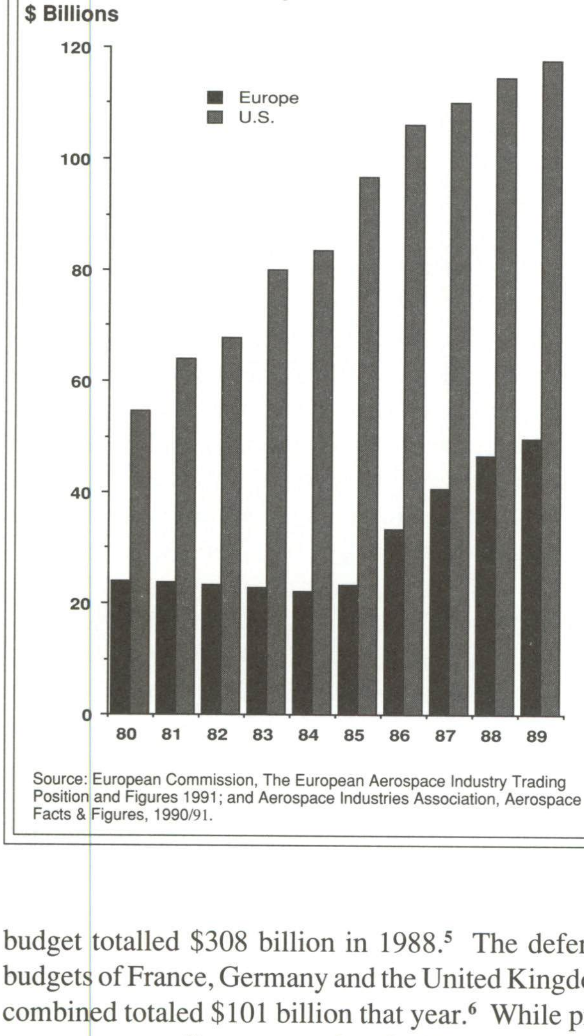
Aerospace Sales

In 1989, European aerospace sales reached $50 billion, compared to U.S. sales of $118 billion (Figure 1). Since 1980, sales of U.S. and European aerospace products have increased at approximately the same rate.[2] The U.S. industry employs approximately two and one-half times as many workers as do European firms.[3]

The composition of European sales is close to the U.S. product mix, although direct comparisons cannot be made due to differing data sources. A breakdown by subsector indicates that aircraft and missiles have accounted for half of all European aerospace sales, followed by equipment, spare engines, and space-related products.[4]

Total defense spending is much higher in the United States than in Europe. The U.S. military

Figure 1
Comparison of U.S. and European Aerospace Sales



Source: European Commission, The European Aerospace Industry Trading Position and Figures 1991; and Aerospace Industries Association, Aerospace Facts & Figures, 1990/91.

budget totalled $308 billion in 1988.[5] The defense budgets of France, Germany and the United Kingdom combined totaled $101 billion that year.[6] While procurement spending cannot be distilled from these numbers, the aggregates demonstrate that U.S. military demand is substantially larger than in Europe. Nevertheless, European firms have always relied more heavily on defense sales as a share of their product mix. Defense sales account, in fact, for approximately 68 percent of European aerospace sales.[7] This underscores the reliance of European contractors—who are generally much smaller than U.S. aerospace companies—on government-sponsored programs as well as the fact that European aerospace exports are weighted heavily in defense products. U.S. aerospace exports have a much larger commercial component.

Nonetheless, the civil market supports a substantial and growing segment of Europe's aerospace industry. The European Commission has stated that "in the medium term, the growth of the European aerospace industry should come mainly from civil aviation" and European companies have been increasing their presence in the civil market—particularly in light of defense reductions.[8] In 1988, their worldwide commercial sales reached $16 billion.[9] As in the defense sector, European commercial sales range far below U.S. industry totals. There are several reasons for this. Scheduled airline traffic operating in Europe is less than in the United States, and U.S. manufacturers serve a large number of European operators.[10] U.S. civil aerospace exports to other parts of the world are also greater than European exports. Nevertheless, Europeans have a strong position in the helicopter and commuter aircraft markets and their share of the large commercial transport industry is growing.

Research and Development Spending

The three European countries who lead in spending on research and development (R&D) are France, Germany, and the United Kingdom, yet even their combined efforts are dwarfed by the aerospace R&D investment of the United States. During 1987, the aerospace R&D activities performed by companies in France, Germany, and the United Kingdom totaled approximately $3.9 billion. That same year U.S. companies performed aerospace R&D totaling $20.5 billion.[11] The large gap is due in part to a smaller European R&D pool but also to the fact that all three European countries allocated a smaller portion of their total R&D funds to aerospace than did the United States.[12] The percentage of industry (versus government) funding to total R&D funding is higher in Europe than in the United States.[13]

Company Size

Due to smaller national and regional markets and the smaller available R&D pool, Western European aerospace companies are not as large as their U.S.

counterparts. In 1988, average sales of the U.S. airframe companies exceeded those of European firms by a ratio of 2:1. Sales of U.S. engine firms were larger than those of their European counterparts by the even larger ratio of 6:1.[14] Notwithstanding these comparisons, European firms are quite capable. They are the only industry in the free world to produce a supersonic commercial transport and were the first to manufacture a vertical take-off fighter. Europeans also manufacture the Airbus line of state-of-the-art commercial transports; very early on they used composite structures to produce Airbus models. Of the top 50 aerospace companies in the free world in 1988, 54 percent were European.[15]

Companies in the United Kingdom, France, and Germany account for most of the European Community's aerospace sales. In 1988, their combined sales figures amounted to almost 90 percent of the Community's total.[16] The aerospace sectors in all three nations have been consolidated along product lines. This structure has resulted through national mergers, which were encouraged and in some cases arranged by governments to improve industrial efficiency. As a result, the three largest aerospace companies in each country control, on average, about 60 percent of their home market. In comparison, the three largest U.S. aerospace companies control approximately 30 percent of the U.S. market.[17] The primary airframe companies in Western Europe are British Aerospace (United Kingdom), Aerospatiale and Dassault (France), and Messerschmitt Boelkow Blohm (MBB) (Germany). The dominant European engine companies are Rolls-Royce (United Kingdom), Snecma (France), and Motoren-und Turbinen Union (MTU) (Germany). Both MBB and MTU are part of a larger German company called Deutsche Aerospace, which in turn is a division of Daimler Benz.

Government's Role in Industry

The degree of state intervention in society has traditionally been greater in Western Europe than in the United States. Europeans have typically maintained large public or quasi-public sectors of production and distribution. An important consequence has been a cooperative relationship between government and industry. In the case of aerospace, the degree of state involvement tends to be on a greater scale than in the United States. This is not only based on Europe's inherent economic and social traditions, but also on national assessments that aerospace is a strategic industry and government support is necessary in light of past and current U.S. advantages.

In the United States, military procurement and defense-related R&D programs provide the defense segment of the industry with essential support and program direction. The U.S. Government, through the National Aeronautics and Space Administration, also funds high risk basic and generic applied research in aeronautics. Private companies invest their own funds in the development of specific commercial products. These efforts generally represent the extent of direct U.S. Government involvement in its aerospace sector.[18] These types of support are also practiced in Europe along with other measures which include: government ownership of some aerospace companies, government assistance through national industrial policies, and subsidized funding for major commercial projects. A brief look at how France, Germany, and the United Kingdom assist their industries is illustrative of European government involvement in the civil side of aerospace.

The French Government plays a central role in its aerospace industry. Through its Ministry of Transport, it has a controlling interest in most key companies and it helps fund the ongoing operations of those enterprises. Government ministers sit on the boards of nationalized companies and participate in decision making. The Ministry of Transport also provides assistance to industry in all stages of the product cycle by issuing grants, government-guaranteed loans, and deferred repayment loans. The National Office for Aerospace Studies and Research (ONERA) conducts and coordinates civil and military aeronautical R&D. ONERA is within the Ministry of Defense and it receives both government and industry funding.

In Germany, the Ministry of Economics sets aerospace national policy through its Aerospace Federal Coordinator. The Ministry also provides partial funding for development, tooling, marketing and product support for commercially-directed aerospace programs. Companies repay these loans if their projects reach profitability. Recently, the government has also provided industry with funding to offset losses resulting from fluctuations in foreign exchange rates. The Ministry for Research and Technology provides funding for civil aeronautical R&D.

The Government of the United Kingdom provides funding for commercial projects through its Department of Trade and Industry (DTI), but it does not implement an industrial policy for the sector. The United Kingdom also has no government organization responsible for undertaking civil aeronautical research. This activity is carried out commercially. The DTI provides partial funding for generic and developmental R&D as well as tooling costs, with repayment based on a sales levy on product deliveries.

Based on these practices, European commercial manufacturers have several advantages in the international marketplace. They can obtain capital at below market rates. In some cases they have a privileged access to national resources. Furthermore, they operate with the knowledge that their governments will provide protection if market conditions deteriorate, thereby reducing company exposure to financial risk. These conditions are not inherently available to U.S. producers of civil aircraft.

In addition to the national support that the European aerospace industry receives, it is also gaining assistance at the regional level from the European Commission. In a Commission report released in 1988, entitled *Toward a Program of Strategic Measures in Aeronautical Research and Technology for Europe*, the Commission outlined the importance of the industry to the region and proposed a Community R&D program—which was subsequently approved—to assist the industry.[19] Furthermore, the Commission has supported corporate mergers and the use of government subsidies to the commercial aerospace industry to help the industry compete internationally. With respect to the European Community's rules on competition, the Commission has given aerospace greater leeway than other industries.

This situation may now be changing. In a study to be completed by 1991, the Commission is looking into the prospects of a deregulated aerospace industry. The results of the study will help the Commission formulate a position on how to liberalize the industry. In particular, the report will focus on issues of financial accountability, cross-border mergers, government subsidies, and over capacity.

An important signal regarding the Commission's position will be its handling of the effort by Deutsche Aerospace to launch a new family of commuter aircraft with France's Aerospatiale and Italy's Alenia. This effort will probably receive government subsidies. The proposed aircraft, the MPC-75, will be in competition with a new British Aerospace version of its BAe 146 aircraft and a possible new Fokker plane. Both the Dutch and the British have already voiced their concern about MPC-75 subsidies. Instead of facing competition from outside Europe, these products will compete regionally.

Factors Behind European Aerospace Internationalization

High Input Costs and Program Risk

Aerospace is a high-technology industry that places great demands on manufacturers to reflect the state-of-the-art in their production processes and product offerings. Much of this demand comes from the military, which place a premium on stretching the boundaries of a system's capability. The need to continually improve on the reliability, safety and economy of civil aircraft also drives technology development. New technology is expensive—and the costs continue to rise. In real terms, new equipment can be 2.5 times as costly as the equipment it replaces.[20] The financial requirements of new aircraft and engine programs can be more than any one nation can afford. The expense of developing the European Tornado fighter aircraft was over $8.5 billion. Since the annual military R&D budgets of European countries are generally less than $4 billion, the only feasible way to carry out the project was through a multination effort.[21]

New technology also increases program risk. Although new products are subjected to rigorous testing, they may still fail to perform as anticipated in sustained use or under different operating environments. Also, aerospace customers (airlines) often favor products with proven track records, so the introduction of new technologies into the commercial market may not meet with the demand expected. The risk of new technology, combined with the fact that hiring skilled labor and setting up a new production facility involves a great deal of expense, makes aerospace a very risky business. These costs and risk factors are magnified when placed in a competitive environment. Working with other companies provides a means of sharing some of these risks. (See section on Joint Ventures)

Competition

The U.S. aerospace industry was not only spared the devastation of World War II, but the war actually helped enlarge the productive and technical capacity of U.S. manufacturers. This enabled U.S. aerospace firms to take the lead over their foreign competitors as the world moved into the jet age. The U.S. advantage has been augmented by domestic economic growth, which continues today to generate a healthy demand for commercial aerospace goods. Furthermore, the United States has maintained the highest level of defense and related research and development (R&D) spending of any nation in the free world. In combination, these factors have provided U.S. producers with the largest national sales base in the world, allowing them to achieve the greatest economies of scale possible at both the prime contractor and supplier levels.

By comparison, Europe's smaller national markets and limited R&D resources imposed serious inefficiencies. Encouraged by governmental support, European aerospace companies began a concerted effort in the 1960s to interact regionally to achieve greater economies of scale and to balance out U.S. advantages. This movement was assisted by several events occurring in the late 1980s.

European Economic Unification

Over the post World War II period, Europeans watched as various segments of their industrial base slowly declined relative to other countries. To address this problem, European leaders decided to rationalize their economies and open up their markets to world competition. In 1985, the economic integration movement—based on the 1958 Treaty of Rome—was given new life through the implementation of the Internal Market Program and the passage of the Single European Act. (See *A Historical Overview of EC 1992.*) It was through these efforts that the 1992 European Economic Unification Movement was born.

Because of political sensitivities, Article 223 of the Treaty of Rome—which was also passed in 1958—excluded military production and trade from European Commission oversight. This suggests that slightly over 60 percent of European aerospace trade will be unaffected by the economic unification movement, which is aimed at the commercial market. Yet it is difficult to imagine that changes which affect the economic foundations of the region would not also affect defense manufacturing, especially since most European aerospace companies produce for both the military and civil markets. Since commercial products will face greater competition after 1992, these companies may have to institute new competitive measures to ensure the success of their products and these measures may also affect their defense operations. Also, many aerospace companies produce dual-use products which serve both the civil and defense markets, and the European Commission has shown an interest in regulating trade in such items. There have been proposals as well to bring defense trade and

A HISTORICAL OVERVIEW OF EC 1992

In 1952, in an effort to rebuild their war-torn industries and foster closer economic ties to prevent the outbreak of another European war, the Netherlands, Belgium, Luxembourg, West Germany, France, and Italy signed a treaty setting up the European Coal and Steel Community (ECSC). Five years later (1957) these same countries signed the Treaty of Rome which created the European Economic Community (EEC). The goal of the EEC was European economic and social integration. The Treaty of Rome exempted specific military production and trade from Community oversight under Article 223. In that same year, the European Atomic Energy Community (EURATOM) was created. In 1967, the executive bodies of the ECSC, EEC, and EURATOM were merged into what is now known as the European Community (EC). In 1968, the EC eliminated duties among its members and installed a common external Community tariff. Subsequently Denmark, the United Kingdom, Ireland, Greece, Spain, and Portugal joined the Community.

Although intra-Community tariffs were suspended in 1968, non-tariff barriers, which hamper the integration process, still exist. In 1985, the European Commission (the EC body responsible for formulating, proposing, and executing Community policy) drafted a program to create a single market with freedom of movement for goods, services, people, and capital by December 31, 1992. The twelve EC nations endorsed the Single European Act in December 1985, establishing new voting procedures which make it easier for the Council (the Community's decision-making body) to pass proposals. The pace of European economic integration accelerated.

EC INITIATIVES

Industrial Standards — New Community-wide industrial standards and certification procedures are being instituted as a part of the 1992 program. Instead of twelve sets of standards, only one will exist. This will permit products that meet essential health, safety, and environmental requirements to be marketed freely within the Community.

Technology Transfer — Currently, each Western European country has its own export control policy. The Commission is reviewing this and will probably attempt to rescind or standardize export controls between member states and between the Community and third-country markets.

Mergers and Acquisitions — The Commission will be a player in deciding some acquisitions and mergers within the Community. In the past, companies submitted proposed mergers to one or more of a dozen national authorities. The Commission was given power in December 1989 to investigate and rule on mergers which meet three criteria: combined world sales of more than $5.8 billion; sales in the EC above approximately $290 million; and no more than 66 percent of the sales of either partner in a member state. The Commission will disapprove mergers if they are seen as having an "anti-competitive impact" in the Community. Decisions on other mergers will be left to national authorities, unless the Commission is invited to participate. Mergers may be exempt from Commission review under certain circumstances, e.g., national security. Defense firms will undoubtedly be treated differently than firms in other sectors, since defense and related technology firms are vital to national security.

Increased R&D Collaboration — The Community launched a cooperative aeronautical R&D program and earmarked $70 million over a two-year period to fund it. Cooperative R&D programs in the fields of information technology (ESPRIT II), industrial technologies (BRITE), manufacturing (EURAM), and communications (RACE) are also being sponsored to improve the efficiency of European R&D.

production under the Community's jurisdiction. Whatever the outcome, economic unification will require that businesses adopt a regional outlook. This realization has already prompted an increase in joint ventures, mergers and acquisitions, and greater intra-European trade among aerospace companies. (See *A Historical Overview of EC 1992* regarding some of the 1992 initiatives that are particularly important.)

Independent European Program Group Initiatives

The Independent European Program Group (IEPG), created in 1976, has become the mechanism for rationalizing Europe's defense sector. The IEPG does not report to NATO, yet it is made up of the national defense ministers of Europe's NATO members (Figure 2). It also operates outside of the Community's jurisdiction. In 1987, the IEPG issued a report entitled *Towards a Stronger Europe*, that reviewed Europe's defense industrial base. The report concluded that the region's defense market was fragmented, inefficient, and suffered from overcapacity. The IEPG is undertaking to address these problems. Through its actions, the IEPG will influence the internationalization process in two ways. By opening up the European defense market to greater competition, it should spur increased European trade as well as possible regional consolidation (if permitted by national governments). It is also encouraging greater use of international consortia to pursue defense R&D programs.

The IEPG is setting up a system by which: information on national armament requirements for weapons/systems procurement and maintenance can be disseminated regionally, companies located in a member state can register with all IEPG countries as potential suppliers, and bid invitation and contract awards procedures can be coordinated in a standardized format. The culmination of these efforts will mean that home market protection will be less tolerated and cross-border competition will be promoted. In this environment, industry will have to accept a regional outlook. Duplicate product lines between companies will eventually be reduced through collaborative offerings, mergers and acquisitions, or the loss of inefficient producers.

To satisfy Europe's need for a more efficient defense-related R&D process, the IEPG is spearheading a technology development program called EUCLID (European Cooperation for the Long-term in Defense). EUCLID will focus on 11 broad R&D areas. Companies interested in pursuing technologies in one or more of these areas will form consortia and submit joint proposals for funding. Governments wishing to fund these projects will do the same. A lead contractor and lead government-sponsor will be appointed to direct their respective sides of the contract. This initiative should eliminate the practice whereby multiple governments fund similar R&D work and various companies duplicate efforts. It should also increase the total amount of money directed at an R&D project. Company participation in a project will be based on its government's financial contribution to the R&D area. Special assurances will be given to encourage less-developed members of the IEPG (Turkey, Portugal, Greece) to participate. The issue of technology transfer is unresolved at this time; some type of compensation will probably be required.

Eastern Europe

The events unfolding in Eastern Europe and the Soviet Union have lifted barriers that existed since World War II, changing the geopolitical landscape. For defense firms, the political fallout will be lower demand from their primary customer—the military. In Germany, for example, defense spending was cut 16 percent in 1991, and is expected to decline about 3 percent annually through 1994. Declining military spending will translate into a smaller procurement pie, which will squeeze the industry further and encourage industrial consolidation and transnational ventures. The shrinking defense market will in turn create a greater need to export outside of Europe and very possibly a surge in licensing with Eastern Bloc manufacturers. Firms marketing dual-use items may target the Eastern European market. Commercial gains from business in Eastern Europe will be gradual: the

Figure 2

Structure - Independent European Program Group (IEPG)

NOTE: Country designations indicate who chairs or participates on each panel or sub-group.

Ministers

National Armaments Directors

Secretariat

Panel I
(Operational Requirements & Programmes)
(NO)
(Sub-Groups Listed Below)

Panel II
(Research & Technology)
(FR)
Sub-Group 6
(CTPs) (NL)

Panel III
(Economic Affairs)
(GE)
(Sub-Groups Listed Below)

Panel I Sub-Groups

Future Large Aircraft
BE FR GE IT SP (PO)

Heavy Support Weapons/ AGL
BE FR GE IT NL SP (PO)

155 MM Artillery Systems
BE FR NO IT DE

Vehicle Robotics
GE SP UK FR

Sonobuoys & Active Dipping Sonar/MAD Buoys
UK FR GE IT

Armoured Bridgelayer Interoperability
BE FR GE IT NL

Anti-Tank Guided Weapons 3' Generation
FR GE UK BE NL TU

Anti-Tank Mine (Direct Effect)
FR GE UK

Microwave Landing System
UK BE FR IT SP GE NO (NL) (DE)

Mistral
FR BE IT SP DE

Light Support Weapons
NL BE FR GE SP (UK)

ASRAAM
NO UK FR TU

Stinger
GE GR NL TU

Maverick D
IT DE GE NL SP TU

M483/M864 155MM Artillery Ammunition
NL TU UK

Panel II

(See discussion on EUCLID, page 40)

Panel III Sub-Groups

Working Group I
(Competition)
(UK)

Working Group II
(Juste Retour)
(NO)

Working Group III
(Technology Transfer)
(IT)

Sub-Group 7
DDI
(TU)

Belgium - BE Demark - DE France - FR Germany - GE Greece - GR Italy - IT Luxembourg - LU Netherlands - NL Norway - NO Portugal - PO Spain - SP Turkey - TU United Kingdom - UK region's consumers will be short of cash, the area is economically unstable, and technology transfer issues will continue to be obstacles to trade.

International Relationships

Because the U.S. aerospace market is the largest national market in the world, most U.S. manufacturers have concentrated on expanding their domestic sales. Opportunities overseas have been given a lower priority. That is not to infer that U.S. aerospace firms have been absent from the international market: on the contrary, they have a long history of international business activity. Exports and licensing have been used extensively by U.S. companies to gain access to foreign markets. Under most licensing arrangements, U.S. companies have been the lead contractors, directing project activities and providing technology to licensed producers.[22] However, collaborative risk-sharing efforts and foreign direct investment have not been used as widely as market strategies by U.S. firms, as they have been by companies in Europe.

In Europe, throughout the post World War II period, cross-border trade and international business relationships have been a dominant part of the growth strategies of aerospace manufacturers. European companies have participated in many licensing projects, but unlike their U.S. counterparts, they have extensive experience on both sides of such partnerships—both as licensors and licensees. European companies have also been very aggressive in exploring codevelopment/coproduction arrangements and have been active in merger and acquisition activity. A look at European aerospace licensing, trade, joint venture and foreign direct investment activity follows.

Licensing

Licensing has been used by European aerospace firms for decades, both to transfer and to receive technology. European countries have applied licensing to intra-European ventures as well as to overseas agreements and their projects have covered various aircraft and engine types. Currently, European companies are working on 20 different engine programs that involve licensed production. European companies are the prime contractors on 10 and are licensees on the remainder.[23] Clearly, licensed production is a common practice on both sides of the Atlantic.

U.S. companies have been important sources of technology for European aerospace firms. Immediately following World War II, the United Kingdom was the only European country capable of producing aircraft and its facilities were near exhaustion. To help revive European industry to further U.S. security interests, the United States launched the Mutual Defense Assistance Program in 1949, which involved U.S. purchases of European industrial goods. Beginning in the 1950s, it also became policy to promote U.S. foreign sales. To satisfy both policy objectives, U.S. aerospace sales were promoted using licensing arrangements with liberal technology transfer conditions. These efforts helped revive Europe's military industrial base.

There have been many U.S./European licensing agreements. One initiated in 1959 is noteworthy because it illustrates the various tiers that still exist among European manufacturers. The agreement called for U.S. and European coproduction of the Lockheed F-104 fighter. Four European production lines were created to facilitate West German, Dutch, Belgian, and Italian participation and 900 aircraft were assembled. The Belgians and Dutch joined the program to enhance their security, gain technology, improve their productive capacity and provide jobs, while minimizing their development costs. This pattern has since been repeated in Europe by many of the economically smaller nations. In 1975, driven by these same motives, Belgium, the Netherlands, Norway, and Denmark signed an agreement with the United States to coproduce the General Dynamics F-16 fighter. A total of 998 aircraft were produced from assembly lines in Belgium, the Netherlands, and the United

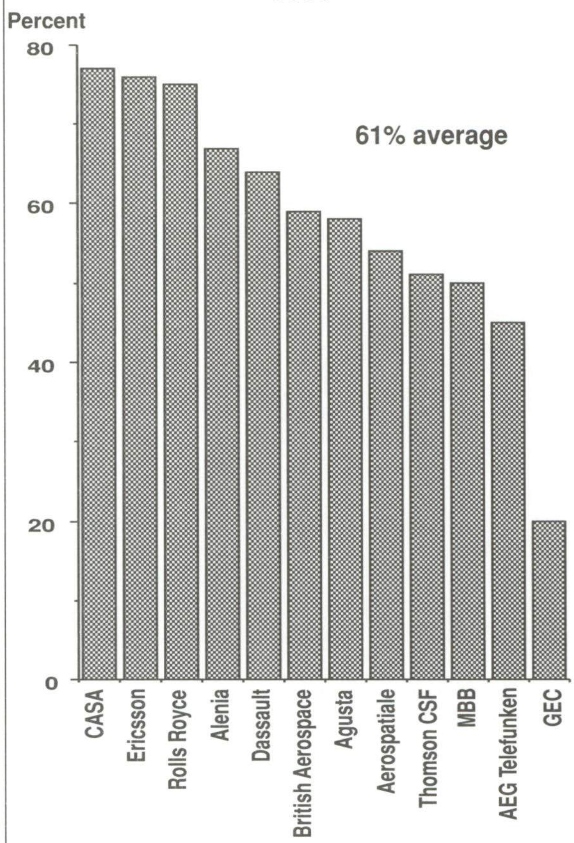
States; no development work was involved. A more recent example of this pattern occurred in 1983 and 1984 when both Turkey and Greece signed coproduction agreements to produce F-16s.

West Germany and Italy saw the F-104 program as an opportunity to gain technology and managerial expertise in a state-of-the-art aerospace program. As licensees, both countries used the program to achieve greater independence and bargaining power for their industries. Each achieved the capability to join the United Kingdom to codevelop and coproduce a European advanced fighter called the Tornado in 1969.

European companies have also licensed aerospace product technology to foreign companies to gain sales. Currently, there are several agreements underway with U.S. companies, including joint U.S. and British development and production of two British Aerospace aircraft—the Harrier (AV-8B) and the Hawk trainer (T-45). Rolls-Royce has licensed its F-41 turbofan to General Motors' Allison division. Europeans also have licensing agreements with non-U.S. manufacturers. MBB has licensing agreements with CASA of Spain and the Philippine Aircraft Company to produce a civil/military light helicopter called the BO 105. Dassault of France has sold its Mirage 2000 fighter to Greece and Egypt based on their agreement for licensed coproduction of Mirage components.

Figure 3

European Aerospace Exports By Company As A Percent of Sales 1988

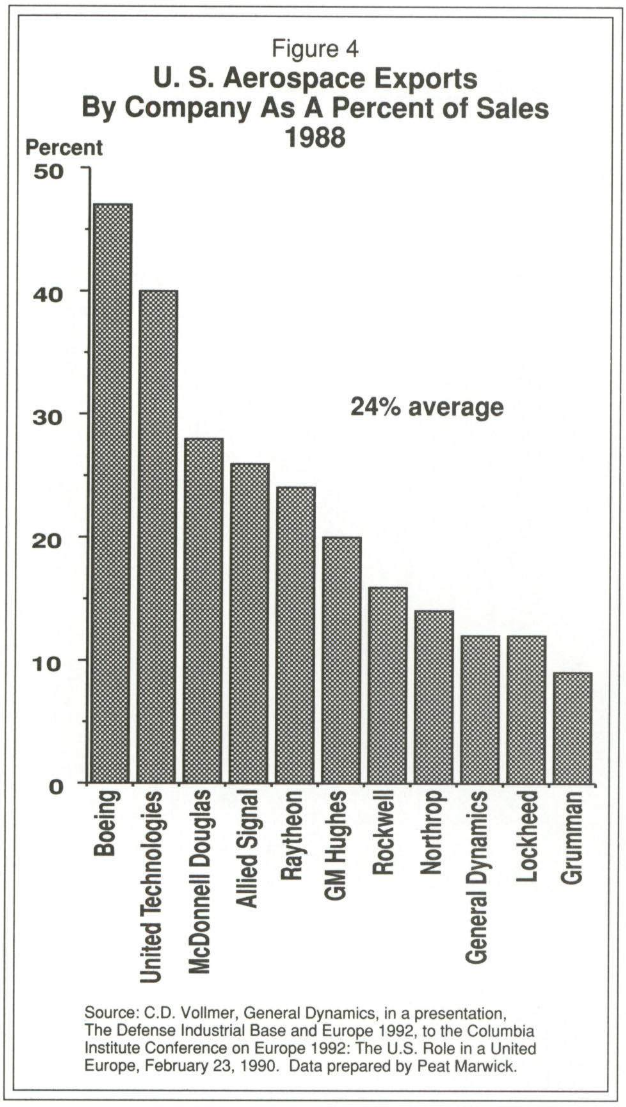


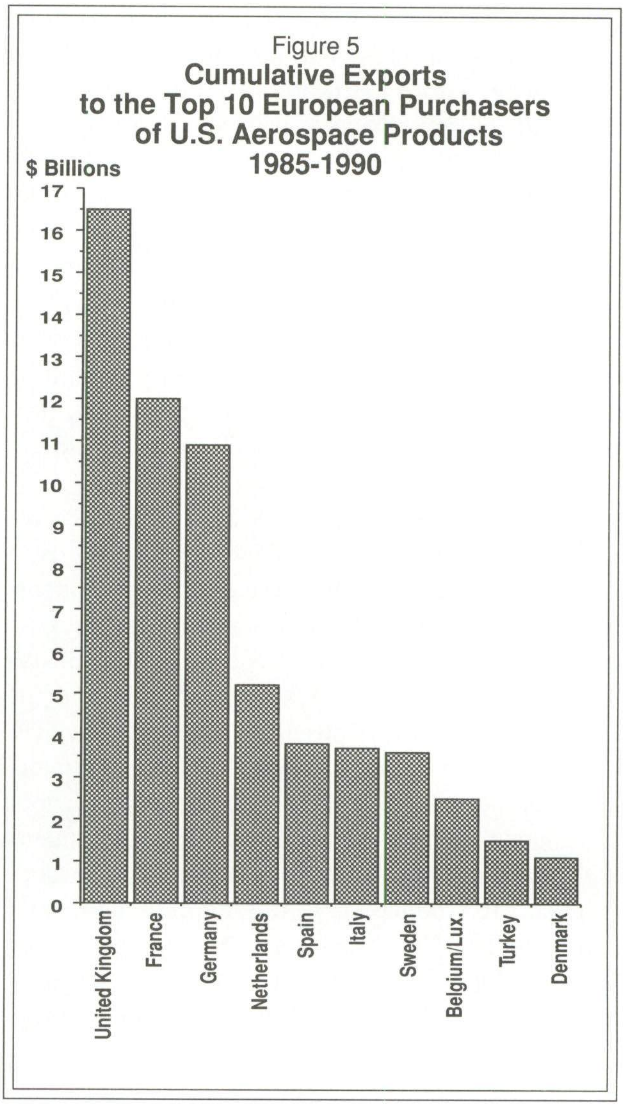
Source: C.D. Vollmer, General Dynamics, in a presentation, The Defense Industrial Base and Europe 1992, to the Columbia Institute Conference on Europe 1992: The U.S. Role in a United Europe, February 23, 1990. Data prepared by Peat Marwick.

Aerospace Trade

No data is available on the total value of European aerospace trade. Nevertheless, company surveys and U.S. trade data show that European aerospace firms are more export-driven than U.S. producers. A recent survey indicated that 61 percent of aerospace sales from European companies were derived from exports, while U.S. firms exported only 24 percent.[24] (See Figures 3 and 4.) Data for the United Kingdom, France, and Germany—the three largest European aerospace manufacturing nations—indicate that in 1989 exports accounted for 54 percent of their combined aerospace sales. This amounted to total aerospace exports valued at $26 billion.[25] U.S. exports amounted to $32 billion that year or 27 percent of sales.

European exports to the United States rose from $5.1 billion (1986) to $7.6 billion (1990). U.S. aerospace exports to Europe have grown at a faster pace, climbing from $6.8 billion to $18.1 billion (1990).[26] Figure 5 presents a cumulative picture of U.S. exports to the top ten European countries from 1985 to 1990. The composition of U.S./European aerospace trade during 1989 is shown below.[27]





U.S. Exports to Europe		European Exports to U.S.
43%	Complete Aircraft	31%
27%	Engines	45%
19%	Aircraft Parts	16%
7%	NEC	7%
4%	Missiles	1%

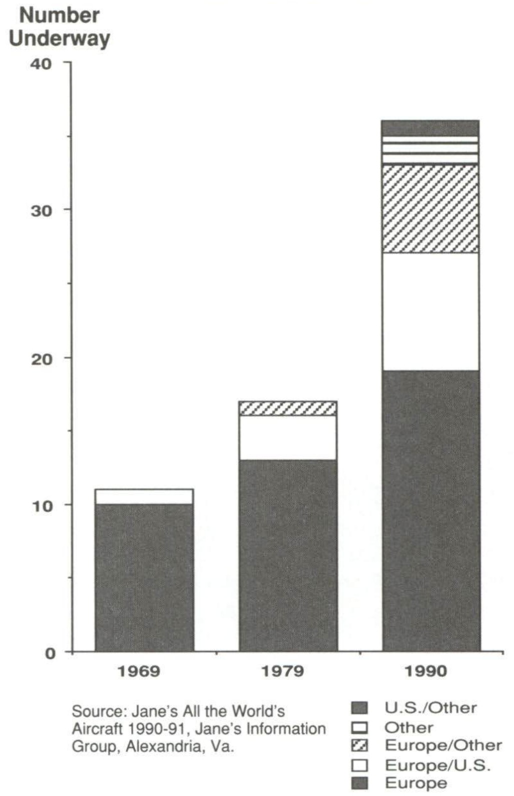
Because of the importance Europeans attach to exports, their governments impose fewer restrictions than do U.S. officials on the export of many high-technology items. This policy difference was highlighted during the European Fighter Aircraft (EFA) radar selection, when one of the radar packages evaluated was based on a U.S. licensed model. Some EFA consortium members were afraid that future exports of the aircraft might be subject to U.S. controls and the U.S. model was not selected.[28] Liberal export policies in combination with active export promotion have helped European companies become established in many parts of the world. Total European defense sales to Africa, Latin America, South Asia, and the Middle East led U.S. exports to those regions from 1984-1988.[29]

Joint Ventures and Other Partnerships

Tracking cooperative relationships in aerospace is difficult and counts of active agreements vary from one source to another. For consistency, the following data is derived from *Jane's All the World's Aircraft*, which reports airframe and jet engine ventures at the primary partnership level. The list is not necessarily comprehensive, since it does not include agreements in avionics, materials, launch vehicles, and other areas which are important segments of the industry. Nonetheless, *Jane's* does provide an historical reference point for analysis. (Also see Appendix B for examples of a variety of international collaborations.)

European aerospace collaborative efforts span over thirty years. In 1969 there were 11 joint ventures underway worldwide. Of these, 10 were intra-European affairs while the eleventh was a U.S./European effort. In 1979, the number of cooperative ventures had risen to 17 and European manufacturers were involved in all of them, while U.S. companies were active in three. By the beginning of 1990, there were 36 such ventures in progress. European companies were involved in 33, while U.S. firms were involved in nine.[30] (See Figure 6 and Table 1.)

Figure 6
Aerospace Cooperative Ventures Airframe and Engine Manufacturers



Source: Jane's All the World's Aircraft 1990-91, Jane's Information Group, Alexandria, Va.

