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National Aeronautics and
Space Administration

Washington, D.C.
20546

OCT 14 1987

Reply to Attn of: RJ

Honorable William R. Graham
Science Advisor to the President
Office of Science and Technology Policy
Old Executive Office Building
Washington, DC 20506

Dear Bill:

As a follow-up to our meeting on September 11, 1987, this letter provides our recommendations on the charter and future directions for the Aeronautical Policy Review Committee, our plans to reassess the NASA Wind Tunnel Testing Cost Reimbursement Policy, and the status of