There are many reasons why Europeans participate in joint ventures, but it is primarily because the costs related to undertaking a project on a unilateral basis can be prohibitively high. Joint ventures allow nations to share total R&D costs among all project members. The United Kingdom's projected R&D cost on the joint European Fighter Aircraft project will run $3.3 billion, while the French R&D cost for their Rafale fighter will be $6.6 billion.[31] Collaborations also extend production runs by committing buyers from several countries to purchase the joint product. This reduces unit costs, making the project more affordable to each member and the final product more competitive in the marketplace. Under the Tornado project, the Italian Government ordered 100 aircraft, but commitments from the other participants increased the production run to at least 885 aircraft. Joint ventures are a source of technology for some members. Spain joined the Airbus project and Italy the Tornado effort to receive technology from more advanced partners. Collaboration lessens the tendency of governments to cancel a project before completion. Many agreements have penalty clauses to discourage premature pullout from a project, and political pressure from other team members also acts to dissuade partners from seeking early release from a cooperative arrangement. This eases corporate fears that once a company has committed resources to a project their government might withdraw support. Joint ventures also allow participants who would otherwise not take on a project to receive an affordable portion of work—thereby advancing the development of their industry.

Table 1
International Aerospace Partnerships

AIRCRAFT

Program	Partners
P120 L Helicopter	Aerospatiale, France SA, Singapore CATIC, China
Airbus A-300, 310, 320, 321, 330/340 Civil Transport	Aerospatiale, France BAe, UK MBB, Germany CASA, Spain
CN-235 Civil Transport	CASA, Spain IPTN, Indonesia
AMX Military Fighter	Aermacchi, Italy Alenia, Italy Embraer, Brazil
ATR-42 & 72 Civil Transport	Aerospatiale, France Alenia, Italy
Alpha Jet Military Fighter	Dassault, France MBB, Germany
Egrett-D-500 Research Aircraft	E-Systems, US Garrett, US Grob, Germany
EH-101 Military Helicopter	Agusta, Italy Westland, UK
CBA-123 Civil Transport	Embraer, Brazil FAMA, Argentina
Eurocopter PAH-2 HAC Military Helicopter	Aerospatiale, France MBB, Germany
Eurofar Civil Helicopter	Aerospatiale, France MBB, Germany Agusta, Italy Alenia, Italy CASA, Spain Westland, UK
Eurofighter Military Fighter	BAe, UK MBB, Germany Alenia, Italy CASA, Spain
Concorde (Discussion)	BAe, UK Aerospatiale, France
FIMA Military Transport	Aerospatiale, France BAe, UK MBB, Germany Alenia, Italy
JEH A1229, Military Helicopter	Agusta, Italy CASA, Spain Fokker, Netherlands Westland, UK
BK-117 Civil Helicopter	MBB, Germany Kawasaki, Japan
Harrier II & Harrier II Plus Military Fighter	MDD, US BAe, UK
T-45A Military Trainer	MDD, US BAe, UK
MPC-75 Civil Transport (Discussion)	MBB, Germany CATIC, China Aerospatiale, France Alenia, Italy
NAMC/PAC K-8 Military Fighter	NAMC, China PAC, Pakistan
NH-90 Military Helicopter	Aerospatiale, France MBB, Germany Agusta, Italy Fokker, Netherlands
N-442 Civil Helicopter	MBB, Germany IPTN, Pakistan

AIRCRAFT

Tornado Military Fighter	BAe, UK MBB, Germany Alenia, Italy
X-31A EFM Military Fighter	Rockwell, US MBB, Germany
Jaguar Military Fighter	BAe, UK Dassault, France
IAR-93 Military Fighter	SOKO, Yugoslavia CNAIR, Romania
Sukhoi/Gulfstream Business Jet	Sukhoi, USSR Gulfstream, US
TBM 700 Business Jet	Socrata, France Mooney, US

ENGINES

Tay/Trent Civil Engine	RR, UK BMW, Germany
CFM56 Civil Engine	GE, US SNECMA, France
EJ200 Military Engine	Fiat, Italy MTU, Germany RR, UK Sener, Spain
V2500 Civil Engine	MTU, Germany RR, UK PW, US IHI, Japan
DV-2 Civil Engine	Lotarev, USSR ZVL, Czechoslovakia
MTR 390 Military Engine	RR, UK MTU, Germany Turbomeca, France
Civil Engine	RR, UK Lyulka, USSR Sokho, USSR
Adour Military Engine	RR, UK Turbomeca, France
Turbo-Union RB199 Military Engine	RR, UK MTU, Germany Fiat, Italy

Source: Jane's All The World's Aircraft 1990/91

Experience has shown that there are also disadvantages to cooperative arrangements. To allow all members to participate in the design and development phase, workshares may be allocated in such a way that overall R&D efficiency is impaired; there may be too many final assembly lines required; workshare arrangements can result in sole-source suppliers who get contracts without adequate competition; the operational requirements of all members must be reconciled, which adds time and can result in products which have too much capability; and more than the usual amount of administrative effort is usually needed to oversee the project. Additionally, changing economic and political goals of participating countries can cause great stress within a joint venture. Consequently, European joint ventures—or attempts to create them—have not always been successful. The marriage between Vereinigte Flugtechnische Werke VFW (West Germany) and Fokker (Dutch) in 1969 was dissolved in the late 1970s due to unrealized corporate objectives on both sides.[32] More recently, a French-British effort to combine their guided missile operations into a manufacturing concern called Eurodynamics fell apart in early 1991.[33] Still, the drawbacks of cooperative ventures have not been enough to dissuade countries from pursuing the potential benefits.

Major cooperative programs involving European firms have varied in focus and type. Some have been product-specific, such as the U.K.-French Jaguar Fighter effort; some have been open-ended. One open-ended agreement, also a purely national arrangement, was the recent formation of Sextant Avionique in France by Thomson-CSF and Aerospatiale to produce flight control systems and instrumentation. Some have involved U.S. companies, such as the AV-8B Fighter program. Others included non-European members, such as the AMX Fighter program involving Italy and Brazil and the Daimler-Benz (Germany) and Mitsubishi (Japan) agreement to conduct aerospace research. A closer examination of three important European collaborations—Airbus, Tornado, and the Eurofighter—is provided at the end of this section.

Because Europeans have participated in joint ventures for years, they have gained experience in knowing what to expect from them and how to operate within such arrangements. They have implemented efficiency-related measures to combat some of the problems cited. In addition, Europeans have established a network in many different product areas between companies and between countries so that people are familiar with each other.

Virtually all European collaborative efforts have been based on some form of *juste retour*. For military programs, R&D and production work are allocated among the participating companies based on the number of units that their respective governments plan to purchase. Each partner is then responsible for subcontracting the work required to complete its area of responsibility. Final assembly lines are set up at each partner company and the company orders parts from its own suppliers as well as from other participating members. A separate organization is generally set up to supervise and coordinate the operation. For commercial programs, workshares are based on the investment in upfront development and tooling costs by each participating company/government. Technology is common and available to all partners. They can even give technology to outside companies that may be competitors of other consortium members. The technology is available because governments paid for the R&D.

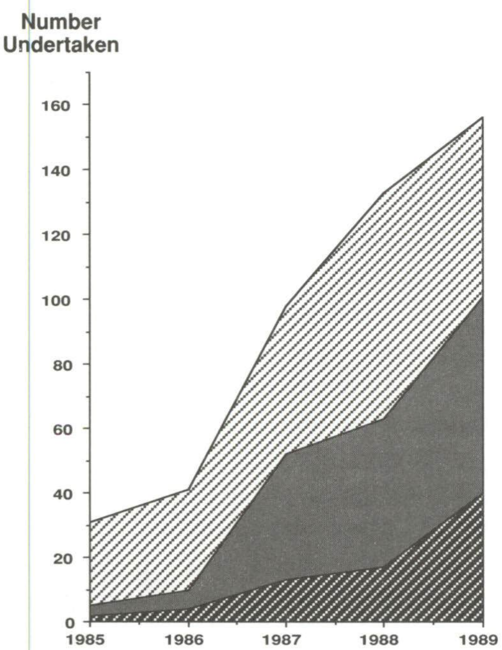
Some European aerospace companies are calling for the establishment of permanent corporate links among companies in all key segments of the industry. For example, the merger between the helicopter units of MBB and Aerospatiale into a joint holding company called Eurocopter—which is expected to be completed by 1991—is viewed by some as just one step toward a greater corporate entity. Both the French and the Germans want to start negotiations to bring the other two European helicopter manufacturers—Westland and Agusta—into the alliance. Similar suggestions have been made to unite European commuter aircraft and military aircraft manufacturers.

Mergers and Acquisitions and Foreign Direct Investment

All industry segments in Europe are consolidating their positions to better participate in what will be a larger regional market. Evidence of this trend is suggested by the increase in merger and acquisition (M&A) activity throughout Europe. During 1988 alone there were 383 mergers in the European Community, a 26 percent increase over the previous year.[34]

Aerospace and defense companies have been swept up in this movement and are undergoing a period of structural change involving national consolidations. For the major players—British Aerospace, Aerospatiale, and Deutsche Aerospace—this process has been underway, orchestrated by their governments, since the early 1970s. For the industry as a whole, the process picked up during the 1980s. Between 1985 and 1989, aerospace/defense M&A activity increased at an annual rate of 38 percent (Figure 7). Through April 1990, European aerospace and related firms were involved in 525 M&A agreements.[35]

Figure 7
Number of Mergers and Acquisitions Aerospace and Defense Firms

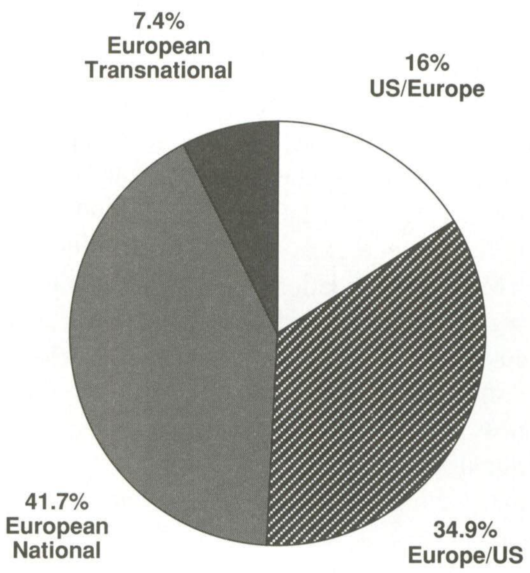


Source: Ardak Corporation, McLean, Va. monthly reports on M & A activity in aerospace and defense.

The most obvious trend has been the rationalization of domestic European aerospace/defense production—approximately 42 percent of all agreements represented national consolidations (see Figure 8).[36] Industry in Germany, Italy and the United Kingdom has recently undergone much corporate consolidation. Many consolidations have been encouraged by home governments to further national technology and employment gains. Also, companies in the same domestic market know each other and follow similar business practices, making mergers smoother. From a national standpoint, such M&As are less controversial than having a foreign company penetrate a strategic industry sector. In most cases, these transactions were undertaken to provide national "champion" firms with increased access to capital, less product competition and greater R&D funding to help them to better compete both in Europe and internationally. Companies of greater size and capability also have greater negotiating leverage in future collaborations. In Germany, Daimler-Benz purchased a controlling interest in Dornier, MTU, AEG, and MBB. These additions gave its Deutsche Aerospace group a commanding position in the German market and placed it on equal footing with the other two European powerhouse companies—British Aerospace and Aerospatiale. The Deutsche Aerospace product line now covers civil and military airframes, engines, electronics, and space products.

Another pattern has been European direct investment in U.S. aerospace and related companies which accounted for 35 percent of European M&A activity during the period (Figure 8).[37] Direct investment in the United States is being used to access the largest defense market in the free world and an enormous commercial market. These investments have been facilitated by a weak dollar and the fact that U.S. tax and foreign investment laws are generally less oner-

Figure 8
European Mergers & Acquisitions 1985 - April 1990



Source: Ardak Corporation, McLean, Va. monthly reports on M & A activity in aerospace and defense.

ous than those of other governments.[38] To date, the European aerospace firms most actively investing in the United States have been avionics and equipment manufacturers. They see the United States as a lucrative market which represents approximately 70 percent of the world's aerospace equipment demand.

Inter-European consolidations have been less frequent than M&As involving companies within a single country. Cross-border M&As account for only 7 percent of all European aerospace/defense M&A activity.[39] Greater activity in this area may result once national consolidations are complete. A major inter-European consolidation took place when General Electric of the United Kingdom and Siemens of Germany combined forces to take over Plessey of the United Kingdom. The effort resulted in a major European electronics company. Given the political sensitivity and long-term effects of transnational M&As, European firms have tended towards joint ventures rather than mergers or acquisitions when establishing relationships with other regional firms.

Finally, 16 percent of the defense/aerospace M&A transactions that involved European firms represented the purchase of various European companies by U.S. firms. In most cases, the companies involved did relatively little defense work.[40]

In general, European M&As have not resulted in an excessive accumulation of corporate debt through borrowing, which could weaken Europe's industrial base. Instead, many involve equity participation agreements, whereby two or more firms set up a joint holding company and each contributes capital and other resources to the venture. These holding companies merge the complementary and/or similar operations of the participants into larger, more efficient enterprises.[41]

Many of the European aerospace/defense M&As appear to be good, well thought out matches. They should result in a stronger European aerospace sector with less product duplication, greater capital reserves, more concentrated R&D—in short, companies that are more competitive and that have greater access to the U.S. market. While an immediate benefit of these M&As is reciprocal market access, the long-term competitive benefits will come only through a rationalization process between the companies involved. This is the difficult phase of the process because it will cause economic dislocation and will affect the work forces in several countries.

In July 1990, the European Commission indicated that mergers and joint ventures involving aerospace contractors should be encouraged in order to help European companies withstand competition from non-European sources. The Commission stressed that it is up to industry to decide on new alliances, but that it would assist through its own rulings on company law, taxation, and competition policy. The Commission has never attempted to prevent a joint venture in aerospace. The European Airbus consortium has been in existence since 1969 and its operations have not been called into question by the Commission under Community merger and acquisition law.

Footnotes

1 Aerospace Industries Association (AIA), *Year-End Review and Forecast 1990*, Tables 2 and 8. Also data from the U.S. Department of Commerce/International Trade Administration/Office of Aerospace.

2 European Commission, *The European Aerospace Industry Trading Position and Figures* (Brussels, Belgium: March 1, 1991), p. 186, and AIA, *Year-End Review and Forecast 1990,* Table 2.

3 *European Aerospace Industry Trading Position and Figures,* February 1, 1990, p. 229, and Aerospace Industries Association, *Aerospace Facts & Figures 1990/91,* p.140.

4 *European Aerospace Industry Trading Position and Figures*, February 1, 1990, p. 183.

5 U.S. Arms Control and Disarmament Agency (ACDA), *World Military Expenditures and Arms Transfers 1989*, (Washington, D.C.: U.S. Government Printing Office), p. 69.

6 ACDA, *World Military Expenditures and Arms Transfers 1989,* pp. 46, 47, 69.

7 *European Aerospace Industry Trading Position and Figures,* February 1, 1990, p. 183.

8 European Association of Aerospace Manufacturers, *Panorama of EC Industry 1990,* pp. 13-38.

9 *European Aerospace Industry Trading Position and Figures,* February 1, 1990, pp. 183, 178.

10 International Civil Aviation Organization, *Civil Aviation Statistics of the World 1988, 1983*, p. 34.

11 National Science Foundation (NSF), *International Science and Technology Data Update: 1988,* Special Report NSF-89-307 (Washington, D.C.: December 1988), pp. 20, 4. NSF numbers updated from published version as of November 1990. These figures are based on NSF numbers using 1982 constant dollars, and NSF supplemental data. Using another measure, European Government financed aerospace R&D totaled $6.4 billion in 1989, while U.S. Government aerospace funded R&D amounted to $15.6 billion (according to *European Aerospace Industry Trading Position and Figures 1991,* p. 243, and Battelle, *Probable Levels of R&D Expenditures in 1989*, December 1988, p. 12.)

12 Ibid., p. 4. In 1988 France, Germany and the United Kingdom collectively spent $49 billion in R&D, while U.S. spending reached $112 billion. NSF numbers updated from published version as of November 1990.

13 Ibid., p. 18.

14 *European Aerospace Industry Trading Position and Figures,* February 1, 1990, p. 228.

15 Ibid., p. 228.

16 Ibid., p. 178.

17 Booz-Allen & Hamilton Inc., *Europe 1992: Threat or Opportunity* (New York), p. 24. Recent national consolidations have probably changed the European ratio.

18 On two occasions since the mid-1960s the U.S. Government provided loan guarantees to assist Douglas Aircraft (1967) and Lockheed (1971).

19 A report released in April 1988, *EUROMART,* evaluated the status of Europe's aerospace sector. Based on its findings, the European Community launched a two-year pilot program to fund commercial aerospace R&D efforts. The EC provided half of the funding and participating countries provided the remainder. Total funding for the period was $90 million. As of September 1990, 28 contracts had been awarded. Other regional R&D efforts in information technology (ESPRIT), industrial technologies (BRITE), advanced materials (EURAM), and communications (RACE) were also launched. A similar R&D effort in defense technology (EUCLID) is underway.

20 Keith Hartley, *NATO Arms Cooperation,* (Boston, Mass.: George Allen & Unwin, 1982), p.30.

21 Captain Casey Wardynski, *European Multinational Development of Combat Aircraft and the*

Prospects for a Competitive European Arms Market. Report for the Office of the Army Chief of Staff at John F. Kennedy School of Government, April 12, 1990, p. 21.

[22] Between 1947-1981, U.S. and European manufacturers concluded 88 licensing agreements involving aerospace products. Of that total, 85 involved the transfer of U.S. technology to a European subcontractor. The Rand Corporation, *Multinational Coproduction of Military Aerospace Programs* R-2861-AF (Santa Monica, Ca.: October 1981).

[23] Department of Commerce/Office of Aerospace.

[24] Data provided by C.D. Vollmer in a presentation, *The Defense Industrial Base and Europe 1992,* to the Columbia Institute Conference on "Europe 1992: The U.S. Role in a United Europe," February 23, 1990. Data prepared by Peat Marwick.

[25] BDLI, *German Aerospace Industries Association Annual Report 1989/90,* p. 17.

[26] Department of Commerce/Office of Aerospace.

[27] Ibid.

[28] U.S. export restrictions were not the only issue in the radar selection, but it was an important one. The competition and subsequent disagreements pitted the British firm Ferranti against the German firm AEG. The German Government contended that British companies were already getting more than their share of work on the project and that Ferranti's financial standing was in question. Adding to the controversy was the fact that the AEG team based its radar on a U.S. model manufactured by Hughes and this raised questions regarding future export restrictions. The Ferranti group eventually was awarded the radar contract. The delay in selection put the radar project almost two years behind schedule.

[29] ACDA, *World Military Expenditures and Arms Transfers 1989.*

[30] *Jane's All the World's Aircraft 1990-91,* Jane's Information Group, Alexandria, Virginia, section on International Programs.

[31] Carole Shifrin, "Lower East-West Tensions May Boast Joint European Defense Projects," *Aviation Week and Space Technology*, March 19, 1990, p. 86

[32] Fokker wanted access to German defense spending but this was being channeled instead into MBB. VFW wanted a greatershare of the civil commuter market, but its launch of the VFW-614 was unsuccessful due in part—VFW believed—to Fokker's protection of its own commuter market.

[33] Each partner was to have owned 50 percent of the company. The joint venture company would have offered a complete range of guided weapons, something that neither of the two companies involved—France's Thomson CSF and British Aerospace—can do separately.

[34] *Wall Street Journal*, August 1, 1989, p. A7.

[35] Ardak Corporation, McLean, Virginia. Monthly reports regarding M&A activity in the aerospace and defense area.

[36] Ibid.

[37] Ibid.

[38] The Trade Act of 1988 includes the Exon-Florio Amendment which gives the President powers to block foreign acquisitions that are a threat to national security. In the first 15 months after implementation, 243 acquisitions were examined, and only one—the China National AeroTechnology Import and Export purchase of Mamco, an aircraft parts manufacturer, disapproved.

[39] Ardak Corporation monthly reports.

[40] Ibid.

[41] Conversations with John Harbison of Booz-Allen & Hamilton Inc., 101 Park Avenue, New York.

EUROPEAN JOINT VENTURES

AIRBUS

Key points:

- Market share appears to be a driving force in this commercial effort
- Profits are a long-term goal
- Long-term international manufacturing relationships can be maintained
- Technology transfer has not been a major issue among participants
- Government concessional financing has been critical to program survival
- European citizens are not swayed by the subsidy issue
- Government/industry cooperation is important
- European Governments will do what is necessary to keep a high-tech, jobs-based effort like Airbus viable
- U.S. manufacturers have lost domestic and foreign sales to Airbus Industrie

Airbus Industrie is a European consortium established in 1969 to manufacture commercial transports. It was established in France as a nonlimited liability holding company owned and operated by four shareholders: France's Aerospatiale and Germany's Messerschmitt-Bolkow-Blohm (MBB), which each own 37.9 percent; Britain's British Aerospace which owns 20 percent; and Spain's Construcciones Aeronautics S.A. (CASA) which owns 4.2 percent. Policy decisions are made by Airbus Industrie's supervisory board which is composed of representatives from each member-company. Airbus Industrie delivered its first aircraft in 1974 and is now well on its way to providing a full range of commercial transports.

Production work is allocated among the four partners based on their ownership shares. Each partner acts as the sole-source supplier for the aircraft section under its area of responsibility. British Aerospace manufactures the wing section; Aerospatiale is responsible for the cockpit, wingbox, engine pylons, and final assembly (except for the upcoming A321 which will be assembled by MBB); MBB is in charge of producing the large fuselage sections and vertical tail; and CASA provides the horizontal tail. Once partners have received their workshare, they pursue subcontracting arrangements on their own.

Airbus Industrie coordinates overall design, development, and production activities. In addition, its internal staff concentrates on sales and support activities. This arrangement creates several problems. It isolates sales and support staff from production activities being performed by the member companies, limiting coordination between the two groups. Also, due to its status as a nonlimited holding company, Airbus Industrie is not required to provide financial accounting. Accounts concerning Airbus work are instead maintained confidentially by each of its four members and they refer only to that company's respective work. Airbus partners negotiate prices with their own subcontractors and their costs are not communicated to other members or to the consortium's management staff. As a result, each member can charge higher than normal prices for its section of Airbus work. This has inflated total costs. This arrangement also makes evaluating the financial standing of the business highly speculative. Without an overall balance sheet, commercial decisions are difficult to make.

Government/Industry Relationship—Airbus makes its own decisions as to the type of aircraft to produce, when to launch, and so forth. Nevertheless, the Airbus Board does factor into its decisions its ability to secure attractive financing from its member's governments. At least this has been the practice in the past. Thus, governments do influence Airbus commercial decisions. In fact, governments effectively have the power to veto launch decisions if they withhold their support, although this has not yet happened. In essence, the government facilitates but does not initiate Airbus launch decisions.

Based on the estimated costs of launching transport aircraft and on the prices at which Airbus aircraft have been sold on the market, it is widely acknowledged that the consortium has yet to make a profit. Airbus has survived due to the production and development support provided by its member's governments. In its earlier programs, e.g., A300/A310, members received outright grants. Now assistance takes the form of government conditional-repayment loans at below market rates with deferred interest and principle payback schedules, or government guaranteed loans made by private lending institutions. The U.S. Department of Commerce claims that these government assistance packages have totalled $16 billion. For the recent A330/A340 launch program, British Aerospace received $830 million in launch support from the British Government and Aerospatiale will receive $816 million in French Government loans. In November 1989, the West German Government approved $2.4 billion in subsidies to prompt Daimler-Benz to take a 30 percent share of MBB. Daimler will acquire all of the Government's shares in MBB by the year 2000. In return, it will receive $1.6 billion in government subsidies to be used for exchange rate protection of its Airbus activity and approximately $800 million to write off MBB's Airbus debt.

The European Commission, eager to promote greater economic competition within the European market, has advocated the elimination of various forms of governmental industrial protection such as subsidies. To date, however, the Commission has made no ruling regarding the Airbus subsidy issue. The Commission is also in charge of safe-guarding the European market from anti-competitive behavior brought about through mergers or acquisitions. Although the German Cartel Office opposed the Daimler-Benz takeover of MBB, claiming that it would result in a less competitive national market, the Commission ruled in favor of the acquisition in 1989. The Commission said that the takeover complied with Community antitrust regulations and claimed that maintaining European competitiveness was a motivating factor in its decision. European Commission rulings on competition and antitrust policy will take a two-tiered approach: businesses producing primarily for European consumption will be dealt with in a European competitive context; those actions that impact industry from an international perspective will be judged from a global standpoint.

Profitability vs. Market Share—When Airbus Industrie was first established, its member companies were nationalized firms and profitability was not a driving concern. Today there are growing pressures on Airbus to be profitable—pressure from British Aerospace (which today is a private company), from Daimler-Benz (parent of MBB,which is becoming private), and also from the United States Government. The declining dollar is an additional economic pressure. After 21 years of operation, member governments are also becoming less tolerant of funding the consortium's recurrent losses. A recent independent study to assess the operations of the consortium, conducted by industry representatives from the four member countries, confirmed the need to improve efficiency and move Airbus towards a more commercially-oriented enterprise with full financial disclosure.

Recent actions by Airbus suggest a move in this direction: subcontracting on the A330/A340 was more competitive than in the past and loans for launching the A321 will be sought on the commercial market. Notwithstanding, Germany wanted more of the value-added work than it received in the past—to give German industry assembly experience and strengthen its hand in future collaborative enterprises. It demanded that final assembly of the A321 take place there. The request was granted, but not for economic considerations. The consortium is still, clearly, mired in politics.

Airbus has not been a success if judged by profit-based criteria, but it has become a major player in the world market. Since 1974, Airbus Industrie has received over 1,300 orders and during 1989 it captured 27 percent of orders for commercial transports. As of December 1990, it had a backlog of 1,038 aircraft orders. Between 1971 and 1973, before the first Airbus delivery, U.S. manufacturers averaged 85 percent of commercial aircraft orders. From 1986-1988 that share dropped to 71 percent. Airbus forecasts that by 2006 it will have 35 percent of the world market for commercial transports.

Airbus has been in existence for 21 years and currently offers a range of products. It has achieved its market presence by offering quality products at competitive prices. Its pricing has been so competitive, in fact, that the consortium did not realize a profit in 16 years of deliveries (Airbus did announce a profit in 1990). The apparent strategy of Airbus is to obtain a growing share of the transport market; profitability is a long-term goal—a strategy that is only possible through heavy borrowing. Given market uncertainty, the lack of financial transparency, and the excessively long time periods required before profits can be realized, commercial lending probably would not have been obtainable. Consequently, member governments stepped in to provide conditionally-repayable loans at attractive (below market) rates, plus outright grants.

TORNADO

Key points:

- European collaborative defense programs can be successful and result in state-of-the-art and highly competitive products
- Long-term inter-European manufacturing relationships can be maintained
- Sustained government political and financial support is possible and vital to project success
- Technology transfer issues were not an obstacle to the Tornado effort

Panavia is a three-nation management organization formed in 1969 to design, develop, and produce an all-weather, high performance fighter aircraft—the Tornado—for the air forces of the United Kingdom, West Germany, and Italy, and for the West German Navy. Three companies own shares of Panavia. British Aerospace (BAe) and Messerschmitt-Bolkow-Blohm (MBB) each holds a 42.5% share, while Aeritalia (now Alenia) owns 15%. Each company has its own area of specialization. BAe produces the front and rear fuselage sections; MBB is responsible for the center section; and Aeritalia produces the wings. Workshares are allocated according to ownership. In total, 500 companies are now involved in the program and they employ approximately 70,000 workers. In parallel, the Turbo Union consortium was created to coordinate joint development of an engine for the fighter. Its member companies are Rolls-Royce, Motoren-und-Turbinen-Union (MTU), and Fiat.

Company to company relationships within Panavia have in general been good with British Aerospace assuming a leadership role. Government support for the project has remained quite strong, even though there have been funding problems and public criticism due to rising program costs. Most of the increase has been due to inflation, although engine failures, airframe production delays and avionics complications have also contributed.

Collaborative ventures involving European firms were not new in the late 1960s, yet the Tornado program, which now is considered a success, instituted some innovative approaches. NAMMA (NATO MRCA Development Production Management Agency) was created by the participating governments to oversee their interests and to channel project funding. Panavia, in turn, deals directly with NAMMA, and as prime contractor, isresponsible for writing contracts, selecting subcontractors, and marketing. This management structure differed from prior collaborative efforts when each government performed these roles separately and their various activities were not centralized and at times lacked coordination. Another key change is the emphasis placed on standardization: English was selected as the common language, all purchasing procedures were standardized, and the overall design of the aircraft displays much commonality (avionics has 80 percent commonality).

Currently, three versions of the Tornado are offered. The production of Tornados is expected to continue into the 1990s and output of more than 1,100 is possible. This production line has allowed manufacturers to remain active as discussions concerning the next fighter project (European Fighter Aircraft EFA) take place. Orders from the three consortium nations total 894 Tornados and many of them are now in operation. Variations are also being considered. Export markets have been explored since the 1970s and sales have been made to Saudi Arabia and Jordan.

EUROFIGHTER

In 1988, four European nations agreed to develop and produce an advanced jet fighter—the European Fighter Aircraft (EFA). The nations participating are those involved in the Tornado project—the United Kingdom, Germany, and Italy— with the addition of Spain. Their principle aerospace companies—British Aerospace, MBB, Aeritalia, and CASA—formed a consortium called Eurofighter Jagdflugzeug GmbH to manage the project. An engine consortium called Eurojet Turbo was also formed. Eurojet Turbo includes Rolls-Royce, MTU, Fiat Aviazone, and Sener and will be responsible for developing and producing an engine for the EFA called the EJ200.

Current workshares for the EFA are: 33 percent for MBB and BAe, 21 percent for Aeritalia, and 13 percent for CASA. The initial EFA agreement commits the countries to provide a combined total of $10 billion to develop prototypes of the aircraft. The cost of the production phase is estimated at $30-40 billion. EFA members expect to place the first aircraft in service by 1996.

U.S. officials, anxious to be involved with the Europeans in a fighter program based on an American aircraft, proposed joint development and production of an upgraded F/A-18, giving Europeans 60 percent share of the project. The offer was rejected due to concerns that the United States would impose restrictions on selling the aircraft to other countries. The Eurofighter Board of Directors also established a requirement that the consortium would not accept subcontractor bids from countries that could not guarantee complete freedom to export all components or that would not list the countries to which the components could not be exported before signing onto the project. This in effect prohibits U.S. suppliers from participating on the project, since the U.S. Government refuses to state in advance which countries are on its export blacklist. (Europeans accept the need to have a blacklist of countries. What they do not want is to have the United States unilaterally adding to the list in the future.)

Although the EFA project is still in its pre-production phase, there have been disagreements within the consortium. The most visible problem dealt with award of the radar contract and pitted the British firm Ferranti against the German firm AEG. The German Government contended that British companies were already getting more than their share of work and that Ferranti's weak financial position could hurt the project. Adding to the controversy was the fact that the AEG team based its radar on a U.S. model manufactured by Hughes, raising questions regarding future export restrictions. The Ferranti group eventually was awarded the radar contract, but the delay in selection put the radar project almost two years behind schedule.

In addition to disagreements within the EFA consortium, there have been major political questions regarding the project. Many in Germany are opposed to the EFA project, due to its high cost at a time when the unification of Germany is occurring and tension with Eastern Europe and the Soviet Union is subsiding. The Social Democrats and the Free Democratic Party are leading this opposition. Although the ruling Christian Democrats support EFA, their support has been tentative at times. There is doubt whether Germany will support the production phase of the project, which is expected to begin in 1992. Daimler-Benz is a strong advocate of the project.

The Tornado program also suffered from internal disputes, but participants of both efforts claim that the conflicts arising in the EFA project are greater. Differences between the two efforts are cited. For example, one less country was involved in the Tornado project, which meant less coordination and complications. Today, East-West tensions are more relaxed, reducing the pressure for building the new aircraft. Also, the relations between Britain and Germany are not as smooth this time around. During the Tornado project, Britain dominated both the government and company efforts. Today Germany has become more assertive. There are also greater differences in military requirements among the participants than existed with the Tornado program.

Japan and the Asia-Pacific Rim Aerospace Industry

Its Market, Structure, and International Relationships

The Asia-Pacific Rim region is a growth market for both commercial and defense aerospace products.

Countries in the region want larger roles in aerospace and will use their leverage as customers to gain manufacturing capacity and technical know-how.

Governments are playing key roles in developing national aerospace sectors.

Over half of the nations in the Asia-Pacific Rim region have some—although generally limited—aerospace manufacturing capability. Japan stands out as the regional leader, although compared with the U.S. aerospace industry, its capabilities, too, are relatively few. While Japan has undertaken aerospace projects on its own initiative, Japanese manufacturers have also relied on U.S. industry to help them develop their aerospace sector through different forms of cooperation.

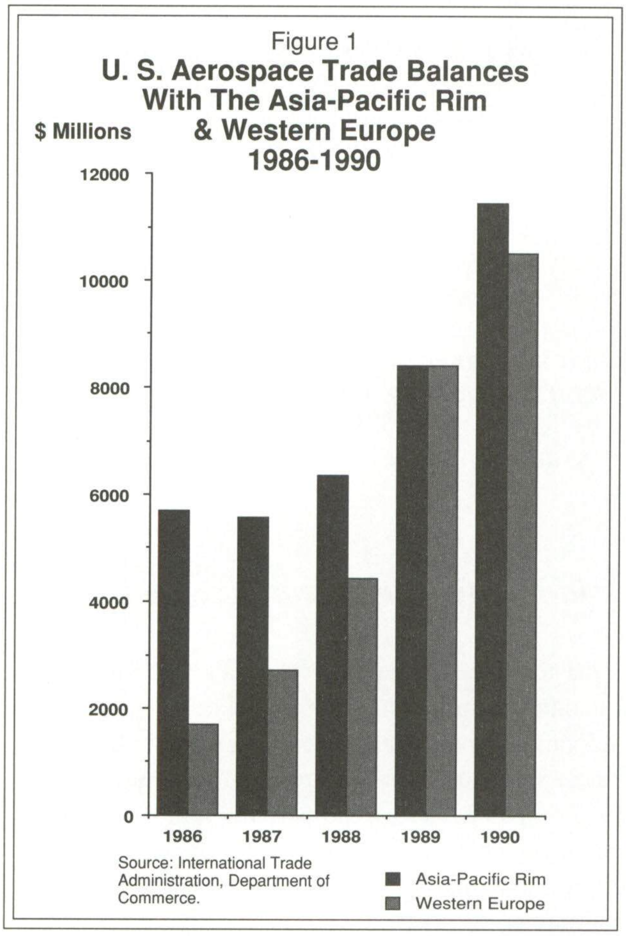
A growing number of governments in the region appear to agree on the need to establish some aerospace manufacturing capability as a way to ensure that their overall industrial base will be competitive in the next century. The Asia-Pacific Rim nations, which currently have the fastest growing economies in the world, also collectively represent a large market for aerospace sales. The region therefore represents an interesting study of how small but growing countries enter the competitive aerospace market.

This section will identify the chief characteristics of the region's aerospace sector and look at its potential for growth. The section will also focus on Japan as an outstanding example of how one nation has attempted to enhance its aerospace capabilities through licensing arrangements, joint ventures, trade, and direct investment.

Asia-Pacific Rim Aerospace Sector

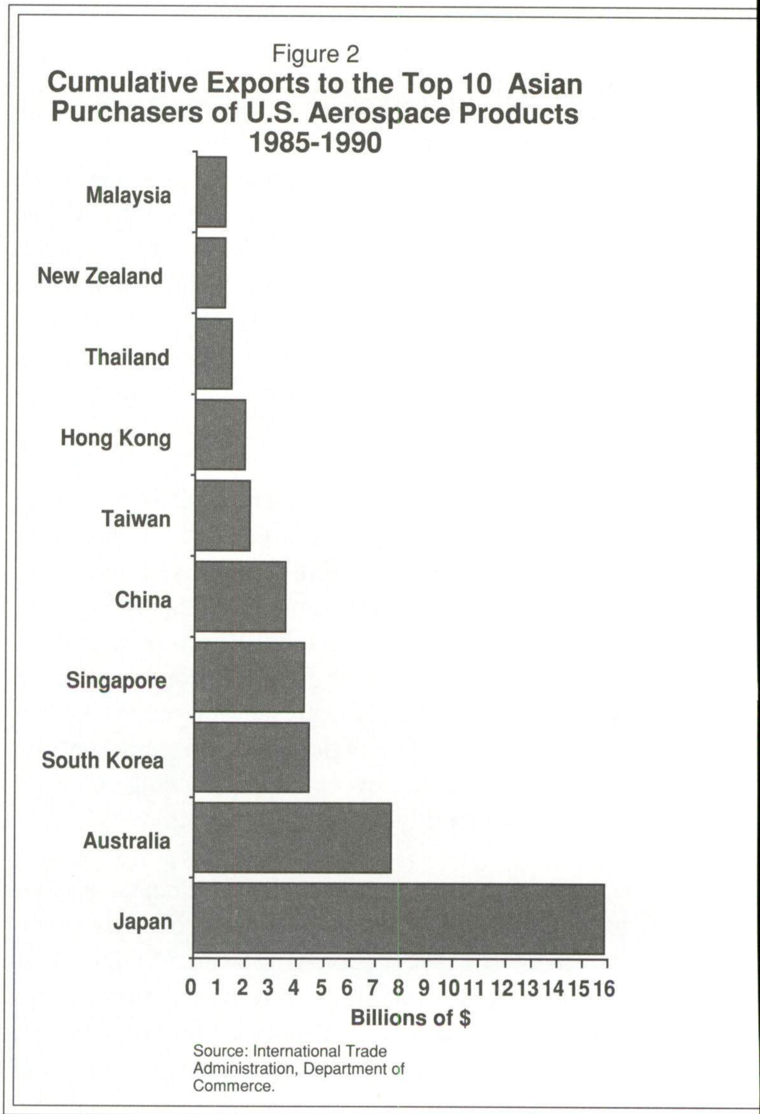
The region known as the Asia-Pacific Rim covers 23 countries including Australia, China, Hong Kong, Indonesia, Japan, Malaysia, New Zealand, the Philippines, Singapore, South Korea, and Taiwan. Between 1985 and 1990, U.S. exports to the region accounted for 30 percent of U.S. aerospace exports and 8 percent of total U.S. aerospace sales.[1] The United States has maintained a growing positive aerospace trade balance with the region. In fact, the U.S. trade balance with the Asia-Pacific Rim has been more favorable than with the European Community (Figure 1). The five leading regional importers of U.S. products are Japan, Australia, South Korea, Singapore, and China (Figure 2). Japan stands out as the second largest single country export market for U.S. aerospace products in the world for the period 1985-1990.[2]

Developing nations face formidable obstacles in their quest to establish an aerospace capability. Government support is essential for any extensive involvement in the high-risk aerospace field, so an agreement must be worked out between government and private industry concerning the direction that aerospace development should take. This in itself can be difficult to achieve. In addition, financial resources from both government and private sources are usually



insufficient. Many nations interested in developing an aerospace industry have a shortage of skilled labor. They have inefficient material acquisition systems. All have a low level of R&D spending, particularly in areas of basic research. In addition, they lack proper testing and R&D facilities, which can result from over-reliance on foreign licensed technology. Finally, their relatively small populations represent an inadequate level of demand for maintaining an aerospace capacity. Consequently, companies producing for the aerospace market must move immediately into the competitive international marketplace to sell their output. In spite of these problems, nations in the Asia-Pacific Rim are moving forward to develop their aerospace industries.

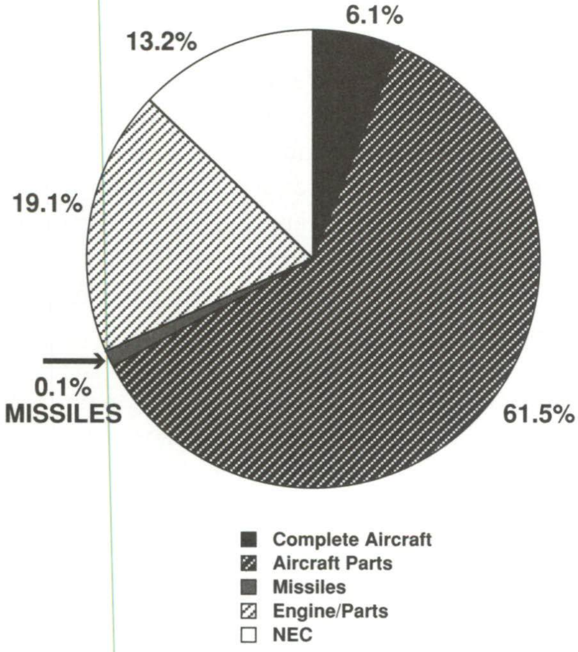
The Asia-Pacific Rim region supports a limited, although growing, aerospace sector based primarily on relatively low-risk programs. Currently, 13 nations have demonstrated a capability for producing aircraft.[3] Most have channelled their resources into the production of helicopters and pilot training aircraft. Developing an infrastructure capable of producing smaller aircraft types is a fundamental step for nations entering the aerospace field. The manufacture of such aircraft requires less capital and assembly experience and lower technology inputs than does the production of more sophisticated aircraft. In all of these countries governments support the development



of both civil and military aerospace projects. Government and industry initiatives are closely integrated in terms of planning, resource allocation, and national promotion. Virtually all major aerospace programs in the Asia-Pacific Rim are based on licensing agreements with western manufacturing firms—a practice that is useful for acquiring aerospace technology and assembly experience. Most countries have also established centers for the supply, maintenance, and overhaul of advanced aircraft models. Five countries from this region now supply parts and components for incorporation into U.S. aircraft.

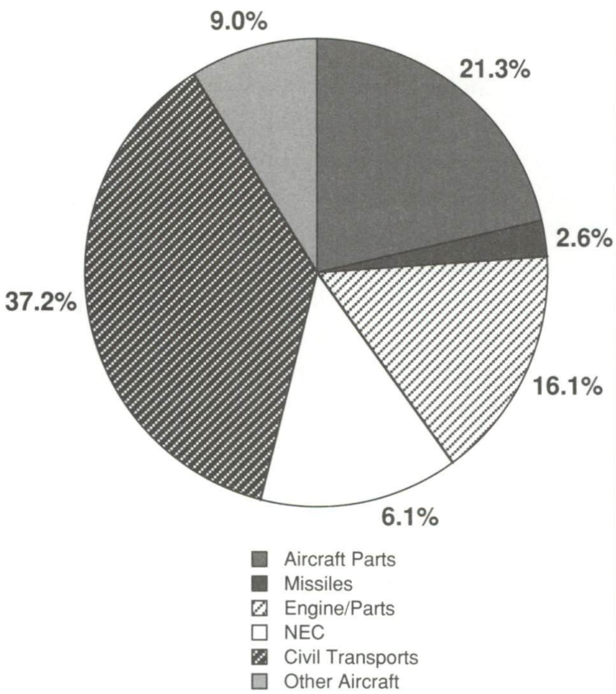
In contrast to the growing network of industrial relationships now prevalent in Western Europe, cooperation among Asia-Pacific Rim manufacturers has been conspicuously absent. Only one regional initiative is now underway—a program between China and Pakistan to design and produce a jet trainer. This is a relatively new program; the design stage began in 1987. Asia-Pacific Rim countries have not yet marshalled a collective effort, such as pooling their R&D resources, to undertake an advanced technical project in the aerospace sector. Instead, they have relied on licensed western technology to move forward. Some

Composition of U.S. Imports From the Five Leading Asian Producers of Aerospace Products* 1989



* Japan, Australia, S. Korea, Singapore, China.

Composition of U.S. Aerospace Exports to the Five Leading Asian Purchasers* 1989



* Japan, Australia, S. Korea, Singapore, China.

argue that this approach has limited the pace of aerospace development in the region. Although several countries in the region have been active in the aerospace industry for some time, all currently lack the necessary R&D infrastructure and production facilities to embark on a highly-technical aircraft or engine program. In Western Europe, where cooperative aerospace programs have been taking place for 40 years, even countries with more limited means—e.g., Spain—are actively involved in full-scale development and production of state-of-the-art fighter aircraft and transports.

Not all countries in the region have the same capabilities, or ambitions. Japan is clearly the regional leader in terms of its commitment to developing its aerospace industry, and its current capabilities. Unlike its neighbors, Japan is not really new to aerospace either; it has been manufacturing aircraft since 1921. Japan's annual aerospace sales greatly overshadow those of other Asia-Pacific nations. Aerospace sales in both Australia and Singapore were under $1 billion in 1989, while sales in Japan totaled over $7 billion. Its relatively large defense spending has contributed to Japan's regional leadership in aerospace. The annual defense budgets of Indonesia, Malaysia, the Philippines, Singapore, and Thailand have been between $1.3 and $l.7 billion. Japan's defense spending is closer to $30 billion a year. In line with its growing ambitions, Japan has launched a program to codesign and coproduce a new generation fighter, the Fighter Support Experimental (FSX). Japan has also taken steps toward leading a major international consortium to do research and development on a propulsion system for a high speed civil transport.

China might be considered second in aerospace capability to Japan in the Asia-Pacific Rim region. It has produced aircraft under license from U.S., Soviet and European manufacturers and has manufactured aircraft using its own design and development centers. China also performs subcontract work for several western companies including Airbus, Boeing and McDonnell Douglas. It has produced a wide range of aircraft models including fighters and transports. All 11 of its aircraft factories are under the jurisdiction of the Ministry of Aero-Space Industry.

Other countries in the region, notably Taiwan and South Korea, have recently launched programs that they hope will spearhead their aerospace industrial base development. Taiwan is building and marketing a fighter aircraft called the Indigenous Defense Fighter (IDF). The aircraft is based in part on U.S. licensed technology and in part on Taiwan's own design. Taiwan is also setting up its first commercial manufacturing center and hopes to nourish it through offset sales arranged through past purchases from Boeing, McDonnell Douglas and United Technologies. South Korea is beginning a coproduction program on a fighter called the Korean Fighter Program (KFP), which is based on the U.S. F-16. In addition to specific F-16 work, the U.S. contractor General Dynamics has agreed to help South Korea design, develop and produce an indigenous trainer aircraft. This experience will then be applied by the South Koreans in an effort to design, develop and produce a more advanced fighter aircraft in the future. The South Korean Government designated three domestic companies to work on the KFP and to receive ongoing government aerospace contracts. This selection will limit domestic competition and facilitate the government's role in aerospace industrial development.

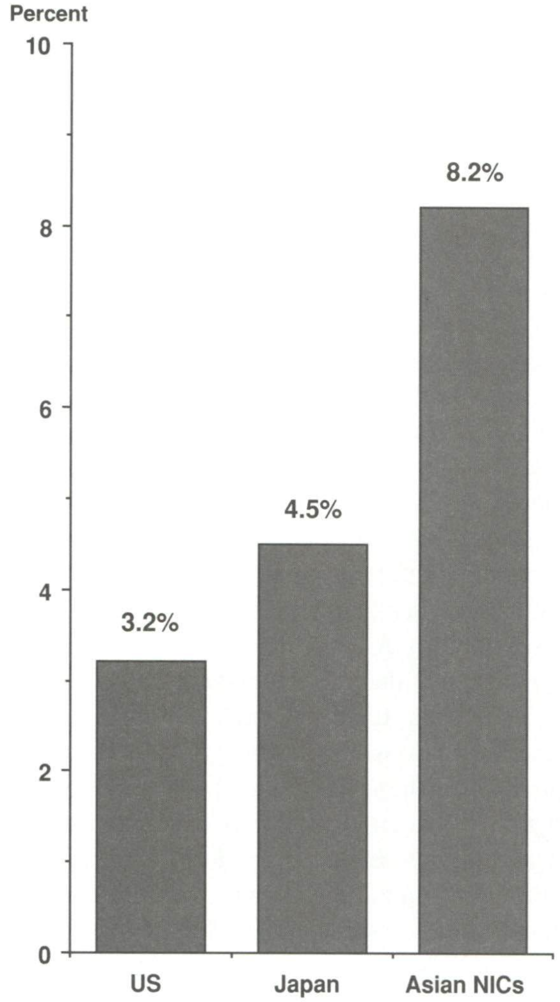
Three countries in the region—China, India, and Japan—are also engaged in national space programs. Each is improving its indigenous launch capabilities, designing and constructing various kinds of satellites, and upgrading and expanding ground support facilities. India and Japan have been particularly active in using cooperative arrangements to build their space capabilities. Japan also has an independent booster program and is planning to launch a Delta-class booster in August, 1991 to place a broadcast satellite into geosynchronous orbit. Japan is moving its space program into ambitious areas, which include space station operations, the development of infrastructure for manned flight, and the launch of spacecraft to the Moon, Mars, and Venus. (See also *The Changing U.S. Role in International Space Activities.*)

Notwithstanding these efforts, the region remains a relatively small producer in the world aerospace marketplace. During 1989, total U.S. imports of aerospace products from the United Kingdom were almost three times greater than imports from Asia-Pacific Rim nations.[4] Based on 1988 aerospace sales, only four companies from the Asia-Pacific Rim were among the top 50 in free-world sales and all were Japanese.[5]

Regional Outlook for Aerospace

One of the drivers of aerospace trade is economic growth and the Asia-Pacific Rim is a region of accelerating economic expansion (Figure 3). Japan has led all developed economies in annual GNP growth, posting a 4.5 percent average (1985-1990), while the United States has averaged 3.2 percent. Hong Kong, South Korea, Singapore, and Taiwan—four of the so-called newly-industrialized countries (NICs)—have the fastest growing economies in the world. Together they have maintained an average annual GNP growth of 8.2 percent since 1985.[6] This expansion has been fueled by exports, particularly in such areas as computer-chip manufacturing, consumer-electronics, and automobiles. This growth is expected to continue into the next decade, with the Asia-Pacific Rim outperforming all other regions in the world.

Figure 3
GNP Average Growth Rates U.S., Japan, and the Asian NICs 1985-1990



Source: International Monetary Fund, World Economic Outlook, May 1990.

Expanding economies generally provide a rising standard of living, which enlarges disposable income and encourages tourism. Increased economic activity also creates a need for greater cargo and business traffic. Passenger and freight movement in the Asia-Pacific Rim region are rising. Projections by the International Civil Aviation Organization indicate that between 1988-2000, average annual travel growth in the Asia/Pacific region will be the highest of all regional markets.[7] Much of this demand will be based on long-haul overseas routes, which should have a positive impact on business for commercial aircraft manufacturers. One manufacturer reports that new aircraft demand in the region should reach $100 billion by the year 2000.[8]

While the Asia-Pacific Rim transport market looks promising, it will be competitive. All three major

Western commercial aircraft manufacturers have made sales to Asia-Pacific Rim customers. As of November 1990, 19 percent of the transport aircraft delivered or on order to the region were from European manufacturers.[9] Also, the region's traffic growth could be limited by system constraints. The region is already experiencing airport and airway system capacity limitations. This could dampen growth for aircraft sales, but at the same time it could create new markets for U.S. manufacturers of air traffic control systems and communications equipment.

Regional defense funding will also promote aerospace development. In terms of overall military spending, the Asia-Pacific Rim has been a growth area. Between 1982 and 1987, the region experienced a compound annual growth rate in defense spending of 6 percent—higher than that of all other free-world regions except North America.[10] Japan, China, South Korea, Malaysia, Singapore, and Thailand are all in the midst of upgrading some facet of their aerospace defense forces and their growing economies will provide sources for funding.[11] Given the shrinking western defense market, the Asia-Pacific Rim provides an opening for sales, but these sales will not represent off-the-shelf buys. Asia-Pacific Rim countries want larger roles in the aerospace field. They will use their leverage as customers to gain greater manufacturing capacity and technical know-how through collaborative ventures. Their choice of foreign weapons systems will be tied to meeting not only their military requirements, but their technology requirements as well. The financing and offset packages offered will be just as important.

The Japanese Aerospace Industry

In many ways, Japan typifies other nations in the region. It is an Asian culture with a different history and social tradition than exists in the west. It has built its economy on exports, particularly items such as consumer electronics and automobiles. At the same time, Japan stands out among its neighbors, due to its economic power and growing political influence. Because of its economic successes, its actions may guide others in the region who are developing their own industrial plans.

Japan is making a national commitment to build an aerospace capability to ensure its future in high technology industries. Japan is already a significant source of demand for aerospace products. It has been consistently one of the leading national export markets for both U.S. civil and military aerospace goods and services and the United States has been Japan's sole foreign supplier of defense products.[12] To meet its growth objectives in aerospace, Japan has turned to the international market for technology.

Aerospace Sales

Although Japan's aerospace industry is relatively small, it is growing. In 1983, the industry had annual sales of $2.6 billion and by 1989 sales reached $7.3 billion.[13] In comparison, the U.S. aerospace sector had sales of $118 billion in 1989, and sales in Germany totalled $12.6 billion.[14] In world markets, Japan's share of total production stood at 4 percent in 1988—in 1980 it was 2 percent.[15]

Since World War II, about 80 percent of Japan's aerospace production has consisted of military aircraft.[16] This has been the case even though Japan maintained a low military profile due to foreign and domestic apprehension concerning a rearmed Japan.[17] Notwithstanding, Japan spends substantial amounts on defense. The nation's current five-year defense budget (1991-1995) is $169 billion—an amount greater than that of most Western European nations. Between 1980-1989, the Japanese defense budget grew at a compound annual rate of over 6 percent.[18] Over the same period U.S. defense spending rose 10 percent annually.[19] Japan's projected military budget for the period 1991-1995 has earmarked $46 billion for weapons procurement, mostly for maintenance and upgrades.[20]

Research and Development

Technology development and process innovation are important to aerospace competitiveness. Japanese Government aerospace R&D funding for 1991 will total approximately $2.3 billion. Japanese aerospace defense R&D will amount to $930 million. MITI is expected to spend approximately $66 million on civil aerospace R&D. Japan's space budget for 1991 will total $1.31 billion. [21] In comparison, the U.S. Government spent an estimated $17.4 billion on aerospace R&D during 1990.[22] Japan's funding of aerospace R&D has historically been small. One reason is that industry in general is the primary source of R&D funding in Japan. Since aerospace projects involve high-risk, have low returns, and require a commitment of funds over extended periods, Japanese companies are hesitant to invest great amounts of their own capital when more promising opportunities may be available elsewhere. Another reason for the historically low investment in aerospace is that Japanese companies have been able to acquire technology from abroad through licensing, instead of through internal financing and development.

Other sectors that support aerospace—e.g. electrical equipment, machinery, computers—have accounted for approximately 40 percent of Japan's industrial R&D spending. Overall, R&D spending in Japan as a percentage of GNP has steadily risen from 2.2 percent in 1980 to 2.9 percent in 1988. In the United States, R&D has increased from 2.3 percent to 2.8 percent of GNP.[23]

Industry Structure

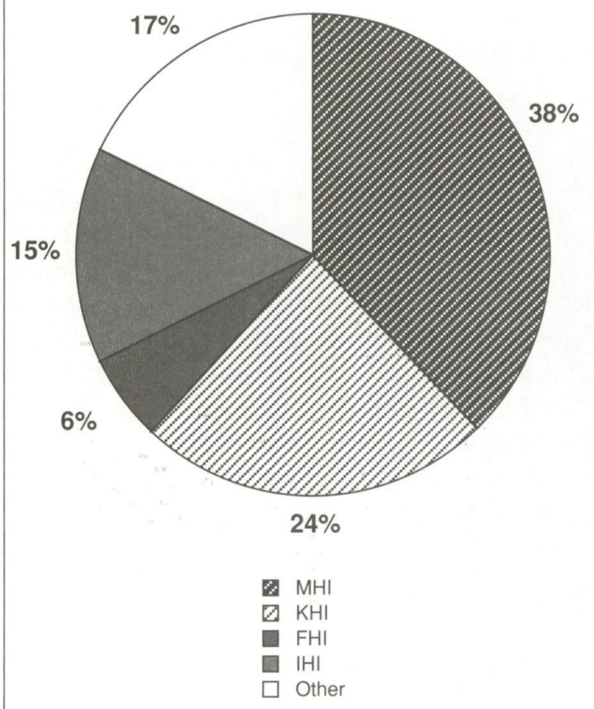
The business structure in Japan is quite different from the U.S. model. The Japanese economy is dominated by giant diversified companies and is characterized by the prevalence of intermarket associations between companies. Intragroup relationships include buyer-seller, lender-borrower, and fractional ownership; they include oligopolistic firms from several industries that generally do not compete against each other. Some companies are clustered around major banking institutions, which are referred to as *keiretsu*. These groups of firms do not display a unity of behavior although some have formed "president's clubs" which are forums for company members to discuss issues of common concern. Group membership may provide participants with business reciprocity, prime contractor and subcontractor linkages, pools of capital and entrepreneurial talent, and assistance from other members during difficult economic times.

The Japanese aerospace sector is concentrated around four privately-held firms—Mitsubishi Heavy Industries (MHI), Kawasaki Heavy Industries (KHI), Fuji Heavy Industries (FHI), and Ishikawajima-Harima Heavy Industries (IHI). These four companies account for over 80 percent of Japan's aerospace sales (Figure 4). IHI produces aircraft engines and space propulsion systems. FHI produces both civil and military aircraft sections and parts, light aircraft and helicopters. KHI manufactures civil and military aircraft sections, parts, engines, and helicopters. MHI has capabilities in all areas of aerospace production. Aerospace subcontracting is loosely based on ties of companies affiliated to the member groups.

The four major aerospace companies are divisions of several of Japan's large conglomerates. Their aerospace sales represent a relatively small fraction of the total sales generated by their parent companies while, for U.S. aerospace manufacturers, the reverse is true. (See Figures 5 and 6.) Aerospace sales for MHI, the largest Japanese aerospace manufacturer, were only 15 percent of the company's total sales during 1989.[24] Aerospace company parent firms are, in turn, closely affiliated with finance-centered business groups—MHI with the Mitsubishi Group, KHI and IHI with the Dai-Ichi Kangwo Bank Group, and FHI with the Fuyo Group.

In general, Japan's large conglomerates have taken a cautious approach to aerospace. These large companies have many divisions and aerospace executives must compete against these other business segments for company resources. The difficulty of their efforts is compounded by the fact that aerospace is perceived

Figure 4
Japanese Aerospace Sales By Company 1988



Source: The Society of Japanese Aerospace Companies, Inc. Aerospace Industry in Japan, 1989-1990 (Tokyo, Japan).

as a high-risk, low-profit endeavor; other company divisions may show greater potential for return.

Although four firms dominate the Japanese aerospace sector, there is competition. Japanese aerospace companies compete head-to-head for domestic and foreign business, although this situation changes when major projects are undertaken. Because Japanese aerospace divisions are relatively small and unable to independently assume the large, high-risk investments required of a major aerospace program, the Government encourages industry to form consortia for such efforts. Through government sponsorship and coordination MHI, KHI, FHI, and IHI have jointly participated in the R&D, design, and production of all of the major aerospace projects undertaken in post war Japan.

Government's Role In Industry

State ownership in Japan is quite small and there is no public ownership in the mining and manufacturing sectors. Nevertheless, the Japanese Government does take an active role in the economy. This role is based on tradition and on the fact that Japan is an island, lacking natural resources, whose economic survival is linked directly to trade. Since some of Japan's industries—such as aerospace—are small and lagging in world competition, government intervention is seen as a legitimate means to move industry towards a more competitive level.

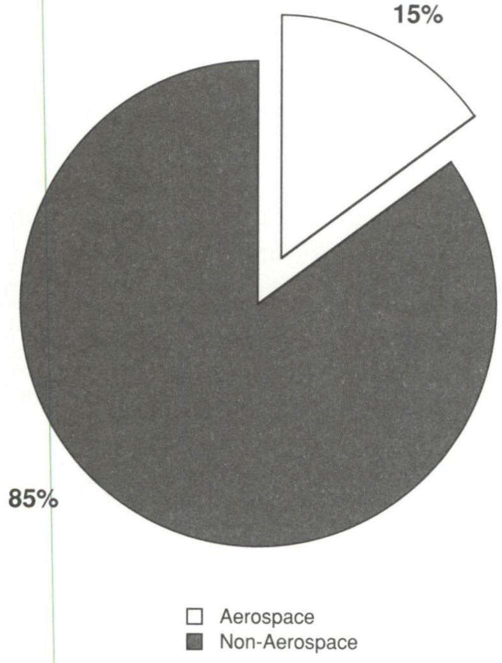
Industrial policy exists as a set of *ad hoc* measures which arise out of the constant interaction between business and government. Each economic sector has a close, cooperative relationship with the ministry or government agency operating on its behalf. Business and government keep each other informed as to their respective undertakings. Business decisions and government policymaking are reached by consensus. Business has traditionally accepted governmental guidance, which may harm short-term interests, in return for long-term gains and national growth.

The Ministry of International Trade and Industry (MITI) plays a significant role in this process, although its mode of operation is not distinctive among Japanese bureaucracies. Through a process of consensus building, industries are prioritized and resources channeled from mature low-priority industries into targeted sectors. Industry is not required to follow MITI's lead, but MITI has an array of incentives to encourage acceptance. It allocates foreign exchange to limit or encourage what companies can import. It uses its licensing authority to control the import of foreign technology. Government research funds encourage business to invest in certain technologies. MITI also has influence in accessing capital for industrial financing. MITI supports the free-market concept, yet believes in supplementing or expediting the market mechanism when it proves ineffective. As such, MITI organizes consortia, apportions business shares for declining industries, and identifies technologies that the government believes have vital commercial potential.

MITI envisions the aerospace industry playing an important role in the government's plan to remold Japan's industrial structure in an innovative, knowledge-intensive direction. This point was enunciated by MITI in a 1980 document, *The Vision of MITI Policies in the 1980s.* Advances in aerospace are expected to help promote high-technology development in related industries and enable Japanese industrialists to stay ahead of regional competition in those areas. Japan has watched its market share decline recently in various manufacturing sectors due to the aggressive targeting of lower-wage countries in the Asia-Pacific Rim region.

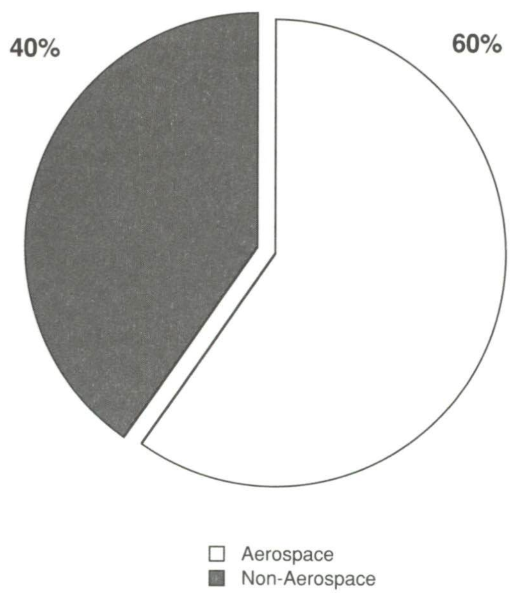
MITI has played a pivotal role in the direction and pace of Japan's aerospace growth. Its Aircraft and Ordnance Division has primary responsibility in this area with input from MITI's various aerospace-related advisory councils (which represent consumer, labor, financial, industry, and government interests).

Figure 5
Combined Sales Of Major Japanese Airframe and Engine Manufacturers



Source: The Society of Japanese Aerospace Companies, Inc., Aerospace Industry in Japan, 1989-1990 (Tokyo, Japan).

Figure 6
Combined Sales Of Major U.S. Airframe and Engine Manufacturers



Source: Annual Reports of seven airframe and two U.S. engine manufacturers.

MITI encourages private companies to undertake specific aerospace projects, as well as to form consortia and enter into international collaborative efforts. MITI works closely with Japan's Fair Trade Commission to make sure these government-arranged consortia are approved. MITI has also supplied venture capital.

The Japanese Government funds all defense-related production and development. MITI works with the Japan Defense Agency (JDA) to ensure that major aerospace defense programs also complement strategic industrial goals. MITI has been willing to pay a premium to undertake a program that will acquire technology for Japan. For example, it is estimated that coproduction of the U.S. F-15 fighter cost Japan $2 billion more than if the aircraft were purchased outright. The limited production run required for Japanese demand significantly inflated the cost.

On the civil side, at one time government grants were provided for both R&D and production. Later, only R&D funding was supported and industry repayment of principal and interest was conditional on program profitability. Since 1985, funding for aircraft programs has been arranged through the Japanese Industrial Development Bank, which has a fund earmarked for aerospace projects. Industry must apply for a loan, as do other commercial enterprises. Interest on the loans is relatively low and is paid by MITI until the aircraft project has reached breakeven; at that point, companies assume interest payments. Companies must pay back the principal of the loan, regardless of the outcome of the project. Loans can be used only for R&D and can only cover half of a project's costs. MITI was instrumental in moving private industry to design commercial aircraft such as the YS-11. MITI has been also been pivotal in arranging Japanese participation in, and financial support for, the Boeing 767, 7J7, and 777 programs.

International Relationships

The Japanese aerospace industry was dismantled after World War II and was dormant when U.S. manufacturers moved into the jet age (1945-1952). When Japan began to revive its aerospace sector, the nation lacked the technology, supplier networks, and logistics capabilities necessary to be competitive in the world market. The Japanese Government and the aerospace industry determined that setting up trading relationships with established foreign contractors was a useful approach for moving their industry forward. This strategy was reinforced by Japan's failed attempt to domestically produce the YS-11 commuter aircraft in the mid-1960s. While a technical success, the program was a financial failure, and it highlighted the problems of Japan's small domestic market and weak marketing and support structure.

Throughout the postwar period Japanese companies used licensing to gain foreign technology, management, and assembly experience and Japan's aerospace trade figures have reflected this effort with a continuing string of deficits. During this same period, Western European companies also recognized the advantages of international programs and launched numerous licensing efforts, both among themselves and with U.S. companies. In addition, the larger European companies recognized that if they wanted to be genuinely competitive in the world market they would have to initiate and carry out their own projects—licensing and codevelopment relationships with U.S. companies would be too limiting. Consequently, they began to pool their resources and undertake regional design, development, production and marketing efforts. While the Japanese were relying on U.S. licensing programs during the 1960s, Europeans initiated 10 major regional aerospace projects including the Concorde and Airbus programs.

As Japanese manufacturers became more capable, coproduction contracts were pursued and, later, codevelopment agreements. These arrangements have helped Japan gain experience and, today, the country is attempting to assume leadership roles in international consortia in next-generation high-technology enterprises. To coordinate, administer, and disseminate the benefits of these initiatives industry-wide, Japan routinely creates government/industry consortia. Since 1983, approximately 65 percent of the aircraft and engine programs undertaken by Japanese firms have involved some form of international cooperation.[25] In pursuing cooperation with other countries, Japanese government and industry have demonstrated a single-minded desire to become major players in the world aerospace industry.

Licensing

Japan's aerospace sector was set in motion in 1952 when Japan was asked to repair and maintain U.S. aircraft during the Korean War. Shortly thereafter, Japan's Self Defense Force (SDF) was established and industry received government contracts to build a small air force. The SDF wanted a world-class fighter, but Japanese industry lacked the ability to build one. International collaboration was seen as a way to help industry acquire needed capabilities, while also providing the SDF with a capable aircraft.

From the 1950s through the 1980s, most of Japan's major military aircraft programs—the F-86, F-104, F-4, F-15, and P-3C—were based on U.S. technology. These sales furthered U.S. national security objectives by arming a regional ally and contributing to standardization and interoperability of weapon systems. Each program followed a phased production process whereby: 1) the first aircraft were delivered off-the-shelf from a U.S. manufacturer; 2) knock-down kits were shipped to Japan for assembly using U.S. components; and 3) Japanese manufactured parts were increasingly incorporated into the aircraft. These projects provided Japanese industry with the demand needed to set up domestic production facilities and supporting industries. By the end of the F-86 program, for example, 77 percent of the aircraft's content was being produced in Japan.[26] In total, 19 models of U.S. military aircraft have been produced under license by Japanese firms.[27] MITI and the Japan Defense Agency have allocated defense contracts among domestic manufacturers to assure that each participated and that technology was thoroughly disseminated. To keep assembly lines and subcontractors active, projects were spaced so that as one ended another began.

Licensing continues to play a part in Japanese aerospace production. Currently, Japanese manufacturers are participating in 19 aircraft programs of which 10 involve some form of licensing arrangement. A similar pattern exists in the aircraft engine sector, where 10 programs are now underway and eight involve licensing agreements (Table 1).[28]

One current licensing program is the F-15J/DJ program, based on a fighter designed and produced by McDonnell Douglas. MHI is producing the F15J/DJ with KHI as a subcontractor. Various Japanese subsystem contractors are also part of the project (Table 2).[29] The program called for the purchase of 187 aircraft through 1990 and is similar to past licensing arrangements. The first two F-15Js were shipped to Japan in March 1981 as complete aircraft. The next eight aircraft were sent to Japan in knock-down kits and assembled by Japanese companies. The first two kits were major subassemblies, the next two kits were minor subassemblies, and the last four were provided as components and parts to be put together by Japan. Midway through the program, Japanese local content had already reached 55 percent.[30] IHI is responsible for the engine and is producing the licensed Pratt & Whitney F100. Technology transfer was an issue during project negotiations. Under earlier programs (F-86, F-4, and F-104, etc.), U.S. technology flowed to Japan quite freely.[31] The F-15 program involved more restrictions. For example, the U.S. Defense Department refused to release sensitive electronic warfare systems information.

Aerospace Trade

Japan's aerospace trade balance has been consistently negative, heavily weighted by the purchase of foreign military aircraft and commercial jet transports. Since 1982, the ratio of aerospace imports to exports has been 10:1.[32] The majority of Japan's aerospace imports have come from the United States. In 1988, U.S. shipments to Japan constituted 87 percent of Japan's aerospace imports, followed by imports from France, Canada, Germany, and the United Kingdom.[33]

Table 1

Current Japanese Development and Production Under License

Engine	Licenser
F100	P&W
TF40	RR, Turbomeca
T56	Allison
T700	GE
CT/T58	GE
T53	Lycoming
T55	Lycoming
V2500	IAE

Aircraft	Licenser
Ch-47J Helicopter	Boeing Helicopter
Sh-670J Helicopter	Sikorsky
AH-1S Helicopter	Bell Helicopter Textron
F-15J Fighter	McDonnell Douglas
P-3C Anti-Sub	Lockheed
KV10711A Helicopter	Boeing Helicopter
204B-2 Helicopter	Bell Helicopter Textron
H-500 Helicopter	McDonnell Douglas Helicopter
FSX Fighter	General Dynamics
BK117	MBB

Table 2

Japanese F-15 Subsystems Contractors

Subsystem	Product	Company
Gun Mounts	AN/APG-63	Mitsubishi Heavy Industries, Ltd.
Radar Display	OD-60A	Tokyo Keiki Co., Ltd.
Data-Link Receivers	Japanese System	Hitachi, Ltd.
UHF Receivers	AN/ARC-164	Mitsubishi Electric Corp.
Instrument Displays	AN/AVQ-20	Shimadzu Corp.
Computing Gyro	CN-1377/AWG	Toshiba Corp.
Inertial Navigation	AN/ASN-109	Toshiba Corp.
Direction Finder	DA/8639/ARD	Mitsubishi Electric Corp.
IFF Device	RT-868A/APX-76	Toyo Communications Equipment Co., Ltd.
Attitude Indicator	AN/ASN-108	Tokyo Keiki Co., Ltd.
Pressure Reader	AN/ASK-6	Tokyo Keiki Co., Ltd.
Radar	Japanese System	Tokyo Keiki Co., Ltd.
20 mm Guns	M61A1	Sumitomo Heavy Industries, Ltd.

Note: Unless otherwise noted the technology for these subsystems belongs to the Department of Defense or individual American companies.
Source: The Wing Newsletter, July 26, 1978 as cited in "Nihon no Heiki Kojo," Satoshi Kamata, October 15, 1983.

Various Japanese companies have become suppliers for western aerospace manufacturers. Japanese exports amounted to 9 percent of aerospace sales in 1988.[34] During that year, 83 percent of Japanese aerospace exports were shipped to the United States, while the remainder were shipped to Germany, Saudi Arabia, Canada, and the Netherlands.[35]

Japanese exporting began in earnest in the late 1960s, after the YS-11 project failed. It was during that period that the Government and industry decided it would be more advantageous to assume less risky roles in commercial projects by working as subcontractors for established foreign manufacturers. This would also allow Japanese companies to concentrate on specific product areas. Industry set up production lines and exported aircraft parts and sections to American manufacturers: doors for L-1011s, inboard and outboard flaps for B-747s, actuator transmissions for B-727s, wing ribs for B-737s, assembled tail cones for DC-10s, engine transmission kits for B-757s, and rudders and inner flaps for B-747SPs.

Japan continues to build on its strengths in the industry, reenforced by the country's manufacturing prowess. Japan is undertaking R&D into new aircraft materials and casting processes (the nation provides approximately half of the world's output of carbon fibers for composite materials). Japan's equipment and parts manufacturers are seeking ways to improve the safety, reliability, economic feasibility and improved performance of their products. They are proceeding with R&D for the miniaturization, weight reduction, and systemization of fly-by-wire, fly-by lights, and control instruments through applications in fields such as integrated circuitry, optical and digital electronic display elements. Japan is also seeking out foreign partners to collaborate in the development of new aircraft components in the areas of hydraulics, flight control, and fuel systems.

Today, Japanese companies are important subcontractors to Boeing, McDonnell Douglas, and Gulfstream Aerospace in the United States, to Fokker in the Netherlands, and in 1990 KHI won the first Japanese contract with British Aerospace to work on an Airbus program. Currently, Japan provides spoilers, ailerons, flaps, tailcones, rudders, and other parts used in the Boeing 737, 747, 757 and 767; the McDonnell Douglas MD-80, MD-11, and DC-10; the Gulfstream G IV; and the Fokker F-50. There is no development work in these arrangements. Instead Japanese firms design and produce parts to meet the specifications of prime contractors. The Japanese manufacturers producing for overseas markets are FHI, KHI, MHI, Shin Meiwa, and Japan Aircraft Manufacturing Company.

To date, Japan has exported eight different models of complete aircraft including commuters, business aircraft, and civil helicopters. Some were produced through indigenous efforts and others were based on licensing agreements. In total, 1,111 Japanese aircraft had been exported as of 1988.[36] The most popular export was a twin-turboprop commuter called the MU-2 of which 703 aircraft were shipped abroad (see Direct Investment section below for more on the MU-2).

The composition of U.S./Japanese aerospace trade during 1989 is shown below:[37]

U.S. Exports to Japan		Japanese Exports to the U.S.
31%	Complete Aircraft	8%
23%	Aircraft Parts	74%
6%	Missiles	0%
9%	Engines	14%
21%	NEC	3%

Direct Investment

Cumulative Japanese investment in the United States totaled $53.4 billion in 1988.[38] Only the United Kingdom had greater investment holdings. Nevertheless, foreign direct investment has not been a major strategy for expanding Japan's aerospace sales—in contrast to their practice in the automotive industry.

As of October 1989, the U.S. Commerce Department listed only one Japanese investment in the U.S. aerospace sector. A major reason for the lack of Japanese investment is American political sensitivity towards that country's investments in U.S. high-technology industries. An attempt by the Japanese firm Fujitsu to purchase 80 percent of Fairchild Semiconductor in 1987—a company that had already been purchased by a French company in 1976—generated much controversy in the United States and the sale fell through. Both national security and economic concerns were voiced by opponents.

In 1965, MHI set up a subsidiary in Texas, Mitsubishi Aircraft International (MAI), to assemble and market its Diamond business jet and MU-2 series of business turboprops. MAI closed down in 1986 and sold assembly and marketing functions to the American company Beech Aircraft. More recently, Ishida Aerospace Research Inc., a Japanese-owned company, began building a facility in Fort Worth, Texas to develop and produce a tilt-wing rotorcraft, the TW-68. The aircraft will use two Pratt & Whitney-Canada engines and carry up to 14 passengers.

Joint Ventures & Other Partnerships *

During the 1960s and 1970s, Japanese aerospace companies undertook the design, development and production of 13 various aircraft models, including the YS-11 regional transport and the C-1 military transport. These programs, along with licensed coproduction work, added to Japan's experience and productive capabilities. Japan's Government and industry realized that to make the industry more competitive, codevelopment work on a major international program was needed. The Japanese worked earnestly at becoming involved in western joint development and production activities. Currently, Japan is involved in eight joint ventures: five are aircraft programs—the B-767, 7J7, 777, the BK-117, and the FSX—and three are engine programs—the V2500, Trent, and the GE90. All of Japan's major aerospace manufacturers are active in these programs.

**See pp. 75-76 for more on Japanese international partnerships.*

Work on the Boeing 767 transport represented the first risk-sharing foreign partnership undertaken by Japanese companies and was a step forward from their previous role as aircraft parts subcontractors. Their responsibilities included design and production of specific airframe sections. The 7J7 project that followed permitted Japanese companies to be full partners in a major aircraft project. Unfortunately, for the Japanese, the 7J7 program was subsequently put on hold because of changing market conditions. Japanese participation in the 777 project, to be launched in the 1990s, will be slightly greater than their 767 contribution, but it will also fall short of full partnership. In each of these efforts, Japanese companies—with government assistance—formed domestic consortia to coordinate their workshares and to represent Japanese member-company interests vis-a-vis foreign partners.

In 1988, the United States and Japan signed an agreement to launch an advanced world-class fighter based on General Dynamic's F-16. The fighter, the FSX, represents another stage in Japan's efforts to advance its aerospace industry. The company-to-company agreement was signed in February 1990. The engine competition for the development phase was completed in 1990; General Electric was awarded the contract. Production alone will cost an estimated $6-7 billion for the construction of 130 FSX aircraft by the year 2001.[39] Aircraft deliveries were originally expected by the Fall of 1997, although project delays have moved that date further into the future. General Dynamics will build the wings for two of the six prototype aircraft and will be responsible for the design, development, and production of the aft fuselage and the leading flaps. Some key avionics changes for the aircraft will be incorporated by the Japanese industry.

To advance the capabilities of its aerospace companies, and enable them to play a major role in an international consortium, Japan has taken steps toward developing a High Speed Civil Transport (HSCT). Three initiatives are underway: development of a turbojet/ramjet engine capable of up to Mach 5 speed;

R&D exploring heat-resistant composites and metals; and a study of aircraft airframes, aerodynamics, systems integration, market research, and social impact. The usual Japanese firms are involved. MITI has also invited foreign companies to participate in the engine phase. U.S. and European firms responded to MITI's invitation and an agreement was signed in February 1991, which included Pratt & Whitney, General Electric, Snecma, and Rolls-Royce. This effort marks the most extensive foreign participation yet in a Japanese research program. Pratt & Whitney and Rolls-Royce will also join Japan in a second R&D initiative involving new composite structures.

MITI is also interested in the development of a new 75-100 seat regional aircraft. Several foreign manufacturers have invited Japan to join their respective regional aircraft programs. Japanese manufacturers are studying whether to join one of these teams, or to initiate and lead their own effort, with a foreign partner.

Footnotes

1 Aerospace Industries Association (AIA), *Year-End Review and Forecast 1990*, Tables 2 and 8. Also data from the U.S. Department of Commerce/International Trade Administration/Office of Aerospace.

2 Department of Commerce/Office of Aerospace.

3 *Jane's All The World's Aircraft 1990-91*, Jane's Information Group, Alexandria, Virginia, section on International Programs.

4 Department of Commerce/Office of Aerospace.

5 European Commission, *The European Aerospace Industry Trading Position and Figures* (Brussels, Belgium: February 1, 1990), p. 228.

6 International Monetary Fund, *World Economic Order* (Washington, D.C.: October 1989), pp. 74, 78.

7 "World Travel Forecast," *The Aviation Economist*, Avmark Inc., November 1989, p. 10.

8 "Asian Aerospace Gets Bigger and Better," *Interavia Aerospace Review*, April 1990, p. 294.

9 "Start-up Briefing," *The Aviation Economist*, Avmark Inc., November-December 1990, pp. 8-9.

10 U.S. Arms Control and Disarmament Agency, *World Military Expenditures and Arms Transfers 1988* (Washington, D.C.: June 1989), pp. 28, 30.

11 *Jane's All The World's Aircraft 1990-91.*

12 Department of Commerce/Office of Aerospace.

13 Yasuichi Arao, *Aerospace Industry in Japan 1991*, The Society of Japanese Aerospace Companies, Inc., p. 14, 32. (For 1983, 237 Yen = $1; for 1989, 138 Yen = $1)

14 AIA, *Aerospace Facts & Figures 1990/91*, p. 13, and BDLI, *German Aerospace Industries Association Annual Report 1989/90*, p.17.

15 *European Aerospace Industry Trading Position and Figures*, February 1, 1990, p. 178.

16 Arao, *Aerospace Industry in Japan 1989-1990*, p. 14.

17 Japan's Constitution bans the use of force to settle international disputes, although it allows for defensive military forces. Japan created the Japan Defense Agency and the Self Defense Force in 1954 and policies were subsequently adopted to restrict these forces. One such policy prohibits military exports, although exports of dual-use items are permitted. In 1976, the Japanese Diet (Parliament) adopted the National Defense Program Outline, which provided guidelines for Japan's defense policies. In the Outline, total defense spending was restricted to one percent or less of the nation's GNP. In 1987, Prime Minister Nakasone's cabinet removed the one percent restriction.

18 Barbara Wanner, "Japan's Defense Industry," *Japan Economic Institute Report*, No. 30A, Japan Economic Institute (Washington, D.C.: August 3, 1990), p. 2.

19 AIA, *Aerospace Facts & Figures 1990/91*, p. 20.

20 The budget calls for the purchase of four Airborne Warning and Control System aircraft and the LTV multilauncher rocket system. *Aviation Week and Space Technology*, December 3, 1990, p. 13.

21 *The Wing Newsletter* (Japan's Aerospace and Aviation Weekly), January 9 and March 20, 1991.

22 AIA, *Aerospace Facts & Figures 1990/91*, p. 106.

[23] National Science Foundation, *International Science and Technology Data Update: 1988,* NSF 89-307 (Washington, D.C.: 1988), p. 6. plus additional NSF data through 1988.

[24] Arao, *Aerospace Industry in Japan 1989-1990*, p. 116.

[25] The Society of Japanese Aerospace Companies, Inc., Japanese Machinery Exporters' Association, *Aerospace Japan 1989-90*, pp. 10-12

[26] Daniel Todd and Jamie Simpson, *The World Aircraft Industry* (Dover, Mass: Auburn House Publishing Co., 1986), p. 211.

[27] The Rand Corporation, *Multinational Coproduction of Aerospace Programs*, R-2861-AF, Appendix A (Santa Monica, CA: October 1981).

[28] *Aerospace Japan 1989-90*, pp. 43, 3, 13-40.

[29] *The Wing Newsletter*, July 26, 1978 as cited in "Nihon no Heiki Kojo," Satoshi Kamata, October 15, 1983. Table most recently provided in *Japan Economic Institute Report*, No. 30A, August 3, 1990, p. 8.

[30] *Aviation Week and Space Technology*, February 4, 1980, p. 47.

[31] U.S. General Accounting Office, *U.S. Military Coproduction Programs Assist Japan In Developing Its Civil Aircraft Industry*, ID-82-23, March 18, 1982.

[32] Arao, *Aerospace Industry in Japan 1989-90*, pp. 23, 25.

[33] Japan's Ministry of Finance White Paper on International Trade in Japan 1989. These numbers cover only aircraft and parts trade.

[34] Society of Japanese Aerospace Companies, Inc., *Aircraft Industry in Japan 1990*, Figure 1 and 5-1.

[35] White Paper on International Trade in Japan 1989.

[36] *Aerospace Japan 1989-90*, p. 12.

[37] Department of Commerce/Office of Aerospace.

[38] Compiled by the U.S. Department of Commerce.

[39] Due to delays brought about by prolonged negotiations and Japanese source code development, the estimated costs of the FSX have risen substantially above the original contract.

JAPANESE INTERNATIONAL PARTNERSHIPS

COMMERCIAL AIRCRAFT

767—Japan's Civil Transport Development Corporation (CTDC) was set up to initiate a program with a foreign partner to succeed the failed YS-11 commuter aircraft program. In 1978, CTDC joined with Boeing and Aeritalia (now Alenia) to assist in the Boeing 767 (175-210 seat) program. Once the aircraft was certified, CTDC transferred Japan's responsibilities to the Commercial Airplane Company (CAC)—a consortium owned by MHI, KHI, and FHI. CAC's three members are responsible for designing and producing the fuselage, the wing to body fairing, and the wing ribs. This work accounts for approximately 15 percent of the airframe value and 15 percent of the 767's development costs. Since CAC provided a share of the program's development costs it will also share in the program's profit or loss. In 1990, CAC agreed with Boeing in principle to build an additional 500 subsets for the 767 program. The importance of the 767 project is reflected in Japan's export figures. In 1989, Japanese exports of 767 parts and sections accounted for 23 percent of Japan's aerospace exports.[1]

7J7—As a follow-on to the 767 program, the Japan Aircraft Development Corporation (formerly the CTDC) signed an agreement with Boeing in 1984 to work on the 150-seat 7J7 propfan project. Under the agreement, Japanese firms would provide 25 percent of the project's development costs, receive 25 percent of the airframe work, and be full equity partners. As full partners, Japanese manufacturers would participate in total aircraft design, development, production, marketing, and support. Initial marketing efforts indicated that airlines were not then interested in the new fuel-efficient propfan engine concept and the 7J7 program was delayed indefinitely. Nevertheless, Japanese R&D for the project continues.

777—Following the 7J7 program postponement, Japanese manufacturers looked for a project to increase their design/production involvement and move them into a full partnership role. In 1990, Boeing offered Japanese firms a substantial program role on a twin-engine, 350-390 passenger widebody called the 767x (777). The program launch cost has been estimated as high as $5 billion. To confer partnership status, Boeing required project equity of 25 percent. Boeing encouraged Japanese participation to defray the program's high development costs and to enhance its close relationship with its Japanese airline customers. Due to the considerable cost, the potential strain on Japan's supply of engineers, and a tense political climate in the United States over collaborative efforts with Japan, the Japanese did not accept the equity offer. Instead, they will supply Boeing with up to 21 percent of the airframe components.

For the 777, Japanese firms will produce the same subsets they now produce for the 767, plus some related components. They will place approximately 250 engineers in Boeing's program office and will be regularly briefed as to marketing results, aircraft progress, test results, and so forth. Nevertheless, they will not be privy to technical procedures involved in assembling the aircraft, nor will they attend negotiations with potential customers.

BK-117—In 1977, KHI and the West German company MBB began joint development and production of an eight-seat utility helicopter called the BK-117. Each company has a 50 percent share of the work. KHI is producing the main transmission, fuselage, and control system. Once components are produced, each company exchanges its components with the other partner and final assembly occurs in both Japan and Germany. Customer deliveries began in 1983; 300 units had been delivered as of summer 1990. [2]

COMMERCIAL ENGINES

V2500—The V2500 project is a joint international effort to produce a high-performance, low-noise, low-pollution fanjet engine for a 150-passenger transport. The project got underway in 1983 as companies from five nations—the United States, Japan, the United Kingdom, West Germany, and Italy formed a company called International Aero Engines. Pratt & Whitney and Rolls-Royce have the leading shares in the project. In Japan, IHI, MHI, and KHI set up a joint venture company called Japan Aero Engines Corporation to coordinate their effort. In total, Japanese companies have a 23 percent share of the V2500 work. Japan Aero Engines Corporation is responsible for providing the fan, the low pressure compressor, part of the high pressure compressor and part of the turbine. Engine sections are manufactured by each team and delivered as modules for assembly. The only technology transfer concerns modular interfacing.

GE90—In June 1990, IHI announced that it will work with General Electric as a full partner to develop, produce, and market the GE90—the largest aircraft power-plant to date. The GE90 will be used on the Boeing 777. General Electric is expected to have 60 percent of the work involved, Snecma 25 percent, and IHI 7 percent. Volvo of Sweden and Fiat of Italy will perform the remainder of the work. IHI expects to develop the low-pressure turbines jointly with Fiat.

PW4000 Growth—MHI and KHI will receive a 1 percent share of work in Pratt & Whitney's PW 4000 engine, which will power large aircraft such as the Boeing 777.

Trent 800—IHI and KHI will receive 5 percent and 3 percent workshares, respectively, on Rolls-Royce's new Trent 800 power plant. This engine will also power large commercial passenger jets such as the Boeing 777.

[1] *The Wing Newsletter* (Japan's Aerospace and Aviation Weekly), March 18, 1990.
[2] *Aerospace Japan Weekly*, July 16, 1990

The International Space Market

Increasing Cooperation and a Changing U.S. Role

The U. S. maintains an across-the-board space program, while other nations target specific areas of expertise. The U. S. faces vigorous competition in commercial areas.

The U. S. must reduce differences between the way it does business in space with the way other nations do business—using political and economic muscle to help their space industries compete.

The U. S. needs a concept of space leadership that permits bold new activities within more limited federal budgets.

At the dawn of the space age in the late 1950s, only two nations, the United States and the Soviet Union, had the technological ability to gain access to space. Both saw their relative power measured by military potential and perceived outer space as advantageous territory. In the United States, terms such as the "missile gap" were rallying cries for the buildup of technology and defense capabilities.

The race to the Moon in the 1960s was a civilian effort—a politically-motivated program intended to demonstrate U.S. technological superiority, particularly after the embarrassment of the Soviet launching of Sputnik in 1957. The development of heavy lift vehicles for the Apollo program, and knowledge gained in all areas of space activity, also had national security uses. Competition between the Soviet Union and the United States was the paramount motivation for the American space program. The United States did share scientific data from civilian space programs with other nations. It also cooperated internationally in establishing worldwide satellite communications capabilities. But the sophisticated guidance systems, electronics, computer software, materials research and propulsion equipment were produced in the United States almost exclusively for U.S. Government needs.

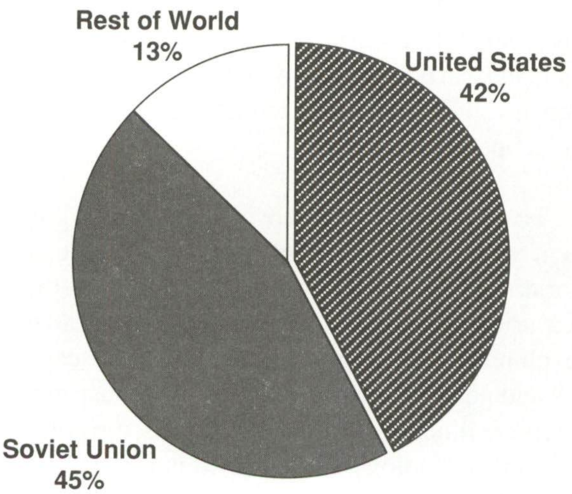
Today, superpowers no longer have a monopoly in space and any nation with the ability to pay for a launch can have access to space. At least seven nations have launch facilities and dedicated launch vehicles (although not all can launch special or heavy payloads).[1] Many more nations have industrial and technological capabilities that permit them to manufacture both components and full space systems. Among Western nations, industrial capabilities in space products and services are rapidly developing into competitive business opportunities. A private company can now build—or purchase—satellites and launch vehicles as well as launch services and subsequent operations support.

However, space is still overwhelmingly a government sector activity. Well over 95 percent of the world's investment in space comes from government treasuries. Most of the investment is for research and development of new vehicles, new satellite capabilities and new major space systems. Because governments are funding most space activities, the initial use of space technology is for public purposes, such as national security, environmental monitoring, treaty verification and basic research. However, because industrial firms and laboratories are actually performing the government work, expertise in advanced state-of-the-art technologies is developing and could result in interesting and profitable new business opportunities.

Worldwide Space Investment

Although total space-related investments are difficult to precisely measure, it is estimated that nearly $80 billion is being spent worldwide on space and space-related activities.[2] Of this, 42 percent (slightly less than $35 billion a year) is being spent by the United States, 45 percent (slightly more than $35 billion) by the Soviet Union and 13 percent (about $20 billion) by the rest of the world (Figure 1).* In the Rest of the World category, Europe invests about 40 percent, China 30 percent, Japan 15 percent, and all other nations together about 15 percent (Figure 2). In Europe, France spends just under 60 percent of the total space investment; Germany is next with 21 percent of the total (Figure 3). Italy has rapidly increased its financial interest in space activities in recent years and now accounts for approximately 15 percent of the European investment in space R&D. The other nations, with the exception of the United Kingdom, invest little on a global scale in space. The United Kingdom, once a major investor and leader in launch vehicles and space research, has significantly decreased its relative share of European space investment. However, it is still a major investor in the satellite communications industry. To put the investment in space in perspective, the worldwide total of $80 billion is greater than the Gross Domestic Products (GDP) of Turkey, Greece and Portugal, and only slightly less than the GDP of Norway.[3]

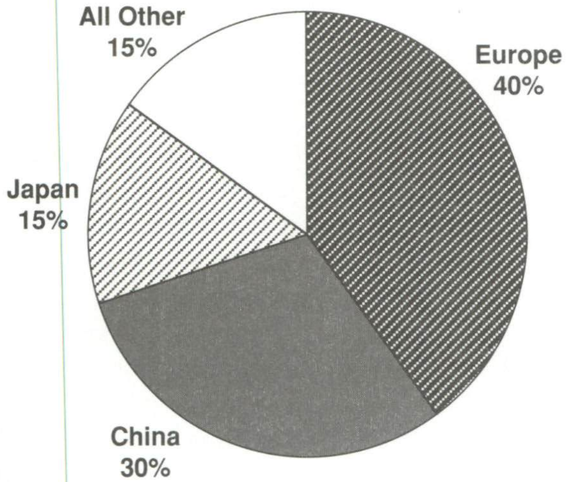
Figure 1
Distribution of Worldwide Space Expenditures



Although a common perception is that, in recent years, the United States has lagged in its investment in space R&D relative to the rest of the world, the data show otherwise. The ratio of U. S. civilian space R&D (government programs) to European spending was 35:1 during the height of the Apollo program in 1965. By 1975, 10 years later, that ratio had fallen to 4.3:1, reflecting both the decline of the U.S. space program and the buildup of capability in Europe. The ratio hit a low of 3.7:1 in 1980, but by 1988 had rebounded to 3.9:1[4] In absolute financial terms, the United States has actually increased its space expenditures relative to Europe, despite the dramatic growth of European investment in the past 10 years. And while not insignificant, Japan's expenditures are only one-third of Europe's. Nonetheless, evidence is mounting that other nations are technologically ahead in many areas of space activity and are aiming for direct competition with the United States. A review of foreign investment in space shows that while the United States continues to take a geo-political view of space, other nations are taking a more narrowly economic approach. And while the United States continues to concentrate on a full, across-the-board space program, other countries are targeting particular areas of expertise.

* *Events in the Soviet Union have placed financial constraints on the Soviet space program. It is difficult to predict the level of spending in the future, but it is likely the Soviets will have as strong a commitment to space as they can afford.*

Figure 2
Distribution of Space Investments Not Including US and USSR

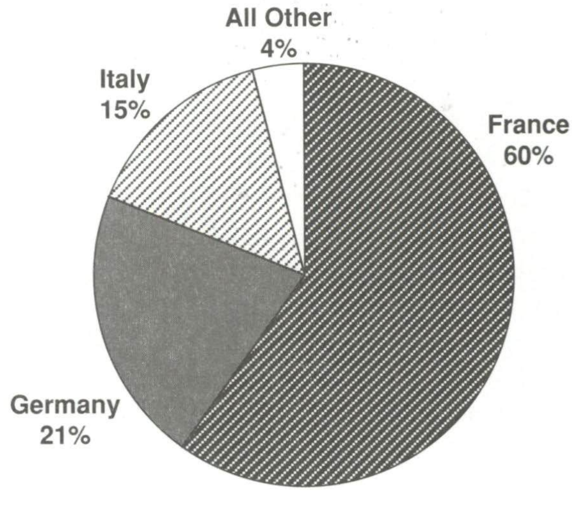


needed in future space programs. Except in the United States and the Soviet Union, a large part of this work is to train personnel and gain knowledge, experience, and resources for major investments in the future.

Even though it appears that Japan, the European Space Agency, and others are gearing for a full-service space program, the near-term realization of such a plan is unlikely. Still, relatively small investments in studies and enabling technologies can reveal specialties that will be essential to all nations in space and are likely to spin off near-term business opportunities.

In addition, foreign companies and banks are investing in American firms that specialize in space activities. For example, Matra, a large French aerospace company, purchased Fairchild Industries. A consortium of six Japanese companies that includes one of the largest banks in Japan, Japan Air Line, and Japanese industrial concerns that produce space hardware announced purchase of 10 percent of the

Figure 3
Distribution of European Space Investments



Increasing Foreign Dominance in Particular Areas of Space

Foreign government space expenditures show a tendency toward specialization in particular areas of space R&D. The two most active areas are communications and remote sensing. However, some nations have targeted materials processing in space (Germany) and terrestrial ground receiving equipment (Japan). For the most part, investment in communications and remote sensing reflects national purposes: security, treaty verification, land-use, environmental and agricultural planning and monitoring. But some of these applications will provide economic and competitive advantages for the investing country.

Most major nations are positioning themselves for a future in space. Multinational alliances are forming to study and evaluate investment in many areas, including manned space activities, long a province of the United States and the Soviet Union. Research is underway to develop the underlying technologies of propulsion, life sciences, materials and other areas stock of Spacehab.[5] Spacehab is a small U.S. firm established to produce and sell research facilities in the microgravity environment of outer space using the mid-deck of the Space Shuttle.

Investments in materials processing and ground receiving equipment represent an investment aimed at long-term economic, competitive gain. For example, the Japanese have positioned themselves to capture the satellite receiving equipment market. If direct broadcast TV materializes, their current investments in terrestrially-based technologies will place them in the forefront of the market for consumer receiving equipment from satellite transmissions. Unlike the small scale (but big ticket) production of satellites, launch vehicles, and other space-based equipment, the mass production consumer equipment market represents vast potential profits.

Future products resulting from space R&D offer U.S. companies truly rich opportunities to capitalize on its large government and private space R&D investment and know-how. However, the U.S. space industry is geared primarily to government programs and there is a serious lack of interest in consumer products. As Figure 4 illustrates, in the future, the United States can expect vigorous competition in areas that promise large economic rewards.

Major Issues in U.S. Space Policy

U.S. Needs New Leadership Concept

Achieving and maintaining leadership in space has been a fundamental objective guiding U.S. space activities since it was first enunciated in the National Aeronautics and Space Administration (NASA) Act of 1958.[6] Often since then—and despite a willingness to share data and know-how in numerous joint projects—the United States has had a tendency to treat other countries as junior partners. Now, however, most major foreign space research institutions are flexing their muscles. The European Space Agency (ESA), in particular, is demanding an equal partner role in negotiations with the United States on cooperative programs.[7] More and more, other nations are forming alliances in space endeavors that do not include the United States. Organizations such as ESA, France's Arianespace, Japan's NASDA, and so on, have their own independent capabilities equal to, or in some cases exceeding, those of the United States.

In commercial remote sensing, for example, the United States has wavered and sent mixed signals about its continued support to industry, both in R&D and in operations. France, meanwhile, has systematically and consistently supported its program in remote sensing and continues to provide satellites and data to SpotImage to sell. Other nations have supported their remote sensing systems and have equalled or exceeded the United States in civilian remote sensing capabilities.

Space is a very multi-dimensional activity. As the complexity of space systems increases and as budgets remain stable or decrease, specialization will become more important and more expensive. Consistent with goals stated in the original 1958 NASA Act, the United States will remain a leader but may not remain *the* leader in all space activities.

The space leadership issue is complicated by the fact that the United States is without the resources to properly fund major new man-in-space initiatives such as the Space Station or the Lunar/Mars programs. Meanwhile, it faces serious foreign competition for bread and butter space programs with commercial potential. Where there is congruence between building strategic hardware (government programs primarily for government purposes) and commercial markets, other nations will use their political and economic muscle to compete. And, since there is no sharp distinction between government and industry ownership of resources in other nations as in the United States, American firms in the same markets will suffer a competitive disadvantage. The reality of the 1990s is that economics will be a primary driver of space development.

Figure 4

Relative Specialization in Government Space Expenditures

Country	Area of Large Relative Expenditure	Percent of National Space Budget
France	Space Transportation: Launch Systems	40 %
	Earth Observations	22 %
Japan	Space Transportation: Launch Systems	60 %
Germany	Space Transportation	32 %
	Space Science	22 %
Italy	Communications	31 %
United Kingdom	Earth Observations	26 %
	Space Science	20 %
Canada	Remote Sensing	39 %
	Space Station/Robotics	29 %

Other Targeted Space Disciplines

(Derived from Reviews of Industrial and Government Programs)

Country	Target Area
France	Remote Sensing
	Largest Comprehensive Program in Europe
Germany	Materials Processing
Italy	Scientific Satellites
Brazil	Launch Vehicles and Systems
China	Launch Vehicles and Systems
India	Launch Vehicles and Systems
	Communications Satellites
	Remote Sensing
Japan	Communications Satellites
	Remote Sensing
	Terrestrial Receiving Equipment

Since the early 1970s, it has been apparent that the finances, technology, and management of the Space Shuttle would not parallel that of the Apollo program. For twenty years, the U.S. Government budget for space has been tight, and funds that were promised to the space program never materialized. To accommodate reduced budgets, NASA attempted to build parts of the technologically new and complex Shuttle with "off the shelf" technology. Original plans for seven vehicles were reduced to four. With the new Space Station program—the "next logical step"—still awaiting adequate funding, similar scaling-back efforts are underway. Designs are being drawn and redrawn and there are no plans for backup hardware in case of failures.

NASA, an organization that grew up managing large-scale programs, is geared to the development of major man-in-space projects. Without a flagship program, the agency is sometimes perceived to be floundering and ineffective, even though many of the lower-budget science and technology initiatives in space show great success.

Given the financial and human resources to do the job correctly, the enormous technological problems associated with major space efforts can be solved and programs will be successful. However, the cost is very large and sustaining a large investment over time requires a political consensus that the projects are worth doing. Another approach is possible—one that does not mean abandoning leadership. NASA and other agencies involved in space activities can continue to plan for future large-scale programs in space—such as the Space Exploration Initiative. The Government can commit to a level of effort that would identify enabling technological needs for the SEI program and begin to fund shorter-term projects that will provide the basis for future big programs.

Discrete short-term goals in space serve several purposes. First, a number of successes that are achievable in a year or two will help change NASA's image of repeated technological failures. Second, new technologies may emerge that will leapfrog existing know-how and shave the costs of major initiatives in the future. Third, spinoff technologies may create new market opportunities for U.S. firms. Finally, NASA will be able to live more comfortably within its budget and still show results—while planning ahead.

Structural/Policy Obstacles to U.S. Space Competitiveness

Lack of Civilian & Defense Technology Sharing

Until the mid-1970s, the major U.S. investment in space R&D was civilian, mainly in support of the Apollo and Shuttle programs.[8] In the mid-1970s, defense expenditures in space R&D began to rise rapidly, accounting for the majority of the government's investments in space. This trend continued through the 1980s, spurred in part by the Strategic Defense Initiative (SDI). Although SDI may not receive the same level of funding in the 1990s, the supporting space technologies are still important research items in the defense budget, which continues to exceed NASA and other civilian agency space budgets.

When NASA was formed in 1958, there was a clear mandate for a civil space program for the peaceful use of space. A clear organizational break was made between civil- and military-oriented R&D. Even though NASA and the DoD share several common bonds, this division of purpose and identity continues today.[9] At the same time, research for one purpose has application for the other. As space research becomes more expensive, complex and risky, the need to share technology between the DoD and NASA (and vice versa) becomes more important for successful programs. However, the historical division which has prevented sharing of some types of military and civilian research results, has meant that opportunities to capitalize on U.S. Government-sponsored space research have been lost. One example is in the remote sensing industry (see Box). There are many others.

Position on Industrial Policy

In the United States, direct aid to new businesses in particular industries, or new elements of existing businesses, has the negative connotation of "industrial policy." It is often highly controversial—as in the recent case of the removal of the director of the Defense Advanced Research Projects Agency (DARPA), who sought an active financial role for DARPA in a firm in the semiconductor industry.

Actually, whatever it is called, the United States engages in industrial policy at different times for different reasons. The development of the railroads and the West would not have occurred without government support. Commercial aviation was encouraged from policies that included National Advisory Committee for Aeronautics' R&D support, post office contracts for air mail delivery, air traffic control operations, and improved weather forecasts. In the 1950s, enabling legislation for improvements to the nation's road system was couched in terms of national defense and mobilization needs. Nevertheless, upgrading of the highway system directly benefitted various sectors including the interstate trucking, construction and construction materials, automobiles, and petroleum industries. The impacts on industrial development, land use, transportation, and so on, shaped U.S. cities, suburbs and industry over the past 35 years in ways that were unforeseen by Congress in the 1950s.

COMPETING WITH HANDS TIED: U.S. REMOTE SENSING INDUSTRY

An example of how technology classification can hurt the U.S. competitively can be found in the remote sensing market. The National Aeronautics and Space Administration (NASA) was permitted to develop sensors with a resolution of 30 meters on the original Landsat satellites, and 10 meters with the more advanced thematic mapper instruments on later Landsats.

By Executive agreement, NASA was not permitted to develop or use instruments that showed resolution less than 10 meters. This agreement was classified information until the late 1970s—meanwhile, the Department of Defense was performing research on advanced sensors with less than 10 meter resolution.

During the 1980s, France developed its own remote sensing instruments, some with resolutions greater than that allowed to United States commercial firms. The Soviet Union, which also developed images with a high degree of resolution, has offered them for sale to the public. The U.S. remote sensing industry now finds itself behind other nations in certain types of products.

Government can clearly support business without getting involved in the choosing of winners and losers—or artificially supporting decaying or noncompetitive industries. Still, in an era of adversarial relations between government and industry, negative attitudes toward direct government support of business continue—and carry over to the research and development relationship. The government heavily supports R&D, which is largely performed by industry and universities, but often government/industry cooperation is clouded by excessive rules, regulations, restrictions, and an attitude of distrust.

As with prior transportation infrastructure programs, the government has a fairly well-defined policy of stimulating particular firms and industry in the space sector through both R&D and operational funds. Examples abound in space infrastructure and transportation. There are even expenditures to develop infant industries (materials and other advanced research in space).

In the space launch vehicle industry, the government hopes that through large military orders, major vehicle manufacturers will realize economies of scale—reducing operating costs while improving methods of production, develop advanced vehicles through internal R&D efforts, and adapt the vehicles developed for DoD for commercial purposes. In addition, restricting government payload launches to U.S. vehicles creates markets for those manufacturers.

Another example is the stimulation of space research through the Space Shuttle and Space Station programs. NASA has made space available to industry to perform research at practically no cost.[10] Eventually NASA will have policies of cost reimbursement and other charges for the use of the system, but initially the opportunity has been offered to U.S. industry to get a head start on foreign competitors.

Despite these instances of government support, in one form or another, virtually every foreign nation has policies that are more aggressive than those of the United States. Other countries pump funds into the development of space with the specific intention of stimulating their own firms in world competition for related products and services. In this regard, it becomes not so much a matter of comparison of U.S. subsidies to stimulate space R&D with other nations' subsidies, but a comparison of the underlying purpose and motivation of the investments.[11]

The commercial orientation of foreign government support is reflected in the ownership of equity in firms in the space business. CNES, the French Government Space Agency, owns equity in Arianespace and in SpotImage, as well as in many other French companies that are suppliers to space businesses.[12] This direct government interest in the companies stimulates cooperation between government and industry. In addition, equity owners are financial institutions that can provide an infusion of money if needed. The atmosphere is one of partnership.

In the United States, the government rarely has equity in private companies and U.S. financial institutions generally lend money but do not take strong equity positions. There is an atmosphere between government and industry—not of partnership, but of competing interests.

Lack of Coordinated Government Action and Consistent Policy

The U.S. space program started as a coordinated effort. The Apollo program, the first major space initiative, was focused almost entirely within NASA, under the overall supervision of the Vice President. Since the early 1970s, a number of additional agencies have become involved in the management of space-related programs. The Departments of Defense, Agriculture, Commerce, State, and Transportation have major stakes in space activity. The Office of Science and Technology Policy, the U.S. Trade Representative and the Office of Management and Budget (OMB) are involved in decision-making. Coordination among these parties has varied over the years, but has never been smooth. The locus of U.S. space policy changes depending on the question asked. Recently formed inter-governmental groups such as the National Space Council are attempting to resolve these issues, but the problem goes deeply into the organization of the government.

U.S. policy with regard to international space cooperation and competition has been inconsistent. Major initiatives of NASA to jointly fund and perform R&D in space with other nations have had very mixed histories. One problem has been financial.[13] Often a U.S. Government agency will negotiate an agreement, only to find several years downstream that the U.S. Congress or the OMB has cut the budget for the program. U.S. agreements in space are often in the form of Memorandums of Understanding (MOUs). This type of agreement is not as binding as a treaty and can be changed by an agency. However, abroad, some of these MOUs are recognized by foreign governments as having the legal status of treaties and other governments have made long-term commitments in reliance on United States' promises.[14] Forced cancellation of U.S. participation in some programs has hurt the nation's reputation as a reliable space partner.

Policy flip-flops on international positions have also hurt the United States. For example, U.S. Government satellites must fly on U.S.-made launch vehicles while U.S. private payload owners may choose on the open market. But, until recently, U.S. payload owners could not fly on Chinese or Soviet rockets. Now, a limited number of U.S. satellites can be launched on the Chinese Long March. And recently, the government gave permission for private U.S. payloads to use the Russian Zenit launch vehicle if and when it operates from Australia's proposed spaceport. In spite of the U.S. free trade position, restrictions still apply to launch vehicles. Foreign firms such as Arianespace cannot compete on the launch of U.S. Government payloads. In and of itself, this policy appears to be in the best interest of stimulating domestic launch vehicle demand. However, the Ariane family of vehicles are not competitive with the Chinese or Soviet vehicles because of pricing policy differences between the market economies of the United States, Japan and Europe and the nonmarket economies of China and Russia. The pricing of nonmarket economy vehicles is less likely to be based on the costs of manufacture and unfair competition may result.

Finally, U.S. commercial space policy has been inconsistent. Recent attempts to standardize policy have helped, but space matters are still largely subject to political pressure rather than market forces. When there are only 15 or 20 launches of commercial satellites a year, there cannot be a highly developed competitive market for services. Since communications satellites are still the only true space activities in the commercial sector, competitive space policy is largely relegated to the launch vehicle and communications satellite manufacturing sectors. Until a free, large and robust market develops, commercial space policy will continue to be *ad hoc* and somewhat unpredictable.

Cooperation and Competition

A very early and basic U.S. Government civilian space policy was that of "open skies," i.e., the United States was to make every effort to share knowledge gained from the exploration of space with the rest of the world. The earliest examples of joint government space programs between the United States and other nations involved scientific exchanges. Most often the United States was the source of the data and other nations provided personnel, equipment and other resources to aid in the evaluation of the data. Because of the nature of fundamental scientific information, and the United States' position as the leader in space exploration, there was virtually no criticism of the sharing of data and hardware. Scientific exchange continues as the easiest to negotiate and most popular form of government to government cooperative effort. But as programs move toward hardware-oriented technology development with economic implications, international cooperation becomes more complicated.

Space policy is closely linked with national security and leadership issues which, in turn, drive technology transfer policies as reflected in U.S. export controls.[15] Historically, a major objective of export controls has been to prevent U.S. advanced technology from entering the Soviet bloc. In the aftermath of the Cold War, export policies are changing and a new relationship between national security and economic and commercial policies is likely to emerge. The United States will be rethinking its policies vis a vis new entrants into the space market who—as new market entrants do—are searching for market niches and are often willing to obtain them at a short-term loss. As it does so, the issue of technology ownership and transfer will become the most sensitive issue in negotiations between governments and between firms in international agreements.

Figure 6 in *Aerospace Technology Trends and Strategies* shows different perspectives of cooperation and competition and makes clear why future space activities cannot occur in isolation. Some forms of international partnerships are necessary considerations for any new space activity. Competition and cooperation are not polar opposites. They exist together and both are necessary for economic growth and advancement. The policy issues revolve around unfair competition and how cooperative agreements should be structured for mutual benefit.

Other nations have become less dependent on the United States for space technology. In some space fields the barriers to entry have fallen and U.S. leadership and cooperation are no longer essential. Consortia of nations that do not include the United States exist and are forging ahead with state-of-the-art programs.

Projection of U.S. Position in Space Activities in the Next 10 Years

The United States is committed to a serious space program. Billions of dollars have been spent in research and in space-based equipment over the past 30 years. And although the emphasis may shift between civilian and defense spending—and also within the technological areas encompassed by space initiatives—U.S. space expenditures will remain at a level that supports current activity and permits some programmatic growth. However, large increases—earmarked for major new space activities—are unlikely to be realized for several reasons, including:

- continued U.S. budget deficit putting pressure on high cost, discretionary expenditures,
- risk of failures in space initiatives as dramatized by Challenger, the Hubble Telescope and other recent problems,
- lack of perception of a political or military "race" with the Soviet Union or other nations, and
- competition with other Big Science programs such as mapping of the Human Genome or the Superconducting Supercollider. [16]

Similarly, large cuts in the space program are just as unlikely because:

- there are proven uses of space for communications and weather forecasting that need to be maintained,
- the military has committed large resources for long-term space programs (the war with Iraq demonstrates the importance of space systems such as surveillance satellites and defensive weapons systems that might be developed from, for example, the Strategic Defense Initiative), and
- technological spinoffs from space R&D contribute to economic development, as do the direct expen-

ditures needed to provide for a cadre of trained scientists, engineers, and research institutions to maintain past investment and provide reserve capacity.

The possibility of large cuts in the space budget is even less likely, in fact, than the possibility of large increases. It is more likely that ambitious long-range exploration programs will be postponed.

Largest, Most Complete Space Capability

Over the next ten years, the United States will have a broad capability in space, spanning virtually everything from sounding rockets to heavy-lift vehicles. U.S. launch capability will be maintained, partly by the commercial sector, but primarily by the continuing need to meet defense and large civil space R&D requirements. As long as the United States operates the Shuttle as a R&D vehicle, U.S. industry will have opportunities to perform advanced research in space. However, the USSR is now offering research opportunities on its space station MIR and on other vehicles for both private and governmental research.[17] As they, and others, offer this capability, the advantages of space access available to U.S. industry from a robust domestic space program will diminish. It will be important to offer U.S. researchers access to space at competitive prices, and on a schedule they can count on.

Growing Commercial Activity in Terrestrial Operations

Opportunities in earth-based operations support of research, development and production involve relatively little risk compared to space-based equipment and manufacturing. The majority of such services are presently provided to the government. However, growing commercial interest in space will mean a growing demand for terrestrial support services. These services include management of launch sites, communications and control services, and preparation and storage of payloads. The United States is very competitive in these kinds of services. For example, an American firm, United Technologies, was chosen to manage the operations of a planned space launch site in Australia.

Involvement in space services ventures has the advantage of putting firms in an on-site, hands-on position to learn the technologies and uses of space, and eventually to design and produce space-based products.

Delays and Postponements of Big-Ticket Programs

An inevitable consequence of a successful long-term R&D program in a scientific or engineering specialty is that new accomplishments build on past accomplishments. At the same time, the cost of research increases at an increasing rate and the probabilities of future success decrease. Risks of new projects are determined by the risk of the new technology being successful multiplied by the risks of integrating two or more technologies and having them work together. There are mitigating factors that can delay this phenomenon, including major scientific or technological breakthroughs that leapfrog over incremental improvements. However, sooner or later both costs and risks of continued research in a particular field increase.

For example, in space transportation, simple rockets are replaced by multi-stage rockets. One-payload launch vehicles are replaced by vehicles capable of launching two or more payloads. In communications, satellites with several transponders that can last several years are replaced by platforms with many transponders and other instruments capable of being refitted and lasting many years. In remote sensing, passive systems with only several spectral bands are replaced by active and passive systems with many bands. Astronomical research done through the use of terrestrial telescopes may now be possible through complicated space-based telescopes.

The Challenger accident and problems with the Hubble telescope illustrate the cost, scope, complexity and risks of programs involving advanced space

THE SPACE INDUSTRY

Space is a relatively new industry without the well-defined production and trade profiles of other manufacturing sectors. Today's "space industry" is a hybrid of large firms primarily engaged in other activities besides space (such as defense contracting), alongside new firms devoted entirely to space activities.

Because the largest financial outlays have been required to get to and return from space, space transportation has dominated the industry thus far. As a result, defense and
aeronautics suppliers with government contracting experience frequently define the industry. However, the emerging space industry also encompasses a multitude of other types of firms, providing:

- Electronics hardware (satellites and guidance systems)
- Computer software
- Advanced and special instrumentation for research
- Launch services (including storage and maintenance of payloads, scheduling, fueling of
  rockets, downrange communications and control)
- Research (microgravity environments, materials)
- Marketing (selling research space on space-based labs)
- Finance
- Insurance
- Technology brokerage

Testimony to the embryonic status of the world space industry is the fact that reliable data are not yet available. Most nations report expenditures for government programs alone. Data on industrial sales of space and space-related equipment and services may not be accurately categorized, may include double-counting (as sales to government entities as well as government expenditures) or may be omitted (proprietary company data).

Most available U.S. data on space includes both the space transportation equipment sector (SIC 376) and the satellite manufacturing sector (part of SIC 366). Space-related business also includes important elements of computer hardware, business services (software development, financial and insurance services, management services), engineering services, and university and government laboratories. Also missing are components of the chemical industry (propulsion fuels, etc. . . .) and instruments (e.g., optical instruments for remote sensing applications as well as medical instruments for astronautical monitoring).

equipment and instruments. In the next decade, it will be difficult to achieve a political consensus that space research is of sufficient priority to command the resources necessary to build all of the ambitious programs the space community may request. Achievement of consensus will be made more difficult because there is no longer an overriding reason to speed up space exploration to meet a Soviet threat. Therefore, it will be important to choose major projects carefully, and to manage them to minimize risks and costs.

Lag in Private Space Investment

With the exception of government contract work and communications satellites, there is not yet much opportunity to make money in space, and therefore a noticeable lack of commercial interest in space investment. Companies formed to provide private research facilities in space or to operate launch vehicles have had difficulty getting the financial community to invest; even when they do, success is more often tied to government contracts than to private purchase guarantees. As the space industry matures this could change, but currently space investments seem to lie beyond the financial planning horizons of most companies.

Part of the problem is the lack of infrastructure to support a commercial space industry. The industry that has made money in space—communication satellites—required significant government spending to develop the systems and technologies that enabled it to be profitable. With the advent of longer-life electronics and the development of fiber optics, the communication satellite market itself is not likely to continue to expand as it did in the 1970s and 1980s. Non-government space business is therefore unlikely to attract much private investment unless major new technologies or markets are identified.

Identification of useful products and services that can flow from space systems will require an infrastructure of support. Increased private access to government facilities and technology could speed development of commercial opportunities in space. It has also been suggested that space operations and commerce be separated from space research and development in the government agencies involved. Technical or service areas where the United States can be competitive could also be removed from the federal budget process and developed through a quasi-government organization that can enter into contracts and price products and services according to market conditions. This would provide a business framework for commercial partnerships with the government, and allow U.S. firms to compete with foreign firms on an equal footing—including having the option of entering into mutually beneficial joint ventures with foreign governments or firms.

Exclusion from International Joint Ventures

Not only the United States, but *all* nations, are making careful assessments of their investments in space. Beyond having a presence in space and positioning themselves for future opportunities, most nations are cautious about large commitments. However, through alliances, they are gaining information and access to all areas of space technology and will be in a position to increase those investments.

For the United States and the Soviet Union the major question is whether to sizably augment existing budgets for new exploratory programs. For other nations, the question is whether space technology development will have economic payoffs. Because the commercial success of space technologies is closely tied to the availability and operations of the space infrastructures developed by the two superpowers, these questions are closely interrelated.

Nevertheless, over the next decade—as other nation's space capabilities mature and the access to space for all types of payloads is available from a variety of providers—dependency on the two major space programs will be lessened. This will open the way for more independent decisions from other nations. Under these circumstances, the United States is vulnerable to being left out of many agreements. Other nations, working together, will have technology with which they can expect to compete—making U.S. participation nonessential.

The United States can benefit from cooperation if it picks partners carefully (particularly where economic interests are at stake). Figure 4, which notes areas of specialization of various nations, provides strong signals for choosing partners in projects of mutual interest. Given the legitimate need to protect certain technologies, the United States stands to benefit from carefully considered cooperative agreements. In space, as in other aerospace markets, countries and companies will be cooperating *in order to* compete.

Footnotes

[1] The United States, Soviet Union, France, Japan, China, India and Israel have all successfully launched satellites and other payloads. Other nations such as Norway, Sweden, Brazil and Australia are either launching small sounding rockets or have plans to develop major launch facilities.

[2] It is difficult to arrive at an estimate of worldwide space activity for several reasons: exchange rate fluctuations make international comparisons difficult over time and imprecise within a particular year; defense-related space expenditures are often classified and, even when published, an accurate accounting of costs of personnel and facilities that have dual purposes is not usually possible; and statistical reporting methods vary across nations. It is not clear in their data whether propulsion and engines data include related space components or not); and, finally, most national space data are reported on government programs alone.

[3] Organization for Economic Cooperation and Development (OECD) Gross Domestic Products statistics for 1988: Norway - $91.18 billion, Turkey - $70.6 billion, Greece - $52.5 billion, and Portugal - $41.7 billion.

[4] *European Space Directory, 1989,* sponsored by Eurospace (Paris, France: 4th ed. 1989). Calculations are based on NASA and other nonDoD government space expenditures compared to totals for Europe in corresponding years. An assumption is made that there were no European expenditures for defense purposes in space activities.

[5] *Wall Street Journal*, June 5, 1990, p. A13.

[6] For example, see 42 USC 2451; *Fact Sheet on U.S. Civil Space Policy*, October 11, 1978; *Fact Sheet for Presidential Directive on National Space Policy*, February 11, 1988.

[7] Pryke, Ian, "The USA and International Cooperation," *AAS Space Times*, July/August, 1987 (American Astronautical Society).

[8] Military procurement of guided missiles, advanced electronic guidance systems and other space-related technologies is normally not included in the statistical comparisons of expenditures in space R&D between DoD and NASA. However, if one were to include these acquisitions, the total expenditures of the government in defense-related aspects of space would have been greater than the civilian expenditures.

[9] Many NASA field centers are located adjacent to military installations. Launch sites such as the Kennedy Space Center serve dual purposes: launching both civil and military payloads. The Space Shuttle, primarily a civil vehicle, is also used for classified launches. The manufacture of expendable launch vehicles for the DoD has been tied to stimulating a civil industry as well. The National Aerospace Plane program is run jointly by the Air Force and NASA.

[10] However, there are hidden costs to this program.

NASA makes space available at its convenience—a schedule is hard for industry to predict. The costs to industry of cooperating with the government are significant: a number of regulations must be complied with, there is a great deal of paperwork, and the risk of proprietary research becoming public knowledge.

[11] The Convention establishing the European Space Agency states in Article II (d), "The purpose of the Agency . . . by elaborating and implementing the industrial policy appropriate to its programme and by recommending a coherent industry policy to the Member States." Article VII states, " . . . improve the worldwide competitiveness of European industry . . . and the development of an industrial structure appropriate to market requirements."

[12] See, for example, Arianespace, *Annual Report, 1988*, p. 37.

[13] A recent example of this recurring problem concerns cancellation of the Omega/VIMS project, which is a U.S.-French experiment that was scheduled to fly on a 1994 Soviet Mars mission. See *Washington Post*, June 20, 1990.

[14] Conversation with Ian Pryke, ESA Washington Representative.

[15] U.S. Congress, *International Space Policy for the 1990s and Beyond*, Hearing before the Subcommittee on Space Science and Applications Committee on Science, Space, and Technology, House of Representatives, December 10, 1987, p. 51.

[16] Several events might trigger sizeable increases in government space expenditures in the foreseeable future: (1) a U.S. reaction to another nation's use of space for military purposes in violation of current United Nation's treaties, and (2) a major renewal of public interest in space as the result of a major discovery.

[17] In fact, a U.S. company, Payload Systems, Inc., has purchased space on the MIR for research purposes.

Technology Trends and Strategies

Cooperating and Competing for Aerospace Market Share

The U.S. needs a national strategy for nurturing generic, enabling technologies and fostering new technology development.

Decisions to cooperate internationally entail careful assessments about what technology must be held back for competitive advantage and national security—and what can be shared for today's sales, market access, and the benefit of commercial and defense alliances.

Technology—the application of knowledge to products and processes—is vital to the aerospace industry, yet technology development and application take considerable time and money. It can take from three or four to 15 years to field new technology. Extending system performance 5 or 10 percent beyond that previously possible can increase cost as much as 30 percent or more. The inherent high cost and risk involved are major reasons why companies are collaborating today— often with foreign partners.

Technology also sometimes inhibits collaboration. For technology leaders such as the United States, cooperation presents the *possibility* of losing a key element of business advantage, and a subsequent decline in competitiveness and market share. But loss of technology and market leadership is not an inevitable outcome of collaboration. Even technology leaders find partnerships useful to acquire technology in areas where others have made important advances. They also benefit by selling or sharing technology through licensing or other means in return for other advantages including access to foreign markets and funds to support their own continuing R&D.

Cost savings and market advantages are not the sole reason for cooperation. For years, the major driver of cooperation in the aerospace defense market was the mutual security of the United States and its allies. Security reasons continue to favor international cooperation.

Technology is clearly a pivotal issue for the aerospace industry. The following section explores the issue from several different viewpoints: first, it looks at a number of trends in technology and the role technology is playing in creating or impeding partnerships; second, it discusses how U.S. companies and the Government are approaching technology development and technology export issues.

Aerospace Technology Trends

- And the Role of Technology in International Partnerships

In aerospace, new technologies lead to materials that can function under the most extreme environmental conditions. They make it possible to process the ever-increasing amounts of information needed to extend the performance of aerospace products. Aerospace systems rely on advancements in a range of technical areas such as sensors, software, and integrated circuitry.

Revolutionary new products and subsystems, produced by new manufacturing methods and processes, will be possible through technology currently under development in aerospace. In the civil sector, the industry will be automating more, with auto land, satellite navigation, and better air traffic control systems. Major leaps in capability will be possible as supersonic and hypersonic technologies are developed. In the defense sector, innovation will occur faster than the customary 10-15 year cycles. A focus will be producing relatively cheap and unmanned weapons in quantity. There will also be extensive upgrading of existing systems. Software developments, advanced materials, and the use of computer-aided design and manufacture will help both civil and defense system manufacturers move more quickly to extend the capabilities of their products. And in basic aerodynamics, technology advances continue to play a key role in new and improved product concepts.

Several General Technology Trends Are Now Apparent

- Technology is becoming more expensive—and new technology content accounts for an increasing share of total aerospace project costs.

- More technology is dual-use—with both civil and military application
  - Spinoff from government-funded technology to commercial application is continuing,
  - Spin on from commercial to defense applications is increasing.

- The technology capabilities of U.S. aerospace industry competitors are growing.

- Nations are collaborating more to develop and apply new aerospace technology.

- Technology export controls are often a stumbling block to U.S. cooperation with other nations.

Technology Is More Expensive

The cost of developing new aircraft, engines or major aerospace subsystems—or extending their performance—can be prohibitive for a single company. More often, companies are doing this work through partnerships—often international partnerships. At the same time that technology costs are rising, the new technology content of aircraft and space vehicles is increasing. About 50 percent of the value of military fighter aircraft under development will be electronics, for example. The percentage of advanced electronics in space systems and tactical missiles is even higher. The demand for advanced materials, sensors, and software technology—to name a few—is similarly greater. The increased cost of high technology systems is directly related to increased risk. Technical advances can be conceived of much faster than they can be developed and implemented. The sophistication of current technologies means that, inherently, new developments have a tremendous risk of failure.

More Technology is Dual-Use

Some of today's aerospace technology has application in both civil and military systems and products. National defense budgets are devoted largely to gathering and processing information, improving communications on the field of battle as well as worldwide, and testing and supporting complex military equipment. The most advanced communications/information technology today is to be found in the commercial sector. Therefore, many of today's military systems, which are produced from materials, components and software imported from many countries, are based on civil products and technology. The distinction between military and civil use has become blurred—and this trend will continue as international collaboration increases. Declining defense budgets will foster the trend. Military planners are looking for ways to get the most from research and development and procurement dollars and they will tend to buy more commercial products for defense applications. In general, there will be more focus on technology development that promises commercial spinoff as well as defense systems applications.

In the past, government R&D programs have rarely attempted to foster commercial innovations but they have had significant spillover to commercial/civil sector applications. "Spinoffs" from the space program are frequently cited. Defense spending has paid off in the commercial sector, too—advanced computers and communications systems, and high performance jet engines are prime examples. There is disagreement on the extent of defense spending spinoff that will occur in the future. But, to one degree or another, it will continue.

On the other hand, there is growing awareness of the potential for "spin ons" from commercial to defense technology. Spin ons could prove particularly advantageous to U.S. competitors who excel in technology niche markets. For example, Japan may be able to develop a stronger position in defense systems production through its capabilities in electronics, developed originally for commercial markets. Because electronics will make up a significant share of aerospace products now being developed, and those envisioned, any nation with strong capabilities in this field will be a major player in both civil and military markets. Japan could very well parlay this market specialization, and other capabilities—in materials, for example—into broader aerospace capabilities.[1]

National Technology Capabilities Are On the Rise

The increasing technological muscle of aerospace and supporting industries in other countries is an important factor to be considered as the United States addresses its own technology development and control issues. In Europe and Japan, support of aerospace research and development is increasing, although total aerospace R&D funding is still dwarfed by that of the United States (see chapters on the Western European and Asia-Pacific Rim aerospace industries). As other countries' capabilities increase, they will have more to offer partnerships with the United States. They will also have more leverage for a stronger partnership position. At the same time, other countries may find partnerships with the United States less attractive and less essential.

Nations Are Collaborating More for R&D

Collaboration among nations in research and development is increasing. (As analysis elsewhere in this report points out, international collaboration in general is an important market strategy for companies in Europe and the Asia-Pacific Rim.) The European Council has established a community-wide budget for aeronautical R&D. The funds have been earmarked from contributions toward several larger Community-wide research efforts in the areas of information, telecommunications, manufacturing, and materials technologies. These broader research programs also have aerospace implications. Any number of company to company arrangements within Europe now have a joint R&D focus.

The Japanese, while actively pursuing international aerospace partnerships, are opening their own research projects to foreign participation, e.g., their invitation to U.S. and European firms to join in developing engine technology for high speed aircraft.

Overall, a multitude of linkages involving research and development are being established among firms in Europe, the United States and the Pacific Rim nations. Some examples appear in Appendix B.

Technology Export - Collaboration Stumbling Block for U.S.

Technology is an issue in most collaborations, but countries that are concentrated on entering the aerospace market—or developing a stronger market position—have less to fear from possible export of technological capability than the United States. For the United States—long an aerospace technology leader—decisions to cooperate with other nations entail careful and continuing assessments about what technology must be held back for future competitive advantage and national security—and what can be shared for today's sales, for market access, and the long-term mutual benefit of a range of commercial and defense alliances.

In the past, much technology export from the United States to other countries was premised upon developing those nations' industries for the sake of the western alliance. Today, with economic competitiveness assuming nearly as large a role in U.S. strategic thinking as military preparedness, U.S. policy makers have become more wary about technology transfer. At the same time, there continue to be sound national security reasons and cost savings associated with technology cooperation between the U.S. Government and other countries. For U.S. companies, there are also strategic business reasons to cooperate. Since aerospace markets no longer coincide with national borders, market access is often defined by partnerships. Partnerships, in turn, are frequently defined by the rules of other governments, who press for genuine technology sharing as the price of market access and project participation.

Technology export was at the heart of the controversy over U.S. Congressional approval of the FSX arrangement between General Dynamics and Japan — an arrangement fully approved and encouraged by the Pentagon and several U.S. administrations. One result was that Japan will be more cautious in the future regarding collaboration with the United States.

The United States' traditional ties to Europe make technology export a less politically explosive matter on transatlantic programs than in relationships with Japan. But even with Europe, it is a sensitive issue. Among Europeans there is a feeling that unless U.S. partners are willing to engage in what Europeans see as true collaboration—i.e., cooperation beginning with research and development—and to share state-of-the-art technology, then they would prefer to collaborate with other Europeans. Beyond that, it seems clear that European companies will be cooperating with firms in Japan or elsewhere in the Asia-Pacific Rim where there are enormous market possibilities. The agreement between Daimler-Benz and Mitsubishi to discuss a range of collaborative relationships, including aerospace opportunities, is indicative. An announced military cooperation agreement between France and South Korea is also evidence of increasing ties between Europe and Asia-Pacific Rim nations.

The fact is: U.S. aerospace firms are doing business in a market where cooperation between firms in different countries is becoming typical. U.S. companies must learn to structure cooperative agreements that benefit all partners, while retaining important technology advantages for themselves. The U.S. Government can help with policies that foster new technology development, and that remove impediments to global relationships. Currently, however, there is no coherent strategy to support U.S. international high-technology business interests. This has serious ramifications for the U.S. aerospace industry, whose continuing health depends upon being competitive globally.

Technology Strategy

- How the U.S. Government and Aerospace Companies Approach Technology Development & Export Issues

The absence of a strategy to foster technology—and address the technology-sharing issues that arise in a global industry such as aerospace—reflects the United States' free market inclinations and anti-industrial policy bias. Instead of a coherent approach to technology development and technology export issues as they impact international competitiveness, the United States pursues a path that is an *ad hoc* blend of U.S. Government and private industry initiatives, both offensive and defensive. If one were to describe the United States' approach, it might be said to include:

- R&D funding - with an ongoing assessment of national and international R&D funding levels and emphases,
- Keeping technology at home - defensive measures such as export controls or offset restrictions through which the Government attempts to inhibit technology export and protect domestic capability,
- Strategies to increase U.S. technology capabilities - offensive strategies such as teaming by U.S. companies for research and development on major government-funded technology initiatives, and targeted spending on critical technologies by both government and industry. Individual companies pursue a range of strategies to better position themselves in the market including acquiring technology through mergers or acquisition of other firms, and forming alliances with other U.S. companies that offer complementary capabilities, and
- International Cooperation - case-by-case decision-making about the value of international collaborations on the part of both companies and the government.

R&D Funding

What Should Be Funded - For How Much?

Industry globalization, the critical role of technology in both competition and cooperation, and the spiraling cost of technology—all force U.S. policy makers to ask where the United States should spend its available "technology dollars."

Debate over funding of R&D revolves around a number of concerns. These include the slowing rate of increase in U.S. R&D investment (2 percent between 1985 and 1989 versus 6 percent from 1981 to 1985, according to the National Science Foundation); the share of national R&D funding dedicated to defense versus nondefense R&D; and emphasis in recent federal budgets on funding major, long-term, and very costly scientific projects. In its FY 1992 budget, the Bush Administration requested $76 billion in R&D funding, a 13 percent increase over 1991 funding.[2] But critics claim that funding for such projects as the Superconducting Supercollider and the Human Genome Project is at the expense of important, ongoing technology base programs. All of these issues affect the U.S. technology base in general and have an impact that extends beyond aerospace. Another important question being debated is the proper role of the Government in focusing funds for R&D through a national technology strategy. A discussion of this issue follows on page 102.

Because the U.S. Government is the leading source of aerospace R&D funding, there are other important issues that have a direct bearing on aerospace technology development. Some of these are:

- Level of funding for technology base vs. technology demonstration in the defense and civil aerospace sectors,

- Appropriate balance between defense-and commercially-oriented R&D, and
- Insufficient investment in manufacturing capability.

Technology Base vs. Technology Demonstration/ Validation - While U.S. industry pays for the greater share of product-oriented research and development, the Government has always assumed primary funding responsibility for basic research and development. However, federal funding of basic research in U.S. industry has been cyclical, according to the National Science Foundation. During the 1970s and 1980s, constant dollar lows occurred in 1975 and 1982. In the 1980s, federal funding of industrial basic research increased about 3.5 percent per year except in the defense sector.[3]

Defense Sector: Department of Defense (DoD) transfers to industry for basic research decreased 3 percent annually from 1980 to 1989. Consistent with the defense buildup during the Reagan Administration, a great deal of defense R&D during the 1980s was dedicated to technology demonstration—to the development, testing and evaluation of specific weapons systems. Since FY 1981, 90 percent of research, development, test and evaluation (RDT&E) budget growth has been devoted to development, test and evaluation rather than to basic science and technology programs.[4]

The Bush Administration's 1992 budget request reflects a continuation of this trend. The DoD technology base, including basic research and exploratory development, is earmarked to receive roughly $3.9 billion, a slight decline in real terms from 1991. The Administration proposal is weighted heavily toward development as it plans to fund the transition of several major programs—including the B-2 stealth bomber and Advanced Tactical Fighter—into full-scale development. Congress may shift some additional funds into the technology base during its budget deliberations. In 1990, Congress strongly supported defense technology base initiatives including $20 million for joint development of dual-use technologies and other programs with Japan, and funds to allow the Defense Advanced Research Project Agency (DARPA) to support precompetitive research on dual-use technologies. Its defense authorization bill provided a 10 percent increase over the administration's request for the defense technology base. The balance of funding between the technology base and technology demonstration will continue to be debated.

As defense budget cutting proceeds, the possibility of developing weapons technology and setting it aside until production is necessary has become an issue. However, the nature of today's electronics-intensive weaponry is such that it requires more training and testing than less sophisticated systems, and such activities are difficult without limited production. Production in small numbers means higher per unit costs; it does not permit training for a sufficiently sized work force, nor sufficient testing so that the producer can incorporate necessary modifications. In addition, defense contractors make their profit principally through production, not through research and development. Without sufficient profit, a company cannot make the continuing investment that keeps it at the leading edge technologically.

However, because pressure to cut defense funding is so strong, proposals have been made to change the process of developing and acquiring major weapons systems. They center on keeping technological options open even while fewer major systems are fielded. They also address the need to provide greater profit incentive for the performance of R&D. (See p. 98, *U.S. Defense Strategy - Rethinking the Procurement of New Technology*.)

Whatever approach is taken, it seems clear the United States should identify technologies that are important and then fund them at appropriate, sustainable levels on the basis of at least 10-year development plans. In this way, strategic thinking will be enhanced by a wider range of options in weaponry and supporting technologies. However, one-year funding is the traditional approach in the United States.

U.S. Defense Strategy
RETHINKING THE PROCUREMENT OF NEW TECHNOLOGY

Fewer defense dollars, lower production levels of expensive weapons systems, uncertain military requirements: this is the difficult scenario facing U.S. military R&D planners today. The demands for new technology development and application in defense systems are considerable but it is not altogether clear which systems will be needed for what jobs. There is also pressure to see that spending for defense technology has a payoff in the commercial sector. In effect, defense planners are being asked to develop "all purpose" technology. Then they are expected to incorporate it, at some indefinite time, into useful, workable weapons systems that can be cost-effectively produced—all without the extensive production and field testing characteristic of U.S. weapons systems development.

Is this possible? A number of policy strategists say "Yes." They favor a system of military research and development based on generating "Technological options of sufficient quality and in sufficient numbers so that . . . U.S. forces can be fully prepared to meet a wide range of contingencies." There is one caveat: it will remain important to focus Defense Department R&D funding on military needs. The Institute for Defense Analysis (IDA) describes the approach as a Flexible Acquisition Strategy. [1]

The current U.S. approach to developing weapons systems involves making production decisions early in the technology development process. The Flexible Acquisition Strategy would focus on developing technologies or a weapons systems concept without a determination that a particular weapons will enter full-scale production. The R&D and acquisition process would be closer to the commercial model of "continuous and evolutionary" R&D, design, development, prototyping and production decisions. It would be geared primarily to: (1) modifications to existing equipment in the field, (2) improvements to and modernizations of systems currently in production, (3) new product developments, and (4) design and design modifications which allow for rapid production in the event of a mobilization. U.S. defense forces would have "as many technology and acquisition options as possible," but fewer programs would enter full-scale production.

A Flexible Acquisition Strategy depends upon:

- Increased funding for science and technology and for development of non-system specific technology options,
- Continuing DoD R&D focus on military needs,
- Weapons systems designs that can be rapidly manufactured in the event of mobilization, and
- Increased use of prototyping.

In addition, with declining demand for weapons systems production, *R&D should become a product in its own right.*

For defense contractors, R&D has always been tied to production, with profit coming from production—not the R&D. Without the clear prospect of production, contractors will not want to invest in defense-related R&D. Profit will have to be tied to the performance of R&D to provide incentive for contractors to continue the independent research and development investment that has provided substantial payoff to national security efforts over the years.

[1] Institute for Defense Analysis, *The Future of Military R&D: Towards A Flexible Acquisition Strategy,* July 1990.

Over the long term, a superior defense capability depends upon a balance between a strong technology base and test and evaluation. Full demonstration of capability can occur only when systems or equipment are rigorously tested under field conditions.

Civil Sector: U.S. civil aircraft manufacturers are applying new aeronautical technology conservatively because of the risks associated with new technology, and because of the airlines' requirements for proven systems and for price and operating cost reductions. However, future sales in the highly competitive global market may depend upon the application of advanced technology: if the price is right, new technology options are an attractive sales inducement. Companies in countries where product development receives subsidy support may have an advantage over American manufacturers because they can introduce new technology in aircraft models without immediate concern that their costs be recovered.

Before a manufacturer can justify use of a technology in new model aircraft it is important that technology be proven—especially that it be shown to improve safety and/or airline economics—through technology validation. Technology validation makes a significant time difference in applying new technology in U.S. commercial aircraft programs. The data base for important aeronautical technology areas must be developed so that technology can be applied with confidence of meeting performance, schedules and cost estimates. Validation amplifies the technology base in critical areas, and reduces the risks of applying advanced technology. The U.S. Government has long supported the concept that technology validation is its responsibility.[5] At the same time, the Government has allowed funding for technology validation programs within the National Aeronautics and Space Administration (NASA) to decline. NASA, with DoD, the Federal Aviation Administration (FAA), the Department of Commerce and industry, have developed a technology development and validation plan for subsonic transports, civil tiltrotor/commuter propulsion, and high-speed transports.[6] Some of the necessary systems technology work has begun but it is not at a level to maintain U.S. aeronautical technology leadership.

Insufficient U.S. Government activity in technology validation, along with a lack of incentives for industry investment, inhibits technological preeminence in civil aeronautics. Eventually, this will be reflected in U.S. products; those produced by other countries could reflect a more advanced state-of-the art.

Defense vs. Commercial R&D - The United States spends more on R&D than any other Western nation when the resources of government, industry and universities are combined; approximately 30 percent of the total is related to defense. Of federal R&D spending, 60 percent is for defense. Some argue that the United States no longer receives sufficient return to the commercial sector from this investment to justify its size.[7] Other countries place a higher priority on commercial R&D. Germany and Japan, for example, have been ahead of the United States in funding strictly *nondefense* R&D for nearly two decades. Their rate of civilian R&D investment as a percent of GNP has been rising faster than that of the United States since 1981.[8]

The Director of the Office of Science and Technology Policy (OSTP) Dr. Allan Bromley disagrees that the United States is overspending on defense technology. He considers the current balance of defense to nondefense R&D "appropriate," based on an OSTP assessment of the nation's national security and commercial objectives. During the 1980s, Bromley notes, U.S. research and development spending peaked with defense getting a 69 percent share versus the civil sector's 31 percent. The Fiscal Year 1992 budget requested 60 percent for defense and 40 percent for nondefense work. Bromley believes that, despite the apparent Soviet/U.S. thaw and changes in the military threat, the United States should be strengthening defense research and development. Not only will this prevent the United States being technologically surprised, but it will keep it a step or more ahead of potential adversaries.[9] For example, the United States capabilities in stealth technology were a clear advantage in the Persian Gulf War.

Stealth, or low observable technology, is a striking example of how technology programs for civil and defense purposes still do diverge in important areas. Stealth technology, which affects the entire airplane configuration and related technologies, has emerged as a significant defense requirement. Stealth has no application in the civil sector. The military also has more esoteric requirements than the commercial sector for electronics and fiberoptics for sophisticated communications systems. And military composite technology requirements are greater in the near-term than those of the commercial sector. Defense needs will therefore drive development in these technologies but there will still be long-term commercial benefits. In general, defense and commercial firms are equal with respect to development of artificial intelligence (AI); however, the military will undoubtedly provide the market "pull." The military has identified its need for AI for expert systems to enhance and assist pilot performance in aircraft and for computer-aided education in the use of systems, maintenance and troubleshooting. The defense establishment continues to require higher performance from propulsion technologies than the commercial sector; however, the commercial space sector will increasingly be a propulsion technology driver.

The civil sector of the economy still benefits from government R&D spending. Spinoff—the return to civil/commercial applications from government technology funding—continues to be achievable, although the extent of return is hard to measure and is continuously debated. Bush administration research budget priorities include robotics, semiconductors, advanced imaging, superconductivity, and high performance computing. All of these areas have high potential for commercial application. Digital mobile radio, high frequency radio and high definition TV are other important defense technology spinoffs. Much of DoD-funded R&D has been dual-use. Time sharing and computer graphics developments by the Pentagon, for example, have been applied commercially in biotechnology and artificial intelligence work. Simon Ramo, one of the founders of TRW, believes that military strategy, which is evolving toward dependence on global information networks and verification systems, will produce more rather than fewer consumer product spinoffs than in the past.[10]

Nonetheless, debate is heightening over how to achieve a proper balance between national security and economic interests—given that the two are more intertwined than in the past and that it is difficult to measure spillover from defense spending or to compare the benefits of military versus civil R&D. There are increasing calls for a "civilian" version of the Defense Advanced Research Projects Agency (DARPA) and a focus on funding technologies with applications in both the defense and civil sectors.[11] Secretary of Energy James Watkins, for example, has asked major nuclear weapons laboratories to expand their non-military work in new energy sources, environmental problems and industrial competitiveness.

Investment in Manufacturing - Ultimately, it is through manufacturing that technology becomes usable either as improved tools and techniques or new products. And it is through new manufacturing technology and processes that tools, techniques and products are improved and costs of quality production driven downward.

In U.S. industry generally, emphasis on short-term shareholder return has discouraged investment in manufacturing technology (i.e., computer-based production processes) that has a long-term payoff. In the defense aerospace sector, profit limitations and lack of financial incentive to invest have inhibited funding of new manufacturing technology. (See *Staying on Top: Strategies to Ensure a Strong U.S. Aerospace Industry*.) Yet manufacturing is the key to transitioning fundamental technology advances quickly into useful products and processes.

If the United States is to maintain a leadership position in aerospace, it must focus heavily on modernizing manufacturing technologies, and the related disciplines of concurrent engineering (where design and manufacturing planning go hand in hand) and quality control. The combination of minimal government funding of capital equipment and process modernization, and lack of incentive for private industry investment, seriously undercuts productivity improvements in the industry.

Questions about how R&D funds should be spent are not simply an intellectual exercise. What is the proper balance of funding between the technology base and technology demonstration? Are we spending too much on commercially-oriented defense, or is the budget mix about right? How can we stimulate greater investment in manufacturing capability? These issues are closely intertwined with the long-term technological vitality of the U.S. aerospace industry.

Defensive Strategies - Keeping Technology At Home

R&D funding is an essentially positive or offensive approach to national competitiveness. Defensive strategies also play an important policy role. For years, a restrictive approach to sharing U.S. technology was rooted in the national security concerns of the Cold War. Now legislation, policy, and policy implementation have taken on a defensive coloration for reasons of economic competitiveness. Measures to prevent the outflow or export of U.S. technology include:

- Export Controls,
- Buy American Legislation,
- Offset Restrictions, and
- Anti-Foreign Direct Investment Initiatives.

Export Controls

The easing of tensions with the Soviet Union lessened U.S. concerns about technology restrictions for security reasons. But the pressure of European members of COCOM—eager to trade with Eastern Europe and the Soviet Union—was even more persuasive for a change in U.S. perspective. The Bush Administration and the COCOM nations have eased restrictions on sales of advanced computers, telecommunications equipment and machine tools to the Eastern bloc, but the United States continues to press for more favorable treatment for Eastern Europe than of the Soviet Union. This is likely to be the case for some time to come in view of the political instability in the Soviet Union. In addition, the Persian Gulf War has brought to the forefront concerns over export of ballistic missiles and biological and chemical weapons.

Effective national security-based controls are imperative. U.S. high technology industries have long urged a shorter, more focused list of critical technologies to facilitate control. At the same time, they believe U.S. companies should be able to market technology that is already available from competitors. Such an approach is based both on the realities of the marketplace and the nation's ability to implement controls. A report of the National Academy of Science (NAS) released in early 1991 called U.S. export controls outdated and recommended greatly reducing their number, thereby making it easier to enforce essential controls.[12] The NAS panel also suggested controls should be fully multilateral so that U.S. companies are not at a market disadvantage.

Important concerns of the aerospace industry about export controls remain unresolved. The U.S. export control establishment is not cohesive: several government agencies have jurisdiction and their perspectives are often at odds. Lack of adequate staffing causes delays in licensing. Too many non-military items are still controlled as military goods. As technology becomes more dual-use, industry is worried that sophisticated civil sector technology will be more subject to export review and control.

Buy American Legislation

"Buy American" provisions of the law are designed to maintain domestic sources of items of supply essential to national security—either through sole source awards or domestic subcontractor set-asides. This can be inconsistent with the Defense Department's efforts to adopt more commercial buying practices, if it prevents U.S. manufacturers from incorporating the best, most cost-effective technology into products. By protecting domestic suppliers whatever the cost and quality of their products, Buy American provisions could make U.S. companies less capable of attaining world class competition standards.[13]

Other legislative proposals would require major defense contractors to perform all research and development, engineering, and production in the United States. This would make it impossible to utilize dual-use technology, and weaken the competitive position of firms doing business with the government.

Offset Restrictions

Doing business in the world aerospace defense market often requires the seller to make "offset" concessions—in the form of subcontract, work-sharing, or codevelopment agreements—to the buyer. Some members of Congress, concerned that offsets transmit both work and technology to other countries, have introduced legislation to require detailed contract by contract reporting of defense procurement-related offsets exceeding a certain dollar value. These requirements are burdensome to industry and add little to an understanding of what is happening to the defense industrial base. Numerous studies show that offsets have gained more work for American industry than is lost. Unilateral restrictions on offsets, which have also been suggested, would limit marketing options and effectively tie the hands of U.S. companies in world competition.

Anti-Foreign Direct Investment Initiatives

Legislation has been proposed that would require detailed reporting of foreign ownership, or increase taxes of U.S. subsidiaries of foreign-owned companies. These proposals are aimed at protecting the United States from an outflow of jobs and technology. They may be as likely to do the opposite if they constrict the flow of foreign investment. It was foreign investment that kept the U.S. economy moving during the 1980s despite the weight of an enormous budget deficit. Such legislation might also invite retaliation from other governments against U.S. investment abroad. It could discourage the cross-fertilization of financial and technological resources that creates stronger, more competitive companies.

Restrictive legislation is at times the necessary policy choice. Certain controls on the outflow of critical, proprietary, or militarily-sensitive technology are essential. But controls should not be applied with the idea of "hoarding" technology. They should not be devised to protect U.S. firms against reasonable competition. They should not become a crutch that delays the United States from taking a more strategic approach to world market competition.

Thinking Offensively - Strategies To Develop U.S. Technology Capabilities

A number of initiatives are designed to improve the position of U.S. companies in the marketplace by enhancing technical and manufacturing know-how:

- National Technology Strategy Development,
- U.S./U.S. Collaborations, and
- R&D Funding Incentives.

National Technology Strategy

The White House Office of Science and Technology Policy (OSTP) is coordinating development of a national technology strategy among all federal agencies. OSTP has concentrated on an approach for federal government "nurturing" of developing technologies, including product and process technology. Central to this process is a highly contentious debate:

how can the United States develop a coherent technology strategy without engaging in "industrial policy"? For many in the United States, an industrial policy—seen as a government-directed and supported approach to business—is wholly antithetical to the United States' free market philosophy. Others argue that the government has long engaged in industrial policy, through heavy funding of defense research and development and the exercise of its massive national security-related purchasing power.

As technology strategy planning goes forward, attention will focus on achieving a middle ground somewhere between "things as they are" and the "choosing of winners and losers" that opponents of industrial policy deride.

In April 1991, OSTP released a list of National Critical Technologies. Various federal agencies provided input to the effort to develop the list (Figure 1). The Department of Commerce identified 12 emerging technologies vital to U.S. worldwide competitiveness. The Department of Defense took a critical technologies approach to assuring superiority of U.S. weapons, with an eye to potential civil applications. DoD's 21 critical technologies list places heavy emphasis on electronics, computer technologies and advanced composite materials. DoD's list is also being tied to a science and technology investment plan.

Technologies on the DoD list have a great deal of commonality with the key technologies identified by the aerospace industry. The industry, working through the National Center for Advanced Technologies (NCAT) sponsored by the Aerospace Industries Association, identified technologies it considers the most important for significant expansion in aerospace capability. These key "enabling" technologies (i.e., technologies that make a range of technical advances and new products possible) are presented in Figure 1 along with those considered important by the various government agencies. The aerospace key technologies promise enormous payoff in both civil and defense products and systems (see page 105 on the Vital Role of Key Technologies). Cooperation among industry, government agencies, and academia resulted in "roadmaps" for each of these technologies; the roadmaps recommend the optimal progression for various elements of each technology, identifying the capabilities or tools, techniques, and so forth, required in order to advance. Through the Aerospace Technology Policy Forum under NCAT's aegis, representatives from industry, government and academia are developing plans that will focus efforts and funds most effectively to reach the roadmap milestones. The Forum provides the opportunity to create consensus on what an *aerospace* technology strategy should be.

About three-fourths of the Defense Critical Technologies are covered by AIA's Key Technologies for the Year 2000 program. NCAT and DoD have worked together toward comprehensive technology plans for five of those that appear on both lists. The plans map out the route to achieving national goals by outlining program objectives, timing, estimated costs, applications, and the involvement of various government agencies.

The work of the OSTP and the Commerce and Defense Departments—and AIA's work—provides a strong case for a national strategy focused on generic, enabling technologies. The case is strengthened by the globalization of technology and the speed with which technology is being developed, transferred, and made obsolete—all at increasing cost. It is strengthened by the fact that, with budget restrictions limiting the number of new system platforms, a premium will be placed upon modular system improvements.

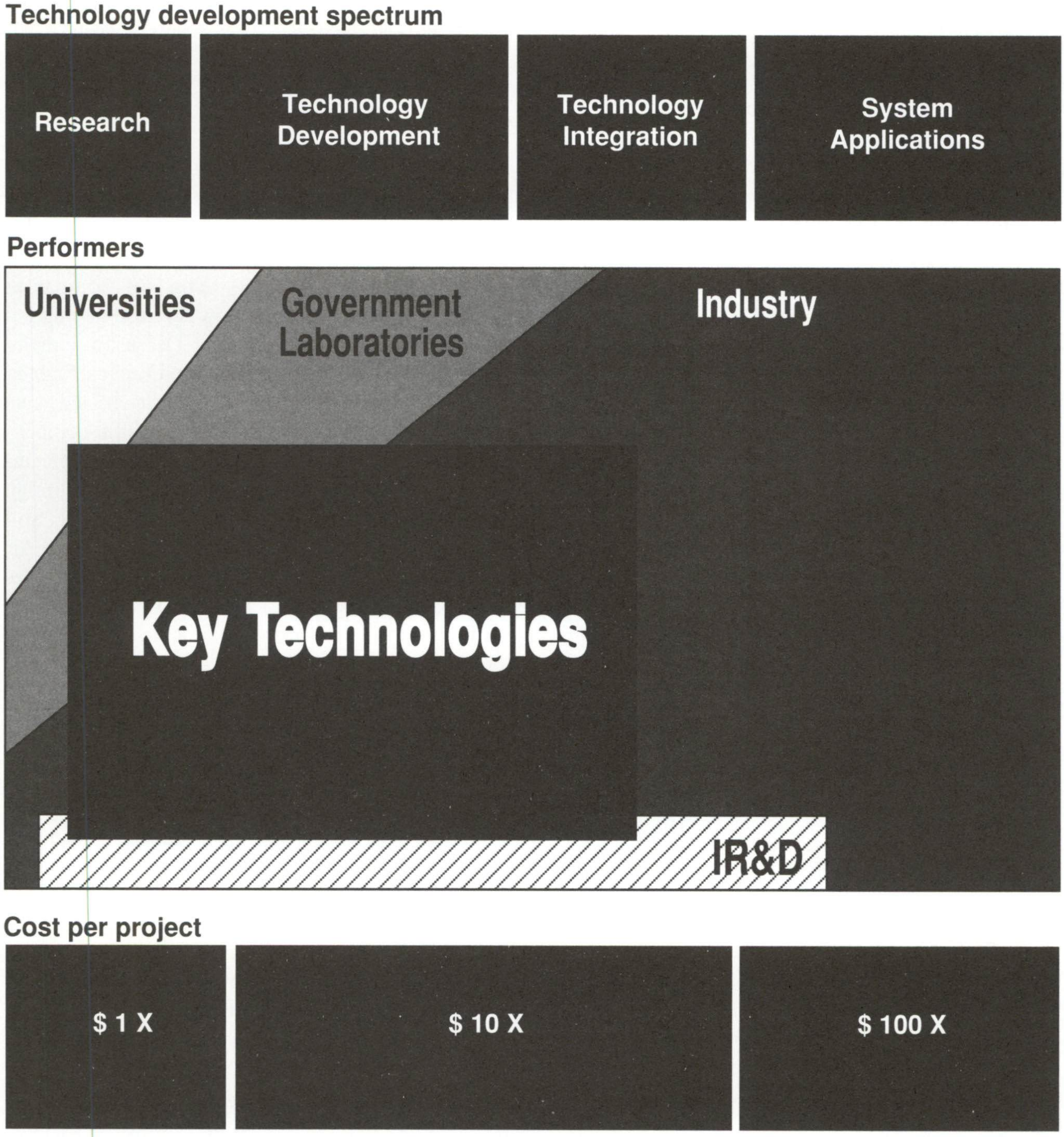
Congress is encouraging the strategic technology approach. The 1991 Defense Appropriations Bill funds a Critical Technologies Institute to be set up under the OSTP, and to coordinate the federal government's critical technologies effort. Congress also provided funds for the Defense Advanced Research Projects Agency to financially participate in consortia that are working to develop critical technologies.

Figure 1

NCAT/AIA KEY TECHNOLOGIES
Compared with
DoD, Commerce, and White House Assessments

NCAT/AIA KEY TECHNOLOGIES	DOD CRITICAL TECHNOLOGIES	DOC EMERGING TECHNOLOGIES	NATIONAL CRITICAL TECHNOLOGIES
Advanced Composites	Composite Materials	Advanced Materals	Ceramics Composites Synthesis & Processing
Advanced Metallic Structures			High Performance Metals & Alloys
Advanced Sensors	Sensitive Radars Passive Sensors Data Fusion	Sensor Technology Digital Imaging Technology	Sensors & Signal Processing
Airbreathing Propulsion	Airbreathing Propulsion		Aeronautics
Artificial Intelligence	Machine Intelligence & Robotics	Artificial Intelligence	Intelligent Processing Equipment
Computational Science	Parallel Computer Architecture Signal Processing Computational Fluid Dynamics	High Performance Computing High Density Data Storage	High Performance Computing & Networking Computer Simulation & Modeling
Optical Information Processing	Photonics	Optoelectronics	Electronic & Photonic Materials
Rocket Propulsion	High Energy Density Materials		
Software Development	Software Producibility		Software
Ultrareliable Electronic Systems	Semiconductors & Electronic Circuits	Advanced Semiconductor Devices	Microelectronics & Optoelectronics
	Biotechnology Materials & Processes	Biotechnology Medical Devices & Diagnostics	Applied Molecular Biology Medical Technology
	Flexible Manufacturing	Flexible Computer-Aided Manufacturing	Flexible Computer-Integrated Manufacturing Micro- & Nanofabrication
	Simulation & Modeling Signature Control Weapon System Environment Pulsed Power Hypervelocity Projectiles		High Definition Imaging & Displays Data Storage & Peripherals Systems & Management Technologies Energy Technologies
Superconductivity	Superconductivity	Superconductivity	Pollution Minimization, Remediation & Waste Management Surface Transportation Technologies

THE VITAL ROLE OF KEY TECHNOLOGIES



Key Technologies are important in the transition from idea to proof-of-concept to application in an industry product. Focused efforts, which validate technologies, can save considerable money (and schedule time) by reducing risk prior to system application.

The Bush Administration's commitment to a national technology strategy or policy has not been clear to many observers. An administration paper, *U.S. Technology Policy*, released in the fall of 1990, talked of ensuring a quality work force and a financial environment conducive to longer-term investment in technology—as well as other factors critical to national competitiveness. It did not discuss specific programs although it cited the need for an efficient technological infrastructure, especially in the transfer of information. (Accordingly, the administration's 1992 budget request included some funding for a nationwide data network connecting universities and companies. The network would permit the speeding up of information in a range of fields as well as the use of high-speed computers.) OSTP's release of the National Critical Technologies List was not accompanied by details of how government might increase its efforts or change its focus in supporting technology development.

Nonetheless, the OSTP's work in developing the critical technologies list, along with the DoD critical technologies effort, and Commerce Department grants to companies under an Advanced Technology Program, indicates greater movement toward the concept of precompetitive or generic technology "nurturing."

A private sector-supported analysis of critical technologies was also published in early 1991.The Council on Competitiveness released a study entitled *Gaining New Ground: Technology Priorities for America's Future.*

U.S./U.S. Collaborations

U.S. firms are teaming not only with foreign partners but also with other U.S. firms, particularly where there are synergies between their capabilities, and where antitrust concerns are not a problem. One example: Rohr Industries and General Electric formed a joint venture to develop, build and sell composite engine components.

U.S. aerospace companies are also beginning to work together in areas where they do compete. A number of major firms announced joint efforts toward developing an experimental National Aerospace Plane (NASP). The enormous costs and risk involved in this technology are driving General Dynamics, McDonnell Douglas, Pratt & Whitney and Rockwell International to combine efforts as a single team. The arrangement advances important technology, which could have many spinoffs, without any one company dominating the field.

Competitive teaming—teams of companies working against each other—was already being encouraged by the Department of Defense for major aircraft projects such as the Advanced Tactical Fighter. The NASP arrangement is a further step, and is an instance of U.S. companies teaming non-competitively. The government has blessed the NASP teaming as a less costly way to stay ahead of foreign competitors in important new technology areas. Still another teaming agreement—on the engine for an Air Force/NASA Advanced Launch System (ALS) has been formed between Rocketdyne, Pratt & Whitney and Aerojet. The prime contractors for the ALS program—General Dynamics, Martin Marietta, and Boeing—may team as well. The Light Helicopter program could also involve coproduction instead of competition among members of joint ventures working on competing designs.

Tighter defense budgets, a reduced amount of business and the stretch-out of programs increased competition among defense contractors, while poor return on investment reduced available company funds for R&D and capital investment (Figure 2). Therefore, in some instances, coproduction may be both necessary and beneficial to the industry, and to the government.

The Bush Administration has proposed legislation facilitating joint production ventures (see Cooperative Research Incentives below). European and Japanese firms having been joining together on production projects for years.

R&D Funding Incentives

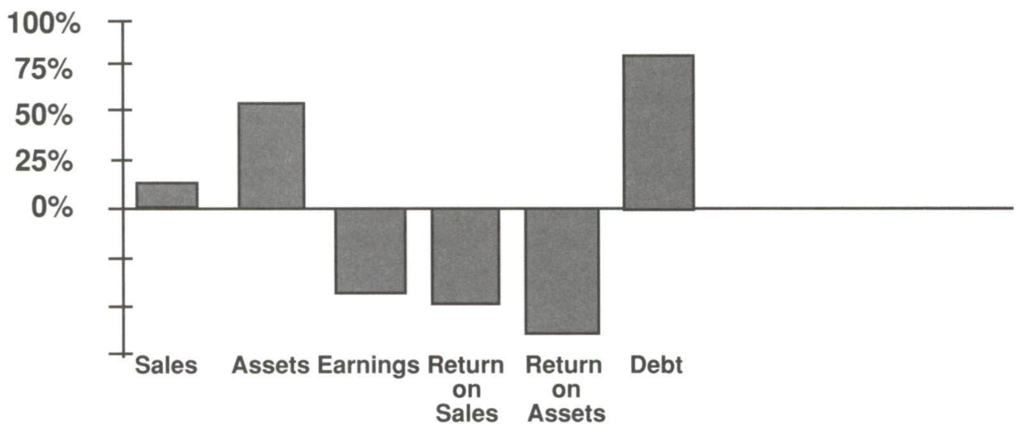
R&D Incentives - The United States invests substantially in research and development through support of work conducted by both government and industry. In addition to the $76 billion of government funding proposed for Fiscal Year 1992, a number of incentives are in place to stimulate R&D spending by industry. Tax and cooperative research incentives are available to all U.S. companies and are not targeted to industry sectors. The allowability of Independent Research and Development expenses in overhead costs is an incentive for private companies that do government contract work. Federal incentives for R&D include:

Tax Incentives: The research and development tax credit provides a 20 percent credit for research expenditures above a company's historic level of outlay.

Independent Research & Development: Independent Research and Development (IR&D) is that part of an aerospace company's total R&D program that is company-initiated and funded. IR&D improves a firm's competitive position by giving it the flexibility to refocus quickly as technology evolves and the marketplace changes. IR&D has provided new ideas, innovations, and technical options to the government, at less cost than if the government had directed and fully funded the work under contract. The government limits the amount of IR&D costs that each contractor may recover as overhead charges allocated to federal contracts. During the latter part of the 1980s, forced up-front cost sharing of R&D, and

Figure 2

Financial Trends of Aerospace Defense Contractors
Percent Change 1985-1989



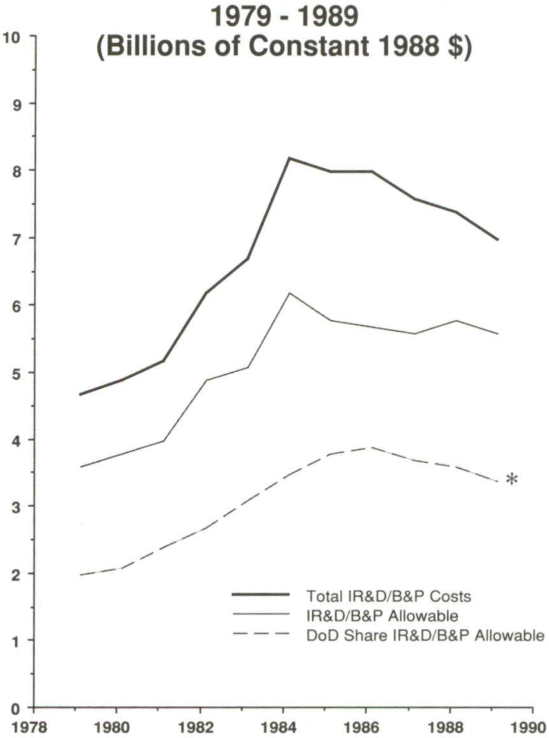
Source: Defense segment data from annual reports of S&P Aerospace Index contractors.

heavy administrative costs involved in justifying programs reduced potential benefits (Figure 3).[14]

Recently, DoD streamlined the IR&D review process, moving toward two-year rather than annual advance agreements with defense contractors. In the 1991 Defense Authorization Act, Congress revised the law governing IR&D and directed DoD to draft new regulations. The changes substantially broaden the concept of potential military relevancy and encourage contractors to invest more IR&D in areas with commercial and international market applications.

As this report is published, the House of Representatives approved major changes to the law governing IR&D/B&P. The changes would eliminate advance agreements used by DoD to impose ceilings on

Figure 3
IR&D/B&P Expenditure and Allowable Cost Trends 1979 - 1989 (Billions of Constant 1988 $)

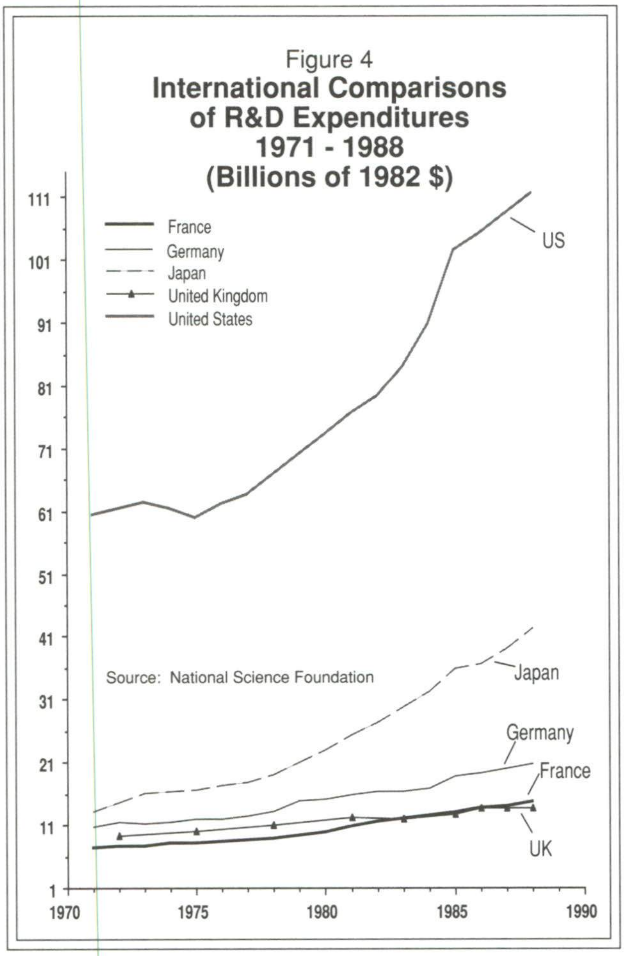


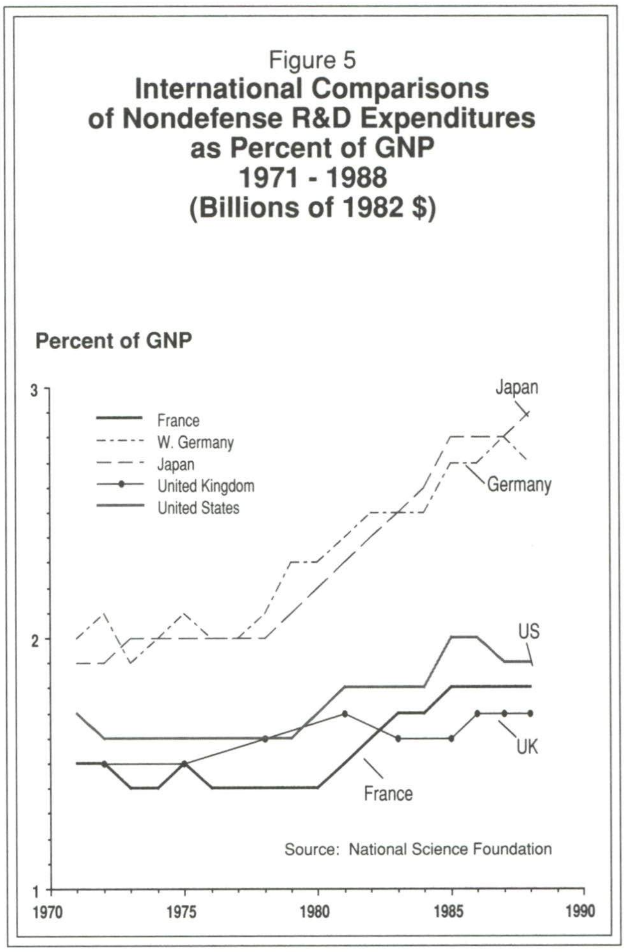
* 1990 allowable costs and share allocated to DoD are expected to be higher.
Source: Defense Contract Audit Agency

recoverable IR&D/B&P costs. They would require full allowability of IR&D/B&P costs, beginning in FY 1993, for activities that: a) are of potential interest to DoD, b) strengthen the defense industrial/technology base, c) enhance industrial competitiveness, d) promote critical technologies development, e) develop dual-use technologies, or f) develop environmentally beneficial technologies.

Cooperative Research Incentives: In 1984, the National Cooperative Research Act removed the possibility of treble damages for antitrust violations in the course of forming pre-competitive research and development joint ventures. Such ventures permit pooling of resources among U.S. companies and thereby provide funding leverage for research and development. The Bush Administration has proposed a further step: removing the threat of treble damages for production joint ventures. If this proposal becomes law, it will strengthen the position of American companies in various fields, permit them to build upon joint research, and potentially, to profit to an extent that will facilitate additional investment in their technology base.

The total U.S. R&D investment is five times that of Germany and two and a half times that of Japan (Figure 4). Nonetheless, U.S. nondefense R&D as a percent of GNP in 1988 (1.9 percent) is considerably below that of those leading U.S. market competitors (Figure 5). Germany spent 2.7 percent of GNP on nondefense R&D in 1988 while Japan spent 2.9 percent of GNP.[15] This comparison indicates the importance of strengthening incentives for U.S. private investment in vital technology development efforts. Privately-funded R&D has the advantage over government-funded R&D of being more flexible in response to changing technology and market conditions. It is more cost-efficient because there is less bureaucratic burden than is imposed on R&D by government justification and accountability requirements.





International Cooperation

Despite its enormous funding of research and development, it is apparent that the United States can no longer dominate in every scientific and technical field. Constraints on capital formation in the United States, and the quality of work and level of funding in other countries, make it impossible. Under the circumstances, collaboration with foreign partners clearly offers advantages. Several points provide perspective:

- Cooperation and competition go hand in hand in the international marketplace, and
- Cooperation is better established and generally less problematic in the civil sector than in the defense sector.

Nonetheless, the advantages of cooperation in the defense sector continue to draw support for international programs from the Department of Defense, the Administration, and Congress.

In addition, it should be recognized that:

- Technology naturally diffuses at an incredible, and increasing, speed,
- Other countries than the United States have significant capabilities to contribute,
- Well-structured agreements can protect critical proprietary data, and
- Technology and innovation do not necessarily equate with economic competitiveness. Strength in science and technology is insufficient without a world class manufacturing capability.

Cooperation and Competition

In the global aerospace industry, "cooperation *versus* competition" is less descriptive and meaningful than "cooperation *and* competition." The two concepts are not genuinely opposites; in reality, they often go together. There is an underlying, basic principle that an organization or nation must have something to offer another in order to trade, barter, compete or cooperate. Aerospace companies must have products, skilled labor, or essential technologies in order to enter into effective cooperative ventures with other firms. They must be able to compete with each other in order to cooperate with each other. Viewed in this light, it is possible to see that one company or nation will never hold *all* the cards—and will not be likely to maintain all of the technological advantages, at least not indefinitely.

International cooperation becomes most complicated when programs move beyond scientific information to hardware-oriented technology development. When doing fundamental research, it is recognized that an eventual market or industrial use of data may be years ahead—and difficult to predict. Technological and engineering information, however, has near-term implications.

For years, the United States' concerns about technology transfer through cooperation were founded primarily on national security reasons, and export policies evolved to reflect this. Today, economic competition is viewed as being on at least an equal basis with military competition. One of the weapons of economic competition is the control of advanced technology—the knowledge and know-how to produce new products and processes that create markets, increase sales, make production more efficient, improve the reliability of goods and services, and advance the quality of human life. To the individual business firm, this means profits, increased market share and growth. To the nation, it means jobs, economic stability, a favorable balance of trade, and healthy growth.

In recognition of the importance of economic competitiveness, U.S. export policies are being reexamined. The United States is working to conform its list of militarily critical technologies to that of other western high-technology suppliers in COCOM—the Coordinating Committee on Multilateral Export Controls. If the United States cannot transfer technology that other nations can, then it cannot cooperate *or* compete. For example, opportunities to do business in Eastern Europe will require new cooperative relationships between Western countries and former Soviet bloc nations—and the transfer of selected technology. The nations of Eastern Europe will be given the tools of *competition* in order that further trade and cooperation can take place.

Figure 6 presents the different perspectives of cooperation and competition. This illustration clarifies the difficulty of finding a single answer about the wisdom of entering into international agreements, either from a governmental or industrial position. It also shows that cooperation and competition are not polar opposites.

Cooperation in the Civil and Defense Aerospace Markets

International partnerships in civil aerospace are well established and all of the major commercial jet transport programs involve partners and/or suppliers from a multitude of countries. Global partnerships have been highly advantageous to the United States—as U.S. aerospace export sales reported earlier attest. Examples of civil aerospace partnerships involving U.S. companies are shown in Appendix B.

Civil aerospace partnerships differ considerably from one to another. Usually, a program involves a myriad of contractor/subcontractor relationships; more frequently today, it will involve degrees of risk-sharing and codevelopment. Technology may be developed jointly or passed from one partner to another, or there may be little or no sharing of critical technology. The complex nature of aircraft permits modular interfacing of systems and parts developed and produced independently.

Figure 6

Different Perspectives on Cooperation and Competition

GOVERNMENT SCIENCE PERSPECTIVE

	Advantages	Disadvantages
Cooperation	Sharing of costs International alliances formed Faster acquisition of knowledge New skills, personnel, resources	Possible technology transfer Appropriation of benefits may flow to others
Competition	Full appropriation of benefits Defense implications	Full cost burden Duplication of efforts

Assessment: Net gain from cooperation.
Major policy risk: Not being able to recognize when scientific information may be translated into commercial gain.

GOVERNMENT TECHNOLOGY PERSPECTIVE

	Advantages	Disadvantages
Cooperation	Sharing of technological risks Sharing of costs International alliances formed Development of international standards Technology transfer New skills, personnel, resources	Technology transfer Downstream applications may lead to foreign commercial benefits
Competition	Full appropriation of benefits Defense aspects	Cost Duplication of efforts

Assessment: No clear advantage to either cooperation or competition.
Major policy risk: Not being able to protect technology with clear commercial applications.

INDUSTRY PERSPECTIVE

	Advantages	Disadvantages
Cooperation	Increased market access Decreased risk Decreased cost Acquire foreign technology	Decreased profits Sharing of technology with competitors
Competition	Stimulates innovation Potential higher profits	Cost Increased risk

Assessment: Advantage to cooperation for cost and market share.
Major risk: Protection of property rights in technology.

U.S. firms in the defense sector also have experience with international partners (see Appendix B). Collaboration with European firms has been largely at the urging of several U.S. administrations seeking greater coordination of defense efforts with those of allied nations.

Congress, too, has supported and encouraged global ties in the defense industry. Congress has tried to foster a U.S. role in Euclid, a European defense ministers' initiative to develop advanced technology through cooperation. The ministers, through the Independent European Program Group (IEPG), have set up a mechanism through which U.S. and other non-European aerospace firms can learn of business opportunities in Europe. It appears unlikely that there will be U.S. involvement in Euclid at the prime contract level but, possibly, as subcontractors.

Despite support at the highest levels, the road to defense collaboration has been rocky. Shrinking defense budgets, the inability to achieve successful business arrangements, and uneven support by the U.S. military services contributed to failure of some highly visible NATO collaborative programs funded under the Nunn-Quayle-Roth amendments to the FY 1986 defense authorization act. The NATO Frigate (NFR-90) program and the Modular Stand-Off Weapon (MSOW) were notable failures. Questions about NATO's direction, in light of the diminishing Soviet threat, make collaborations even more problematic.

Despite the fact that the United States itself backed out of several Nunn amendment programs, the Pentagon continues to encourage transatlantic projects. Deputy Defense Secretary Atwood has strongly urged U.S. involvement in international cooperative programs. He has spoken in favor of fully funding the United States' share of joint programs, if a decision is made to participate. The Pentagon has announced plans to streamline foreign sales policy across the military services and improve management of cooperative projects.

The Defense Department has pursued cooperation with the Japanese, not only in full-scale projects like the Japanese FSX fighter, but in basic research and development. Cooperation has been slow to develop despite long-standing agreements (since 1983) offering guidance on U.S./Japan cooperation. Among the obstacles have been Japanese restrictions on the export of technology for defense purposes, and the fact that much Japanese technology resides with private companies, not with the government. Another is the apparent failure of the U.S. Government to make specific requests for Japanese technology. The Bush Administration is currently pursuing cooperation with Japan in advanced technology areas where the United States can benefit from Japanese research. The technologies include: ducted rocket engines, magnetic field analysis and assessment, millimeter-wave/infra-red-ray combined seekers, advanced steels for vessels and armored vehicles, and ceramic engines for fighting vehicles.

The U.S. Government's efforts to obtain Japanese and European technology indicate that collaboration with other nations represents more than just an outflow of technical knowledge and know-how. Collaboration provides opportunity for the United States to expand its knowledge base in important areas.

Examples of collaborations involving U.S. firms (both civil and defense) with nonEuropean companies appear in Appendix B.

Technology Transfers - Faster Than Ever

Modern communications systems have made it possible and economical to design and produce products and their components in far-flung locations; this has hastened the diffusion of technology around the globe. In addition, as Lewis Branscomb, former chief scientist of IBM, now professorial director of the Harvard University, Science, Technology and Public Policy Program, points out: " . . . codification of modern engineering and the detailed specifications and documentation that must accompany the use of automation and computers in design and production greatly decrease the training time needed to absorb a new technology."[16]

Technology diffusion among nations occurs not only through cooperation in design, development and production but through the movement of students and R&D professionals, through technical journals, and a myriad of trade linkages. Technology transfers through the normal course of business activity such as the sale of licenses. Multinational companies routinely engage in R&D in laboratories around the world and share the information and technology with employees and manufacturing plants in many nations. Electronic communications media speed ideas and information to every corner of the globe.

Normal business activities and normal R&D investments create their own forms of technology transfer and are virtually impossible to stop. In fact, these activities stimulate international competitiveness, open borders to the infusion of new ideas from abroad and can create overseas markets for U.S. products. With the exception of technologies that are critical to national security, or are company proprietary, trying to stop the international flow of advanced products through excessive restrictions on cooperative programs is expensive and nonproductive. In a competitive environment, a good offense is better than tight security. Creating the next system and advancing the state-of-the-art is a better investment than protectionism.

The futility of staying ahead through over-reliance on technology controls is evident in the foreign availability of many products and systems the United States has declined to export. In some instances, U.S. refusal to cooperate or to export has actually hastened competition toward independent capabilities, e.g., the aerospace defense industry in Brazil and the European space program.

No technology lead can last long on the basis of purely defensive strategy. For example, technical parameters and thresholds for computer technology change so quickly they are almost obsolete every three months. In the high technology world of supercomputers, U.S. firms may be forced to underdesign products to meet export controls. If so, American firms risk losing the market edge to nations whose strategy is to be the first to market with the best technology available.

Cooperation and Technology - Not All Is Flight

The United States can gain a great deal from collaboration with other countries. Europeans have made significant advances in carbon/carbon composites, ceramic matrix composites, infrared technology and gallium arsenide computer chips. Technology developed through the Ariane rocket program, for example, was sold to the Kaiser Corporation for U.S. ballistic missile work. Europeans, along with Americans, dominate the market for application-specific computer chips which have important civil as well as defense technology uses. The DoD says NATO nations have growing capabilities in stealth technologies—in reducing infrared signatures and ship noise, and modeling and measuring broadband scattering characteristics of complex shapes.

Japanese advantages in semiconductors, robotics, superconductivity, biotechnology and photonics are well recognized. The DoD is actively seeking Japanese technology including fiber optics and military communications systems.

As the Soviet bloc opens to the West, analysts have identified USSR advantages in pulsed power and one American firm has joined with the Soviet Academy of Sciences to develop Soviet technology in optoelectronics, ceramics, thin films for electronics, and high energy lasers. Techniques in metal forming and coatings that extend life of cutting tools are among Soviet technologies already in use in the United States.

Data from the Defense Department's critical technologies analysis (Figures 7, 8) show the kind of technical capabilities other countries can offer.

Figure 7

MACHINE INTELLIGENCE & ROBOTICS
Capabilities of NATO Allies and Japan Relative to the United States

Examples	NATO Allies	Japan	Other
Development of specialized techniques for AI applications of advanced processing architectures	▲▲▲	▲▲▲	
Practical telecontrol of military vehicles	▲▲▲	▲▲	
Application of advanced structural materials to robots (having high dynamic loads or required to operate in hostile environments)	▲▲▲	▲▲▲▲	
Integration of smart sensors and improved actuators	▲▲▲	▲▲▲▲	
Overall*	▲▲▲	▲▲▲▲	▲▲ Finland, Israel, Sweden

* The overall evaluation is a subjective assessment of the average standing of the technology in the nation(s) considered.

Capability of others to contribute to the technology

▲▲▲▲	significantly ahead in some niches of technology
▲▲▲	capable of making major contributions
▲▲	capable of making some contributions
▲	unlikely to have any immediate contribution

Figure 8

PHOTONICS

Capabilites of NATO Allies and Japan Relative to the United States

Examples	NATO Allies	Japan	Other
Ultra low-loss (less than 0.001 db/km) fibers	▲▲	▲▲▲	▲
Research in photonics, bistable devices, other specific components	▲▲▲	▲▲▲	▲ China
Increased volume productions of high-power laser diode arrays	▲▲▲	▲▲▲▲	
Development of optical interconnects, including fiber optic backplanes	▲▲	▲▲▲	▲ Brazil
Greater than 2 Gbit LAN	▲▲▲	▲▲▲▲	
Radiation-hardened components	▲▲	▲▲	
Applications of fiber optics to improve inertial sensors	▲▲	▲▲	
Overall*	▲▲	▲▲▲▲	▲ Various

* The overall evaluation is a subjective assessment of the average standing of the technology in the nation(s) considered.

Capability of others to contribute to the technology

▲▲▲▲ significantly ahead in some niches of technology
▲▲▲ capable of making major contributions
▲▲ capable of making some contributions
▲ unlikely to have any immediate contribution

DOD Critical Technologies Plan/1990

Not all technology flows from the United States. Partnerships with other countries can provide technology flowback as well. For example, advanced composites and flat panel displays for the Boeing 767X were developed by the Japanese and transferred to the United States. The Rockwell/MBB X31 program to develop an enhanced fighter maneuverability system is based on German—not U.S.— technology.

Critical Data Can Be Protected

Highly proprietary or strategic technology can be safeguarded through carefully structured cooperative agreements. In addition, the complexity of aerospace systems permits breaking them apart into segments that enable partners to learn and perform various technical skills of varying levels of sophistication. This is certainly true with propulsion technology: separation of technical and production responsibilities has permitted a variety of highly successful multinational collaborations including that of General Electric in the United States with Snecma of France. The ability to develop and build an engine jointly by limiting areas of participation also permits Western manufacturers of aircraft engines to pursue the idea of codevelopment of business jet engines with the Soviets.

The ability to do systems engineering and to integrate systems on a large scale is the most unique advantage of U.S. original equipment manufacturers. This ability cannot be learned on a single project nor transferred through a technical license. Subcontract and codevelopment arrangements will develop capabilities to contribute extensively to large civil jet aircraft programs but systems integration experience, and the cost of new programs, are prohibitions against entering the market as a prime equipment manufacturer.

Competitiveness - It's Not Just Technology

Lewis Branscomb calls it a fallacy "that scientific progress leads naturally . . . to technological progress. . . . technology increasingly avails itself of science at every step of the innovation process . . . Yet, appropriating the economic fruits of innovation cannot be ensured with any amount of science . . ."[17]

Branscomb compares the Japanese approach of incremental, conservative, cost-effective improvements to the latest technical processes and materials—allowing room for continuing improvements—with the American approach of pushing a design as far and fast as possible, but often at higher cost and with less opportunity for extensibility. "Our competitiveness problems," he says, "lie more often in the time it takes to put new ideas into practice, in design for manufacturability, and in low-cost, high quality manufacturing . . . "[18]

The message is clear: the United States needs to maintain scientific and technological strengths *and* enhance them with greater manufacturing capability. Competitiveness is based on more than developing—and locking up—essential technologies. It is a blend of staying ahead in key technology areas, restricting access for a reasonable time to important new knowledge, and developing the manufacturing skills that translate knowledge into world-class products. It is entering the market at the right time with quality products at a competitive price.

Footnotes

1 Richard J. Samuels and Benjamin C. Whipple, "Defense Production and Industrial Development: The Case of Japanese Aircraft," in Chalmers Johnson, Laura Tyson, and John Zysman, eds. *Politics and Productivity: How Governments Create Advantage in World Markets* (Cambridge, Mass.: Ballenger Books, 1988).

2 *Budget of the United States Government, FY 1992.*

3 National Science Board, *Science & Engineering Indicators - 1989,* NSB 89-1 (Washington, D.C.: 1989), p. 93.

4 Ibid.

5 Executive Office of the President, Office of Science and Technology Policy, *National Aeronauti-*

cal R&D Goals, Agenda for Achievement (Washington, D.C.: February 1987). Also see *National Aeronautical R&D Goals, Technology for America's Future*, March 1985, and *Aeronautical Research and Technology Policy, Vol. 1: Summary Report*, November 1982.

6 Office of Aeronautics and Space Technology, National Aeronautics & Space Administration, *Civil Aeronautics Technology Development and Validation Plan*, March 1988.

7 For example: Judith V. Reppy, *Defense Spending as Technology Policy for the United States*, a paper presented at the annual meeting of the American Association for the Advancement of Science, San Francisco, January 1989.

8 *Science & Engineering Indicators - 1989*, p. 3.

9 *Defense Daily*, February 8, 1990, p. 210.

10 Simon Ramo, "National Security and Our Technology Edge," *Harvard Business Review*, November-December 1989, p. 115.

11 Senator John Glenn (with others) is sponsoring a bill for an Advanced Civilian Technology Agency within the Department of Commerce. Expanded financing has been proposed for the Advanced Technology Program at the National Institute for Standards and Technology.

12 National Academy of Sciences, *Finding Common Ground: U.S. Export Controls in a Changed Global Environment*. The study was mandated in the 1988 Omnibus Trade and Competitiveness Act.

13 U.S. Department of Defense, A Report to the United States Congress, *The Impact of Buy American Restrictions Affecting Defense Procurement*, July 1989.

14 Aerospace Industries Association with Electronic Industries Association and National Security Industrial Association, *Maintaining Technological Leadership: The Critical Role of IR&D/B&P*, 1989.

15 National Science Foundation, *International Science and Technology Data Update 1988,* NSF-89-307 (Washington, D.C.: 1988), pp. 4 and 8, plus additional NSF data through 1988.

16 Lewis M. Branscomb, "Technological Change and Its International Diffusion," *Capital, Technology and Labor in the New Global Economy* (Washington, D.C.: American Enterprise Institute for Public Policy Research, 1988).

17 Ibid.

18 Ibid.

Staying On Top

Strategies To Ensure A Strong U.S. Aerospace Industry

As the largest single contributor to a positive U.S. balance of trade, with a $27 billion surplus of exports over imports, the U. S. aerospace industry is holding its own in the world marketplace. Civil products such as transport aircraft are in demand, the market for space products is growing and, despite U.S. defense budget cuts, national security needs will continue to be high on the American agenda. The Persian Gulf War dramatically demonstrated this. The war also made U.S. high technology defense systems more attractive to other countries.

But, as this report makes clear, the United States has no assurance that the aerospace industry will continue to be as dominant in the marketplace as it has been for decades. Major markets for aerospace products lie outside the United States, and foreign manufacturers have proved their mettle. U.S. market share has declined in important areas, and competitors are counting heavily on increased spending on aeronautical and related technologies, and on international partnerships, to further boost their market presence.

The Aerospace Industries Association proposes a two-pronged agenda to meet the challenge:

Strengthening the Aerospace Industry Here At Home

- Creating better, lower-cost products faster than competitors through
  - aggressive pursuit of advanced state-of-the-art technology,
  - investment in manufacturing capability, and
  - commitment to management programs that motivate employees and foster continuous productivity improvement.
- Establishing an investment climate that supports a strong industrial/technology base.
- Educating, motivating and developing a high-calibre work force.

and,

Promoting Export Sales

- Removing barriers to trade through negotiation.
- Establishing pro-trade policies.
- Implementing technology export policies that make national security and market sense.

Strengthening The Aerospace Industry Here At Home

Create Better, Lower-cost Products Faster

Aggressive Pursuit of Advanced State-of-the-Art Technology

The United States needs to focus resources on strong pre-competitive, generic technologies efforts.

Recognizing that the best marketing tool is a good product, the Aerospace Industries Association (AIA) has initiated and is pursuing a cooperative effort between industry, government and academia to target generic, enabling technologies, called "Key Technologies," for priority development. These technologies are essential to a strong aerospace market position—and a superior global defense capability—in the 21st century.

The 11 technologies presently identified are:

- Advanced composites
- Advanced metallic structures
- Advanced sensors
- Airbreathing propulsion
- Artificial intelligence
- Computational science
- Optical information processing
- Rocket propulsion
- Software development
- Superconductivity
- Ultrareliable electronic systems

Efforts to accelerate progress in these areas is being led by the National Center for Advanced Technologies, established in 1989. Advising this body is the Aerospace Technology Policy Forum, composed of high-level leaders in industry, government and academia. The aim of this program is to pursue research in an organized, focused and cooperative manner, thus stretching each dollar of R&D money.

The first step was to create "road maps" detailing the technical progression necessary to excel in each area. Now national technology development plans are being established for each technology, outlining programs, funding, schedules, and organization involvement required to dramatically advance the state-of-the-art.

It is expected that the Key Technologies for the Year 2000 program could lower the cost of American-built commercial aircraft by as much as one-third and increase safety of operation in half a dozen ways. Space systems will be enhanced by perfection of these technologies, as will air defense and air traffic control systems.

The key technologies are priority areas for technology base funding. At the same time, demonstration/validation programs—which develop new technology and test or demonstrate its readiness for application—are essential steps in achieving new aerospace systems and aircraft.

In recent years, there has been discussion within the Department of Defense (DoD) of increasing defense technology base work at the expense of development programs. The most recent administration budget does not reflect such an orientation and, in fact, leans heavily toward development. Both aspects—technology base and demonstration/validation—are equally important and a balance must be maintained. (See *Aerospace Technology Trends and Strategies* chapter for a discussion of R&D priorities.)

As it is in the defense sector, validation is the most time-consuming and costly part of civil aeronautical research and technology. During the 1980s, the White House Office of Science and Technology Policy (OSTP) set important research goals for the industry aimed at creating superior subsonic, supersonic and transatmospheric aircraft. The goals were seen as key to continued U.S. aeronautical leadership—in view of the resolve of foreign countries to excel in aeronautics. The OSTP called for action by government, industry and the university sector to meet the "unprecedented" opportunity and challenge.[1] The OSTP clearly stated the importance of the government's role in advancing research until technology is at a risk acceptable level of readiness for incorporation into a product—at which time private industry rightly assumes investment responsibility. Since then, the National Aeronautics and Space Administration (NASA)—which carries out aeronautical systems technology—has identified near- and long-term goals for subsonic transport, civil tiltrotor/commuter propulsion and high speed civil transport programs.[2] NASA frequently emphasizes its rightful role in technology validation. Despite this policy support for strong civil aeronautics validation programs, it is the industry's judgment that NASA's aeronautical systems technology budget is underfunded. The industry would also like to see closer cooperation on aeronautical research and development (R&D) between NASA and the Federal Aviation Administration.

Incentives are needed for private R&D investment. The government assumes a larger share of R&D funding for aerospace than for any other industry yet manufacturers have picked up an increasing share of the investment in recent years. Still, in constant dollar terms, company R&D funding has declined from its 1986 peak level. Investment would be eased by making the R&D tax credit permanent. When extension of the credit is on a year to year basis, long-term planning is difficult. Companies cannot count on the credit being available to them in the future.

Depreciation of R&D facilities and equipment should be accelerated from five to three years. The current depreciation schedule provides no real incentive to R&D as technology development speeds up and product cycles get shorter. In semiconductor technology, for example, the product cycle is about two and a half years.

Recognition that new approaches are necessary to help companies invest to meet world market competition is welcome and long overdue. In the defense sector, companies have had to absorb an ever-larger share of developmental expense for programs such as the next-generation Air Force and Navy fighters. Now manufacturers are cutting the cost of product development by pooling their resources in various forms of "teaming" and cooperation. This approach is being used in work on the National Aerospace Plane and other major government-sponsored programs. Joint commercial research activities between companies have been permitted since the mid-1980s. Several bills have been introduced in Congress to encourage companies to work together on production. These are all steps in the right direction. In many cases, it has been easier for U.S. companies to work with firms in foreign countries than to form domestic partnerships.

The United States must remain committed to the space program for its contributions to the technology base as well as to science, and for its significant spinoff for commercial application. The development of technology to support the Missions to and from Planet Earth and the Space Exploration Initiative holds out the probability of much usable technology, as well as planetary information, and the potential for commercial operations in space. Even with tighter budgets, the nation can move incrementally toward the long-term goals of these programs by funding work in the enabling technologies. Support should continue for Space Station Freedom—the first step for a permanent manned presence in space. Freedom will provide invaluable information about life sciences, micro-gravity research and processes in space and help ensure America's leadership in space and high technology. It also represents the first large-scale international cooperative space program.

The United States should collaborate with international partners where benefits justify. Space projects provide outstanding opportunities for bilateral or multilateral cooperative efforts with overseas partners. Cooperation can distribute risk to all the partners, permit partners to capitalize on each other's area of specialization, and improve trade relations.

It is paramount that government and industry create a viable commercial space industry, providing clear rules and direction for expansion of private firms into space markets. A strong U.S. Government role, particularly in generic technology development, is appropriate given the high R&D and startup costs, unknown demand, and probable domination of the system by government users. Launch facilities and associated industries in other countries are highly government-subsidized, for many of the same reasons. If U.S. companies are to compete commercially, it will be necessary to reduce the differences in the way the United States and other countries do business in space. The United States needs to clearly separate space R&D from space operations and commerce to strengthen management and provide a stronger market focus.

Invest in Manufacturing Capability

Strong government and industry commitment to state-of-the-art manufacturing technology, including government incentives for industry investment, could prevent a decline in aerospace manufacturing capability. Particular attention to upgrading the manufacturing capability of suppliers would significantly enhance the industrial base.

It is through manufacturing that new technology is incorporated into products and made available in the marketplace. A fertile technology base means nothing in the end if the timing of new products lags that of competitors. However, America's industrial base—itself strongly dependent on the technology base—is in urgent need of modernization. New manufacturing techniques are making other nations, such as Japan, formidable competitors to American industry.

A world-class aerospace industry depends heavily on up-to-date manufacturing technology. Plant modernization and new production techniques can determine how fast technology transitions into cost-effective, quality products. Product innovation, cost and quality are decisive factors in aerospace market competition, and are key to a strong national defense.

Manufacturing investment has been inhibited by the aerospace industry's rising debt burden, the high cost of capital, and uncertain business prospects. Subcontractors are in an even worse investment position than prime contractors.

In the defense sector, manufacturing investment can be stimulated by incentives such as the DoD's Industrial Modernization Incentives Program (IMIP), and through full reimbursement of company independent research and development funding (see "Establish An Investment Climate That Supports a Strong Industrial/Technology Base" below.) Various military services have undertaken to help contractors modernize. The Air Force's ManTech (Manufacturing Technology) and TechMod (Technology Modernization) programs are examples. On a wider scale, the DoD's IMIP program allows the services to share the costs of modernization with contractors. Estimated improvements in productivity (150 percent better machine utilization, 90 percent less scrap and rework) more than justify these programs. Yet, the budget support for manufacturing programs is fragmented within the defense establishment. Funding levels are low, and the military services have not adequately supported the IMIP concept, which encourages industry investment. Total funding for IMIP is less than 1 percent of the DoD procurement budget.

In the 1991 Defense Appropriations Bill, Congress called for the Defense, Commerce and Energy Departments to encourage development of advanced manufacturing systems through a National Defense Manufacturing Technology Plan. Implementation was encouraged with initial funding of about $50 million. Further support of this effort could go far toward strengthening the U.S. industrial base.

Probably the most useful incentive for manufacturing investment would be ensuring availability of affordable capital. (See "Establish An Investment Climate That Supports a Strong Industrial/Technology Base.")

Commit to Management Programs

A commitment to productivity enhancing disciplines such as Total Quality Management and concurrent engineering is as important as manufacturing investment. The improved use and motivation of people is vital in a high technology industry where hardware represents only the tip of the iceberg.

Total Quality Management (TQM) is a term that characterizes various continuous quality improvement programs that require cultural change in companies. Change comes about through long-term commitments, persistent training and new ways of doing things. TQM is approached from both an individual and an organizational focus. It addresses every phase of business from product conceptualization through prototyping, testing, final design, fabrication, delivery and product support. Aerospace companies adapt the concept to their own situation beginning with motivating employees toward continuous quality improvement in day-to-day operations. TQM—by whatever name—is a strategy to enhance competitive position in the marketplace.

Concurrent engineering is a process concept. It involves coordination and integration of the disciplines responsible for designing and controlling products: the production process, tooling, design, quality control, suppliers, training, and field support. One important aspect is the integration of manufacturing and engineering in the product design process so that design is performed with manufacturing needs and limitations in mind. Teamwork from the beginning enhances an optimal product life cycle. The approach is critical to quality improvement, cost containment, and reduction of development/production time.

The aerospace industry's future success depends not just on technology and capital investment but on how it develops and motivates its work force to manage those resources.

Establish An Investment Climate That Supports A Strong Industrial/Technology Base

The United States must pursue fiscal and spending policies that will make capital available and affordable for business investment. It is time to consciously promote a climate that fosters long-term capital formation. U.S. business is too often oriented to the nearer-term return; tax policy changes can help change this thinking by making long-term investments in productive assets more financially attractive.

Interest rates, kept higher than those in other countries by the large national deficit, place U.S. companies at a competitive disadvantage. Civil aircraft manufacturers, competing internationally against firms that have the benefit of government subsidization, face the additional problem of higher-cost capital for investment in research and production. High U.S. interest rates can lead to pricing U.S. products too high for export. They also depress business profits and the consumer economy. By lowering demand for airline tickets, ultimately they decrease demand for new aircraft.

Interest rates are extremely important to U.S. commercial aerospace manufacturers who face long, capital-intensive product development cycles. It can take as long as six years to develop a new engine, and five years for a new aircraft model. Companies require from $2-$5 billion of capital during this period, of which a considerable share must be financed.

Once a new engine or aircraft is introduced, the breakeven point on sales can be as far as 12-15 years into the future. Manufacturers anticipate that the price set by competition will be high enough to cover production costs, non-recurring R&D, and interest on the capital that has been tied up during the development period. However, fierce market competition—often influenced by foreign government support of their aircraft and engine manufacturers— will keep prices as low as possible. Manufacturers have no assurance of recovering their costs.

A business plan that looks attractive with real interest rates of 3 percent may not be attractive at 6 percent. A company in Japan, Germany, Canada, or elsewhere that can obtain development capital at lower rates than in the United States has an important edge over U.S. manufacturers.

The high cost of capital in recent years, in conjunction with other government sector policies, has contributed to a substantially increased debt burden for defense contractors, and to decreased industry profitability.

Both Congressional and DoD policy have long favored the use of performance specifications (as opposed to detailed design specifications) and the acquisition of commercial products wherever they would meet defense needs. Despite this policy, there is very limited acquisition of commercial products and limited opportunity for industry to design and build hardware to meet certain performance requirements. The government must be willing to give up unnecessary design specifications and "how to" requirements which inflate the cost of hardware, and work more closely with industry to take advantage of available technology and ingenuity. The potential benefits of lower cost and a more competitive industry are significant, particularly as the defense budget shrinks.

U. S. government policies and planning should be reordered to relieve financial pressures on industry. The first step is to make fully allowable under government contracts the costs of independent research and development (IR&D) and bid and proposal (B&P). IR&D (research initiated, controlled and financed by individual companies) and B&P (efforts made by companies to respond to technical requirements in bidding on contracts) are both forms of company overhead. These efforts are essential to the government. Because it is controlled by the companies themselves, IR&D can be directed relatively easily to promising areas of inquiry—often those areas associated with R&D being performed under contract to the DoD or NASA—thus amplifying the payoff for the government. Technological breakthroughs, even development of entire technologies, due to IR&D expenditures are legion. Computer miniaturization, integrated circuits, laser technology and gyros are just a few of the fruits of IR&D.[3]

Bid & Proposal (B&P) expenditures also directly benefit the government by allowing companies proposing for government work to detail their ideas and capabilities on highly complex technological projects. Accurate and exhaustive information on contracts translates directly to wise awards. Unlike rent, electricity and salaries, however, IR&D/B&P costs are not fully allocable to overhead on government contracts. The government places a ceiling on the amount it will allow in overhead contract rates when such efforts could result in a product or service the government wishes to buy. (Recently, Congress broadened the concept of potential military relevancy to encourage work with commercial and international market applications.) IR&D/B&P—like any normal cost of doing business—must be allowable in full by the government if the industry's high levels of innovation are to continue.[4]

Complicating the industry's financial situation for several years in the 1980s was the DoD policy of moving away from cost reimbursement-type contracts toward fixed price contracts, thus shifting more financial risk to industry. Fortunately, this policy is now changing. Defense contractors have also had to accept lower profit levels and have been required to finance their inventories, for which they receive less than full reimbursement under progress payments.[5]

Providing contractors with higher progress payments on contracts will facilitate the flow of operating capital and reduce the need of companies to rely on costly capital markets. It would be a major step toward keeping the defense industrial base strong and viable.

The defense budget cycle should be reoriented toward more multi-year procurements. For cost-effectiveness, a greater number of programs should be funded for more than one year at a time. Multi-year procurements stabilize schedules, reduce materials costs, permit capacity planning and strengthen the supplier base by making it worthwhile for contractors to pursue large projects.

As the defense budget shrinks, some if not several, significant programs will be terminated or cut back. Such terminations or cutbacks may result in 1) idle facilities, 2) unamortized investment in special tooling and test equipment and industrial production equipment, 3) relocation and severance costs, and many other similar costs. At the very least, such terminations or cutbacks will reduce the business base, raise overhead and make firms less competitive. Industry has taken the position with respect to economic adjustment that Congress should let the forces of the marketplace work rather than single out the defense industry for special legislative relief. However, the government can and should provide some protection against extraordinary costs resulting from a termination, which could threaten the viability of a firm because of their drain on other programs.

The current DoD policy on recoupment of nonrecurring research, development, test and evaluation (RDT&E) and production costs should be rescinded, and recoupment applied only to the export of major defense equipment. Current policy imposes substantial costs on the industry. By raising the price of U.S. products in the international marketplace, it limits the ability of the industry to compete. Recoupment involves a surcharge, which can be as high as 24 to 74 percent, on commercial sales of defense equipment to foreign governments. Initially, recoupment applied to foreign military sales of "major defense equipment." However, current DoD policy is to apply the surcharge to all sales, domestic and international, of major and nonmajor defense equipment, and licensing of technology, as well as sales of equipment and technology derived from such development and production. DoD defines a "derivative item" as one consisting of common parts equal to or more than 10 percent of the defense item. This policy effectively taxes domestic and commercial sales of a wide-ranging group of products and/or technologies, which may be only in minor part derived from government funding.

Aside from the recoupment surcharge itself, recordkeeping to track "derivative" items is considerable. By increasing costs, this policy discourages participation in the defense business. It is also a disincentive to commercializing defense technology and thereby encourages the physical separation of defense and commercial activities within the same company in order to reduce liability for failure to adequately trace the origins of particular technologies. Commercial products produced by defense companies will incur a higher price structure than those produced by companies without defense business.

A healthy investment climate will help second- and third-tier suppliers as well as large prime contractors by fostering investment in new facilities, R&D, and manufacturing technology. It will also facilitate partnerships between companies wherein larger firms assist their subcontractors and vendors to improve quality, productivity and service. Although many second- and third-tier aerospace suppliers do business globally, some may not be able to afford the continuous investment required to compete effectively. Other suppliers may not participate in the international market at all. Through teamwork, smaller companies can enhance their position as suppliers to U.S. original equipment manufacturers, and then expand their business internationally from a stronger domestic sales base. Stronger second- and third-tier companies will also be better positioned to do business—and even to form partnerships—with companies in other countries.

Many U.S. aerospace manufacturers are developing closer ties to their subcontractors. Through improved communication of requirements and improved performance feedback they are establishing the basis of long-term relationships. Suppliers who demonstrate consistent excellence can be assured of continuing business. They share in delivery and sales projections so that they can improve factory planning and increase efficiency. A more stable business base permits greater profits and, in turn, the resources and flexibility to make further productivity improvements. Suppliers benefit, and large prime contractors benefit, too, through lower production costs and better delivery schedules. A sound investment climate will help large U.S. companies maintain their commitment to strengthen the industrial/technology base through training, R&D and manufacturing assistance to suppliers.

Educate, Motivate And Develop A High-calibre Work Force

An educated, highly motivated work force is critical to the aerospace industry's competitive posture in the years ahead. Government, industry and academia together must strengthen American education programs—particularly the study from kindergarten through the university level of science, math and languages.

Aerospace companies are seriously concerned about the lagging scholastic scores of American students vis a vis foreign students (and even in comparison to American students just a decade ago). American youths also show a general disinterest in science and technology careers, which does not bode well for high technology companies in the United States. The failure of American education—and the failure to interest and motivate young people to pursue technical careers—can easily translate into the failure of U.S. products in the international marketplace.

Two-thirds of aerospace companies in a 1989 AIA survey reported shortages of scientists and engineers in certain areas. A full 85 percent predicted recruitment difficulties in the future. While defense budget cutbacks will cause work force downsizing and dislocations of technical talent within the industry, in the long run aerospace will continue to seek talented scientists and engineers. There will be a particular need for those trained in the advanced technologies that provide a competitive edge when incorporated in new systems and products. Aerospace companies are just as concerned about a shrinking pool of well-educated people from which to draw their technicians and skilled production workers.

In an international business such as aerospace, good language skills, including the ability to converse in foreign languages and to appreciate foreign cultures, are also important. It requires an extremely bright, articulate, sophisticated work force to negotiate multi-billion dollar sales and partnership agreements around the world — and to produce products on the leading edge of technology here at home.

Aerospace companies are providing hundreds of millions of dollars on school system and student support from kindergarten through university level. They are offering on-the-job training including advanced-level courses and retraining, tuition reimbursement for employees, and remedial education when necessary. They are targeting women, minorities and the disadvantaged for special assistance. Beginning at the elementary level, companies provide tutoring, plant tours, career day speakers, academic competitions, equipment, summer jobs and internships, and assistance in developing curricula.

Aerospace companies have always worked closely with the university community, sometimes in contract research relationships, and at other times in consortia and other cooperative R&D efforts. Various exchange and support programs focus on enhancing the education and experience of both industry and university personnel. A current industry effort is providing information on the Key Technologies program to universities to help them fine-tune their curricula to respond to future needs of industry. More cooperation is needed to relate curriculum to knowledge-intensive manufacturing and to development of generic, enabling technologies.

Financial incentives could help encourage vital industry assistance to, and cooperation with, universities and public education.

The continuing strength of the U.S. aerospace industry depends as much on its human resources as on its technology. A strong industry/school/government partnership is needed to educate, motivate and train a work force that can compete globally.

Promoting Export Sales

Assuming the United States is operating from the strongest possible technological, financial and educational base here at home, the American aerospace industry will still face challenges—based both on the actions of its competitors and its government—affecting commercial and defense sales.

Remove Barriers To Trade

The U.S. civil aircraft sector—particularly commercial transport manufacturing—is the major contributor to the aerospace industry's positive trade balance. Approximately two-thirds of commercial jet transports are shipped outside of the United States. The international rules of trade—established through the GATT and the Civil Aircraft Agreement—profoundly affect the ability of the U.S. civil aircraft industry to compete around the globe. The Government must continue to work for a free and open climate for international trade and investment, and take aggressive action against violators. Despite the virtual elimination of tariff barriers in the civil aircraft industry among developed countries, a number of non-tariff barriers prevent a fair and free market environment. Government subsidization of industries that compete against U.S. manufacturers is a major issue that has not been satisfactorily resolved despite years of negotiation.

In early 1991, the United States asked a General Agreement on Tariffs and Trade (GATT) panel to examine exchange rate guarantees through which the German government is subsidizing the participation of Deutsche Aerospace in Airbus, the European commercial transport consortium. The subsidy is reportedly worth hundreds of millions of dollars. The U.S. trade action came after the European Commission rejected U.S. demands that development subsidies be cut to 25 percent, and announced no change in German exchange rate payments to Deutsche Airbus. In mid-year 1991, the United States was seriously seeking to expand the case to include other subsidies covered under the GATT Subsidies Code. A U.S. Department of Commerce study estimates Airbus development and production subsidies at between $10 and $20 billion. [6]

The Airbus issue relates to government funding, provided either directly or indirectly, to support the costs of commercial transport development, production and marketing. These types of support are covered by the Subsidies Code and the Civil Aircraft Agreement of the GATT, to which Airbus consortium members are signatories. The Aircraft Agreement sets out the conditions of fair and free trade with respect to non-tariff barriers in the civil aircraft manufacturing industry. Subsidy support of this type distorts the market by affecting the price of aircraft to the disadvantage of private companies that must internally generate investment funds.

U.S. manufacturers must finance the enormous production, development, and marketing costs of new aircraft from company funds or by borrowing at market rates. Yet they compete for sales, not simply against other manufacturers, but against governments who have made a commitment to assist aircraft manufacturers until they succeed. Government support makes it possible to launch a new aircraft program even when expectations of cost recovery and profit achievement are unrealistic. It also affects the timing of entry of new aircraft and technologies into the market. With government financial assistance, an aircraft model can be launched even before a significant market exists; government support can maintain production facilities and production even when there are no orders. Inventory buildup is readily available to be sold or leased cheaply; this distorts the market for manufacturers who are borrowing money at market rates and who can initiate and sustain production only in response to market signals. When aircraft are priced below what is necessary to achieve a commercial rate of return, it forces a lowering of the price of aircraft produced under true market conditions. The end result for U.S. firms: lower profits and/or smaller market share than might have been expected.

As an increasing number of countries become involved in the manufacture of civil aircraft, systems, and parts, it is important that they, too, become signatories to the Civil Aircraft Agreement. Various import barriers continue to protect aircraft manufacture in countries that have not signed the Agreement.

The United States should continue to support and work for a strong multilateral trading system. Failure of the Uruguay Round of the GATT could increase unilateral trade actions; unilateral initiatives could easily bring retaliation to U.S. companies in industries—including commercial aerospace—that depend heavily upon international sales. Trade actions outside a multilateral, international trade regime will be rooted more in politics than in economics and will tend to restrict rather than expand trade opportunities.

The GATT subsidies code should be strengthened by a more effective dispute settlement and enforcement mechanism. Stricter disciplines are essential to protect U.S. companies against the loss of intellectual property. Intellectual property protection is key to the development and commercialization of new technologies—to the "payoff" from the United States' investment in R&D. The intellectual property issue is particularly important in a global industry where U.S. companies engage in joint manufacturing and coproduction programs with firms in other countries.

A strengthened GATT international trading system will be important in many respects in the coming years as U.S. manufacturers—and companies from other market economies—face competition from firms from nonmarket economies. For example, in the commercial space arena, China and the Soviet Union are important contenders for commercial launch services. Both of these countries can significantly underbid profit-making enterprises in free market economies. U.S. companies could quickly become noncompetitive in certain space markets unless the government moves to effectively regulate the entry of launch systems developed in nonmarket economies into the limited commercial market.

At the same time, aerospace markets are developing for the West in Eastern Europe and the Soviet Union. U.S. and Western European firms are already making sales and forming business relationships in the region. As aerospace industries develop in these countries, the differences between economies will be highlighted.

While the United States is trying to foster private enterprise in nonmarket countries, and to cement good relationships with these nations, it is important to establish ground rules based on fair trade standards.

Outside of the GATT arena, the U.S. Department of Commerce has launched a major initiative to negotiate with the European Community in the areas of standards, testing and certification—a concern to many U.S. industries including aerospace. European regional actions in support of the European Community Internal Market may pose problems to U.S. trade and competitiveness. The development of new regional standards and certification systems in the EC is occurring at the expense of international harmonization efforts through the North Atlantic Treaty Organization—for defense—and the International Organization for Standardization—for nondefense.

European procedures exclude the United States from participating in their standards and certification development processes, and the requirements now being established in Europe differ in significant respects from those of the United States. Other, non-EC nations, including the nations of Eastern Europe, are watching EC technical developments with interest and may adopt EC standards and certification systems.

Developments in Europe could negatively affect the United States by posing non-tariff, technical barriers to the entry of U.S. products into the European—and other—markets. The cost to manufacturers of complying with non-U.S. standards and obtaining non-U.S. certification would add to the cost of American products. Standards significantly different from those of the United States will also pose barriers to international cooperative efforts.

Establish Pro-trade Policies

U.S. commitment to strengthening the multilateral trading system must be supplemented by policies that promote the integrity of U.S. federal airworthiness regulations (FARs).

Over the years, the Federal Aviation Administration's certification system, regulatory standards and airworthiness directive approach to development of safe and efficient air travel have ensured safety and promoted the use of U.S. aircraft around the world. Today, however, the marketplace is global and more dynamic, and the type and nature of services required of the agency continually change. The agency must work with European nations to achieve common performance-based design standards—and do so without full input to European deliberations (see "Remove Barriers to Trade" above). The European Joint Airworthiness Requirements (JARs) have gained credibility worldwide and could become more internationally accepted than the FARS without an active FAA effort to defend and promote U.S. certification requirements.

U.S. and European manufacturers have agreed that certification and safety should not be competitive issues. They are working to develop criteria and guidelines that will prevent this from happening. The effort needs strong governmental support.

As the commercial aviation business expands globally, FAA's role also includes support in establishing or updating certification agreements with other countries, and providing technical assistance for the development of airworthiness capability in these countries. These activities are vital to the support of U.S. manufacturers forming supplier or joint venture relationships in order to do business around the globe. Budget and administrative constraints should not be allowed to undermine the FAA's ability to move quickly, to hire the best technical talent, and to support the U.S. commercial aviation industry to the fullest extent possible.

The United States should speed up efforts to harmonize international product liability laws. Present U.S. laws on product liability impose delay and uncertainty upon accident victims and their survivors by encouraging lengthy litigation. They also damage American manufacturers—especially the smaller general aviation manufacturers, who are particularly vulnerable to foreign competition. Foreign aircraft manufacturers can price their aircraft more attractively because they do not have to absorb the high cost of U.S. product liability laws on the bulk of their sales. U.S. product liability laws increase insurance costs, which are passed on to buyers. They can affect even the viability of smaller producers. One general aviation manufacturer estimates that insurance costs can add $75,000 to the cost of every new plane. Uniform federal standards on manufacturer product liability with automatic, prompt compensation for victims, would provide equity for survivors of air accidents, while making American aviation products more cost-competitive.

Foreign sales of defense items benefit the United States by helping maintain a strong industrial base in a time of falling domestic defense expenditures, reducing the unit costs of equipment to the United States, and by supporting national foreign policy objectives. The Administration should develop a comprehensive policy on defense exports, which also addresses industrial base and technology transfer issues. So fragmented has the government position become that manufacturers often have to get second, third and even fourth opinions before proceeding with an overture or sale.

The Administration should clearly state its support for defense exports—and for international cooperative programs—in the defense arena. Over the years, administration support of defense trade has ranged from hostile to lukewarm. Often support has been expressed but not acted upon. Implementation guidance should support policy statements. In the case of defense cooperative programs, there should be a single point of coordination within the DoD.

As competition increases in world arms markets, the U.S. administration must not only speak with one voice, but must actively promote defense exports, where such exports are consistent with foreign policy interests. Even as the U.S. plans its weapons systems, it must keep in mind the interests of potential buyers from other countries. In the post Cold War environment—as the United States seeks to project a presence in various regions of the developing world and to form cooperative defense partnerships—this requirement is increasingly important. American manufacturers should be encouraged to show defense products at exhibitions around the world and should be supported by the government in arranging such appearances. Defense export prices should be kept competitive by eliminating or capping recoupment surcharges designed to reimburse DoD for R&D costs it paid when the equipment was originally developed. (See "Establish an Investment Climate That Supports A Strong Industrial/Technology Base.")

In an effort to prevent the American defense system from becoming too dependent on foreign components and commodities, the Congress considered amendments to the Defense Production Act of 1950 that would require contractors to report offset agreements totaling more than $5 million. (Offsets are arrangements, such as subcontracts or coproduction agreements, that American companies sometimes have to offer or accept in order to conclude sales with foreign buyers.) Repeatedly, studies have shown that offsets are an accepted part of defense sales abroad and do not harm overall U. S. competitiveness. The willingness of foreign competitors to fulfill offset requirements might give them an advantage if U.S. suppliers are not allowed to negotiate offsets. Burdensome offset reporting systems increase costs to U.S. manufacturers. When efforts are made to standardize data, it can present a misleading picture, exaggerate the perception of the problem, and possibly even encourage offset demands by other governments. Companies also risk disclosing proprietary information, to their competitive disadvantage.

While the U. S. government should work toward reducing offsets through multilateral consultations, it would not be in the national interest to interfere with such arrangements on a deal-by-deal basis. The Bush Administration has agreed that the decision to engage in offsets should reside with the company involved. At the same time, the White House declared that it was time to consult with U. S. friends and allies regarding the use of offsets in overseas defense sales. The aerospace industry supports such discussions as long as industry is also consulted and government takes no unilateral action to limit offsets.

Adequate financing should be available for all—commercial and defense—U.S. exports. Often an export sale hinges on the ability of the American seller to arrange financing for the foreign buyer. Yet U.S. Government policies for export financing are neither competitive nor consistent, while many foreign competitors' governments work closely with their industries to finance exports. Since Foreign Military Sales financing and Export Import Bank funds for civil export financing are declining, policy changes are needed. Financing is needed for sales outside the United States, and for sales to domestic airlines, when American manufacturers are competing against foreign government-subsidized companies. Since funds for civil export financing are limited, the U.S. Treasury is often unwilling to take aggressive action against these sales into the U.S. domestic market—despite Eximbank's legal mandate to do so. When subsidization can be verified, funding should be available to the Eximbank to completely fulfill the mandate of this provision of the law. Government guarantees, political risk insurance, extension of repayment terms, and cooperation with foreign financing agencies to support international collaborative programs are all positive export strategies. Extending government guarantees for military exports would be particularly effective in promoting sales of American defense products abroad. Government guarantees would make foreign sales of defense items a more promising investment for commercial banks. Any mechanism to support defense exports in this fashion must neither reduce financial or political support for the Eximbank nor compete with guarantees for commercial products.

Implement Technology Export Policies That Make National Security And Market Sense

The United States needs a technology export policy with a sharp market focus: one that seeks out technology useful to U.S. companies, one that protects the nation where transfer will truly be damaging but yet does not micromanage to the point of harm.

This can be accomplished with more precise definition of products and technologies to be controlled—rather than broad, generalized prohibitions, by clarification of control jurisdiction within the government, and by stronger government efforts to obtain access to technology developed abroad.

In an effort to identify and safeguard technology vital to the security of the United States, a number of U. S. departments, agencies and committees have been scrambling—often at odds with each other—to limit or control the transfer of technology to foreign governments. The result has been a maze of conflicting regulations. There have been cases in which a company obtains the permission of one agency to sell abroad, only to be fined by another for the transaction. The United States needs a more coordinated and sensible approach beginning with a resolution of the commodity jurisdiction issue.

Products with civilian applications are approved for export and controlled by the Department of Commerce under the Export Administration Act. Products with military applications are subject to the Arms Export Control Act administered by the Department of State. An increasingly problematical issue for aerospace revolves around "dual-use" products—parts and equipment with both military and civil applications. The problem is that these definitions are not as clear-cut as they once were. The Arms Export Control Act was designed to control the shipment of weapons, but increasingly military systems are made in many countries and are assembled using components and software based on civil technology. Similarly, thousands of existing products can be used for either civil or military purposes. The situation is complicated further when a potential product or system is sold as a commercial item and is then re-exported by the foreign purchaser to a buyer who may convert it to defense use. Over time, the State and Defense Departments have placed a number of these dual-use items on the U. S. Munitions List—which presently contains a number of products and technologies, which are widely used in the commercial sector. As a result, civil goods are caught up in sanctions aimed at arms exports or imposed for political reasons. The Departments of State and Commerce both may claim jurisdiction when this happens.

The executive branch must formulate a system in which State and Commerce will work together. A company should be able to appeal to either and get a prompt determination. If the two agencies cannot agree, the matter should be promptly referred to the President for a timely ruling.

The U. S. Munitions List should be trimmed of nondefense items and made to conform to the COCOM International Munitions List. A sensible definition of "defense article" must be reached keeping in mind that the United States is unilaterally controlling items as munitions that competitors define as dual-use (civil space hardware, civil aircraft engines, navigational equipment, etc.).

The dual-use commodity issue is only part of the problem. The export licensing system in general is cumbersome and time-consuming. There have been considerable efforts to improve the system but problems remain. Unfortunately, inordinate delays translate directly to lost sales. Industry needs better access to licensing officials, and processing time needs to be cut sharply.

Technology transfer cuts both ways. The U.S. Government should be working to gain American companies greater access to technology developed abroad. Each year, foreign companies develop and license thousands of products and processes, yet American companies often learn of developments too late to prevent duplication of effort or loss of competitive advantage.

The industry's innate respect for its competitors lies at the heart of its concerns over technology transfer policy. The United States does not have a lock on technology and the old way—relying too heavily on defensive strategies—will no longer work. Instead, the United States must forge a new path to technological leadership in aerospace.

Footnotes

1 Executive Office of the President, Office of Science and Technology Policy, *Aeronautical Research and Technology Policy, Vol. l: Summary Report*, November 1982, *National Aeronautical R&D Goals, Technology for America's Future*, March 1985 and *National Aeronautical R&D Goals, Agenda for Achievement*, February 1987.

2 Office of Aeronautics and Space Technology, National Aeronautics & Space Administration, *Civil Aeronautics Technology Development and Validation Plan*, March 1988. See also Aerospace Industries Association (AIA), *Technology Readiness: Key to Long-Term Market Strength of U.S. Civil Aircraft Manufacturers*, September 1989.

3 AIA, *National Benefits of IR&D*, January 1988.

4 AIA with Electronic Industries Association and National Security Industrial Association, *Maintaining Technological Leadership: The Critical Role of IR&D/B&P*, September 1989.

5 The MAC Group for the Aerospace Industries Association, *The Impact on Defense Industrial Capability of Changes in Procurement and Tax Policy, 1984-1987*, February 1988; *Updated for Changes in Progress Payments, Special Tooling Policy and Tax Policy*, January 1989.

Appendix A - U.S. Exports of Aerospace Products, 1985 - 1990

COMPOSITION OF U.S. EXPORTS OF AEROSPACE PRODUCTS
Calendar Years 1985 - 1990
(Millions of Dollars)

Aerospace Exports	1985	1986	1987	1988	1989	1990
TOTAL	$ 18,725	$ 19,728	$ 22,480	$ 26,947	$ 32,111	$ 39,083
TOTAL CIVIL	$ 12,942	$ 14,851	$ 15,768	$ 20,298	$ 25,619	$ 31,517
Complete Aircraft - TOTAL	$ 6,694	$ 7,365	$ 7,518	$ 10,295	$ 13,447	$ 18,643
Transports	5,518	6,276	6,377	8,766	12,313	16,691
General Aviation	191	243	295	348	419	561
Helicopters	210	277	201	219	156	161
Used Aircraft	333	501	503	639	533	712
Other, Incl. Spacecraft	442	68	141	323	217	518
Aircraft Engines - TOTAL	923	987	1,207	1,570	1,948	1,754
Aircraft and Engine Parts Incl. Spares - TOTAL	5,325	6,499	7,043	8,432	10,019	11,120
TOTAL MILITARY	$ 5,783	$ 4,875	$ 6,716	$ 6,650	$ 6,492	$ 7,566
Complete Aircraft - TOTAL	$ 2,012	$ 1,502	$ 2,628	$ 2,157	$ 6,492	$ 1,481
Aircraft Engines - TOTAL	146	111	158	223	236	203
Aircraft & Engine Parts Incl. Spares - TOTAL	2,800	2,604	3,085	3 ,214	4,134	4,124
Guided Missiles, Rockets & Parts - TOTAL	825	658	845	1,056	1,037	1,758

Source: Aerospace Industries Association

U.S. Imports of Aerospace Products, 1985 - 1990

COMPOSITION OF U.S. IMPORTS OF AEROSPACE PRODUCTS
Calendar Years 1985 - 1990
(Millions of Dollars)

Aerospace Imports	1985	1986	1987	1988	1989	1990
TOTAL	$ 6,132	$ 7,902	$ 7,905	$ 9,087	$10,028	$ 11,801
TOTAL CIVIL	$ 4,984	$ 6,398	$ 6,409	$ 7,604	$ 7,200	$ 8,251
Complete Aircraft - TOTAL	$ 1,502	$ 2,050	$ 2,038	$ 2,702	$ 2,788	$ 3,061
Transports	599	742	551	1,125	1,282	737
General Aviation	673	1,053	1,337	1,369	1,160	1,599
Helicopters	45	63	79	104	109	162
Other, including Used Aircraft & Gliders, Balloons & Airships, Incl. Spacecraft	185	192	70	103	238	563
Aircraft Engines - TOTAL	I,019	1,133	1,117	951	999	1,234
Aircraft and Engine Parts - TOTAL	2,463	3,215	3,254	3,951	3,414	3,955
TOTAL MILITARY	$ 1,148	$ 1,504	$ 1,496	$1,483	$ 2,828	$ 3,550
Complete Aircraft - TOTAL	$ 20	$ 35	$ 33	$ 2	$ 17	$ 44
Aircraft Engines - TOTAL	217	286	199	106	971	1,209
Aircraft and Engine Parts - TOTAL	911	1,183	1,265	1,376	1,841	1,954
Other						343

Source: Aerospace Industries Association

Appendix B - International Aerospace Partnerships

The following list is not meant to be comprehensive, but rather is illustrative of the variety of cooperative relationships being established in the global aerospace industry. Listings are based on news reports on various agreements over the last several years. Some relationships may have changed; they may now include other partners, have moved into another phase, or been terminated. Also see Figures on pages 27 and 46.

US/EUROPEAN PARTNERSHIPS

Civil

General Electric, US Snecma, France	Joint venture to produce commercial jet transport engines
General Electric, US Alenia, Italy Matra, France MBB-Erno, Germany	Joint development of European Retrievable Carrier (Eureca) unmanned free-flying platform for space microgravity experiments
Pratt & Whitney, US MTU, Germany	Agreement to be "preferred partners" on future engine programs. Companies will integrate commercial and general aviation R&D, manufacturing and marketing
Pratt & Whitney, US MTU, Germany Soviet Ministry of Aviation	Agreement for eventual development and coproduction of jet engines for two Soviet passenger planes
Gulfstream Aerospace, US Swearingen Engineering & Technology, US Williams International, US Rolls-Royce, UK	Partnership to develop and market entry-level business fan jet aircraft

Textron Inc., US British Aerospace, UK	Textron is major subcontractor on wing structure for A-330 and A-3440
ITT Avionics, US Plessey Avionics, UK	Jointly produce and market receives and modules for Global Positioning System (NAVSTAR) program
Lockheed, US Aerospatiale, France	Agreement to develop cooperative space programs
Lockheed,US Lucas Aerospace, UK	Joint development, manufacture, marketing of mechanical coolers for spacecraft
Orbital Science Corp., US Hercules Aerospace, US Arianespace, Europe	Arianespace to market OSC's Pegasus vehicle in Europe
General Electric, US Snecma, France MTU , Germany Japan	Partnership to develop commercial jet engine for Boeing 777
General Electric, US Marconi, UK	Building third generation satellites for Inmarsat, 59-nation mobile satellite communications cooperative
McDonnell Douglas, US Spacehab, US Alenia, Italy	To development, qualify and construct Spacehab laboratory modules
Westinghouse, US IBM, US AT&T, US C. Itoh, Japan Daimler-Benz, Germany Aeronavigatsia R&D Institute, USSR	Form Global Air Transportation Systems and Services Group to modernize USSR's air traffic management system

Defense

General Dynamics, US British Aerospace, UK	Agreement to cooperate on international defense procurement and technologies projects including M1A2 tank

Grumman, US Agusta, Italy	Bid on U.S. Air Force T-37 trainers with modified version of Agusta AIAI Marchetti S.211 trainer
Boeing, US McDonnell Douglas, US Deutsche-Airbus, UK	Jointly study potential for a follow-on to French-British Concorde supersonic transport
Beech Aircraft, US Pilatus Aircraft, Switzerland also Lockheed, US Aermacchi, Italy also Grumman, US Agusta, Italy	Offer Pilatus PC-9 turboprop trainer for Air Force/Navy Joint Primary Aircraft Training Program (JPATS)
McDonnell Douglas Helicopter, US Westland, UK	Produce advanced version of McDonnell Douglas Apache
Martin Marietta, US Diehl, Germany Thomson-CSF, France Thorn EMI, UK	Joint venture MDTT, Inc. to develop terminally guided warhead for Multiple Launch Rocket System
McDonnell Douglas, US Matra, France	Marketing French Mistral missile in US
Raytheon, US Italy	Coproduction of Patriot missile systems for Italian air defense
TRW, US Siemens, Germany General Electric, UK Plessey, UK	Develop prototype for SHAPE/ Central region mobile C31 system
General Electric, US Thomson-CSF, France Thorn EMI, UK Siemens, Germany	Advanced counter-battery radar (Cobra) for W. European ground forces

Raytheon, US Martin-Marietta, US AEG Telefunken, Germany MBB, Germany Siemens, Germany	Advanced version of Patriot missile
Hughes Aircraft, US Esprodesa, Spain	Develop and produce in US and Spain the Aries medium-range anti-tank missile
Computer Science Corp., US Alenia, Italy	Form joint venture, Space Software Italia, to produce software and systems engineering for aerospace software systems
US Denmark Norway Netherlands Belgium	F-16 upgrade
Eldec Corp, US Dunlop, UK	Form Dunlop-Eldec Electronics Ltd to design and build electronic equipment for commercial and military aerospace and marine markets
Atlantic Research, US BAJ Ltd, UK	Joint venture to build weapon propulsion systems
Hughes, US Raytheon, US MBB, Germany	Coproduction of Advanced Medium Range Air to Air Missile (AMRAAM)
Fairchild Aircraft, US CASA, Spain	Agreement to market CASA-212 to US Government
Allison Gas Turbine, US Rolls-Royce, UK	Propose Rolls-Royce RB211-535E3 engine for USAF C-17 program
Hughes, US Aerospatiale Helicopter Corp. France/US	Team for Army's Initial Entry Rotary Wing Integrated Training Systems program

E-Systems, US Hughes Aircraft, US MBB, Germany Telefunken, Germany Elekluft, Germany Grob, Germany	Marketing venture to meet German environmental and disarmament verification needs
Chrysler Technologies, US Alenia, Italy also Rockwell, US CASA, Spain	Bid for G222 turboprop for USAF C-27A Intratheater Airlift medium transport Proposing CN-235
McDonnell Douglas, US Italy	Agreement to codevelop radar-equipped night-attack AV-8B Harrier II attack jet
Westinghouse, US Pilatus Britten-Norman, UK	To produce airborne surveillance aircraft using Islander aircraft and Westinghouse APG-66 radar
Boeing, US Sikorsky Helicopter, US MBB, Germany	Agreement to compete for development and production of US Army's Light Helicopter program
General Electric, US Alfa Romeo Avio, Italy Fiat Avio, Italy	Codevelopment of engine for Italian Navy's AH101 helicopter
General Electric, US Deutsche Aerospace, Germany	Interim cooperative agreement to target areas in commercial communications satellite market
FIAR, Italy Rockwell, US	Rockwell to manufacture, under license, FIAR's F-5 aircraft rădar upgrade systems. Companies to pursue other segments of avionics upgrade market
Chrysler Technologies, US Alenia, Italy	Agreement to modify Alenia C-222 transports with mission avionics for USAF
Boeing, US Deutsche Aerospace, Germany	Agreement to coordinate selected areas of supersonic aircraft research
Boeing, US Thomson-CSF SA, France	Five-year relationship to explore military and civilian joint ventures

EUROPEAN PARTNERSHIPS

Aerospatiale, France Dassault Aviation, France Deutsche Aerospace, Germany Alenia, Italy	Form consortium, Hermespace, to develop Hermes spaceplane
Marconi, UK Matra, France Spar Aerospace, Canada Dornier, Germany Remote Sensing Consult, Denmark	Cooperating on design studies of multi-frequency imaging microwave radiometer for polar-orbiting Columbus platform
Aerospatiale, France MBB Helicopter, Germany Agusta, Italy Fokker, Netherlands	Join to produce NATO NH-90 rotorcraft
France Germany European Space Agency (14 European governments)	Produce Ariane space launcher
Aerospatiale, France British Aerospace, UK CASA, Spain Aeritalia, Italy	Form European Future Large Aircraft Group (Euroflag) to develop replacement for Lockheed C-130 Hercules
Germany Italy UK Spain	To develop and build a European Fighter Aircraft (EFA)
Aerospatiale, France Thomson-CSF, France Selenia, Italy	Join as Eurosam to design, produce, sell air defense systems
Aerospatiale, France Selenia, Italy	To study cooperation in satellites
Rolls-Royce, UK BMW, Germany	Joint development, manufacture, marketing of engines for small civil and military jets.
Aerospatiale, France British Aerospace, UK	To study potential for a follow-on to French-British Concorde supersonic transport

General Electric, UK Thomson-CSF, France	Agreement to co-design and develop next-generation radar for post-2000 follow-on to the European Fighter Aircraft
Thomson-CSF, France Ferranti, UK	Joint venture, Ferranti-Thomson Sonar Systems UK Ltd, to develop sonar systems
France Spain Italy UK	Sign protocol pledging development of new ground-to-air missile systems
GEC-Marconi, UK Thomson-CSF, France	Form GEC-Thomson Radar (GTAR) to jointly develop active array technology for airborne fire-control radars

EUROPEAN AND US PARTNERSHIPS WITH REST OF THE WORLD

European Partnerships

Aerospatiale, France CATIC, China Aerospace Technologies, Australia	Agreement for joint study and development of lightweight civil/military helicopter
Aerospatiale, France CATIC, China	China producing French Dolphin under license. Joint development of single-engine, light, multi-purpose helicopter for civil and military markets
Short Brothers, Ireland MBB, Germany CATIC, China	Joint company to oversee pre-development of proposed MPC-75 twin-engine propfan transport
Arianespace, Europe Australia	Arianespace to help Australia develop space capabilities
Daimler-Benz, Germany Mitsubishi, Japan	Agreement to jointly conduct aerospace research in small passenger planes & engines, space technology, ultrasonic aircraft

France Korea	Military cooperation agreement for joint production and increased technological and industrial cooperation
British Aerospace, UK Ministry of Aviation Industry, USSR	Study to assess feasibility of launching version of HOTOL (Horizontal Takeoff and Landing Vehicle) from Antonov An-225 heavy-lift transport to create low-cost satellite launch system
Rolls-Royce, UK Kamov Design Bureau, USSR	Agreement to study putting RTM322 engine on Ka-62R helicopter (civil versions for export)
Alenia, Italy NETZ Scientific Research Institute, AIRE Institute & Proton Co., USSR	Forming joint venture company, Buran, to develop air traffic control systems for USSR and for export
Dassault, France Mikoyan Design Bureau, USSR	Agreement that Soviet Bureau will produce some structural elements for the Falcon business jet

US Partnerships

Sikorsky Helicopter, US Daewoo, Korea also Bell Helicopter, US Samsung, Korea	Competing to produce Korea's next generation medium helicopter
Boeing Company, US Mitsubishi Heavy Industries, Japan	Boeing 777 commercial jet transport
McDonnell Douglas, US CATIC, China	China producing nose and tail sections for MD-80 commercial jet aircraft as well as assembling MD-82s for China's airlines.
McDonnell Douglas, US Pratt & Whitney, US Northwest Airlines, US	Memorandum of Understanding to develop twin-jet MD-95 aircraft

LTV, US Turkey	Agreement to produce Multiple Launch Rocket System in Turkey
Hughes Aircraft, US Nippon Electric, Japan	Building weather satellite for Japan
McDonnell Douglas Helicopter, US Hawker de Havilland, Australia	Produce helicopters in Australia for assembly in US
Gulfstream, US Sukhoi Design Bureau, USSR	Develop 50-passenger supersonic business jet
TRW, US Israeli Aircraft Industries, Israel	TRW is leading subcontractor for US short-range unmanned air vehicle
Ford Aerospace, US Rafael, Israel	Joint bid on thermal viewer for M1A1 tank using Israeli thermal imaging technology. Agreement to explore other applications of Israeli technology
Grumman, US CATIC, China	Study to upgrade and market Chinese F-7M fighter
TRW, US Mitsui, Japan	Joint venture to design and market security systems and engineering services in Japan and Pacific Basin
Boeing, US Mitsubishi, Japan Kawasaki, Japan Fuji, Japan	Production of Boeing 777 fuselage panel, fairings, etc. in Japan
Jepson Burns, US Automatika Design Bureau, USSR	Joint venture to make commercial aircraft seats and seat components
US Israel	R&D cooperation on anti-armor warhead technology, self-propelled howitzer, laser night attack system, tactical decoy system
General Electric, US	Cooperative R&D center in Taiwan

Evergreen Group, Taiwan	to design and develop aerospace components, and acquire overseas technology and expertise.
LTV, US FMA, Argentina	Offer FMA's IA 63 PAMPA jet trainer for Air Force/Navy Joint Primary Aircraft Training Program (JPATS)
Sikorsky Helicopter, US General Electric, US Korean Air, Korea	Korean licensed coproduction of Blackhawk helicopter and engine parts
Westinghouse, US Radwar Co., Poland	Agreement aimed at forming joint venture to develop and market radar and other electronic equipment
Honeywell, US Northwest Airlines, US Soviet Radio Ministry, USSR	Agreement to flight test and integrate GPS/Glonass navigation system for transport aircraft

Appendix C - Definitions

Acquisition - An acquisition occurs when one company buys a controlling interest in another company. The purchasing company keeps its identity. The acquired company may or may not maintain its identity. Often the acquired company becomes a division of the purchasing company.

Arms Export Control Act (AECA) - intended to control export of weapons systems and technology related to their production and components. State Department has primary responsibility for its administration.

Coproduction - Shared production and/or assembly of a product. In many cases some type of licensing is involved to facilitate manufacturing or production integration.

Codevelopment - Joint design, development, engineering and manufacture of a product.

Consortium - A consortium is a partnership between companies to carry out a specific task that is beyond their individual resources. Participants pool their complementary resources to achieve their project objectives but do not form a separate corporate entity. In many aerospace consortia, divisions of major participating companies act as lead contractors in their assigned areas of responsibility—subcontracting elements of their share of the project to lower-tier contractors. A management organization is set up to improve coordination among consortium members and facilitate contact with customers. This organization usually consists of a board of directors (comprised of representatives of the various member companies), customer support representatives, and sales staff.

DOD's "technology base" - basic applied research (budget lines 6.1, 6.2, and some of 6.3(a)—as opposed to "demonstration,"which is program driven.

Enabling - facilitating technologies that make a range of technical advances and new products possible.

Export Administration Act (EAA) - provides authority for controls for the export of commercial technology. Distinguishes between controls imposed for security reasons, and those applied to accomplish foreign policy objectives, unlike the AECA. Commerce Department has primary responsibility for EAA administration.

IR&D - a contractor's technical effort not sponsored by, or required in performance of, a contract or grant - distinguished from work performed for government under contract or grant. R&D costs on products sold to the Government on a fixed price, price competitive basis are recovered in the cost of products. But for other contracts awarded by DoD and NASA, contractor-initiated IR&D is considered an indirect or overhead item and allocated proportionately. IR&D is generally related more to future business than current sales and is recognized as a normal cost of doing business. There is one significant difference from other overhead costs: the government places a ceiling on the combined IR&D/B&P costs that a contractor can allocate as overhead to government contracts, regardless of what the contractor actually spends.

Joint Venture - The term joint venture is used to describe various types of risk sharing codevelopment, manufacturing and marketing arrangements. It can imply two or more companies working together to develop a specific product, or it can mean that participants contribute resources which are merged into a new company. In the latter case, the new entity handles all aspects of product development, manufacturing, etc. While the identity and structure of all participating companies remain fundamentally unchanged, the resulting new corporate entity operates as an individual company. The parent companies provide start-up capital and assume shares of the joint holding company based on their investment.

Merger - A merger occurs when two or more companies come together and form a new entity. Typically corporate structures and accounting systems of the companies are merged and any duplication of resources is eliminated.

Licensing - An arrangement whereby one company sells to another company the technology and/or manufacturing rights to produce a given product.

National Cooperative Research Act of 1984 - established a rule of reason for evaluating the antitrust implications of each research joint venture on an individual case basis and limited potential liability to actual rather than treble damages.

Research, Development, Test and Evaluation - programs which support modernization through military research, exploratory development, fabrication of technology demonstration devices, and development and testing of prototypes and full-scale preproduction hardware.

Research & Technology Development - activities primarily aimed at producing physical understanding, new concepts, design data, and validated design procedures for aircraft systems, subsystems, and components. Activities range from theoretical analysis to laboratory investigations to flight-testing experimental aircraft. (DoD budget categories 6.1, 6.2, and some of 6.3(a), and in NASA budget categories "R&T Base" and, with some exceptions, "Systems Technology.")

System Development - activities aimed at producing a specific aircraft or aircraft system for operational use — beginning with DoD budget category 6.3(b).

Technology Demonstration - activities primarily aimed at demonstrating improved subsystem or system characteristics to provide the development and manufacturing decision maker with the confidence that the anticipated improved level of performance is achievable in a new system. Characterized by testing configurations similar to the intended applications and by a modest degree of uncertainty in the outcome. These efforts are the final technology activity before system development, but before a decision to develop a specific system is made. A transition activity, which occurs during some of the large-scale testing stages of technology development and during technology demonstration, ensures effective and efficient handoff to industry for military and civil development.

Technology Development (variously called technology validation, proof-of-concept, or technology demonstration). Work directed to developing new technology and testing and demonstrating its readiness for application to a product to the point where designers and developers can use the technology with reasonable confidence. It is not specific design activity or preproduction and/or prototype activity. It is directed at such matters as:
• data development for performance estimating
• assessment of the effects of system integration,
• data development pertinent to design for FAA and/or DoD certification and flight safety, and
• development of bases for estimating new design benefits and costs in the process of making major design and development commitments.

Technology Development Strategic Plan - maps out the route to achieving national goals. Outlines programs needed including timing and estimated costs, program objectives, motives, payoffs - also the impacts of programs on various missions and applications and the involvement of various government agencies. Addresses the questions: How much funding is needed? From whom? Who will do the work? How can a program be structured?

Technology Roadmap - identifies the recommended development paths or progression for technologies with the most significant potential return in future systems. Identifies capabilities or levels of technical development, tools, techniques, etc. required in order to advance technologies, e.g., high temperature materials, refined structural analysis methods, unified technical data base, advanced automated design techniques.

Aerospace
Industries
Association

1250 Eye Street, N.W., Washington, D.C. 20005
(202) 371-8400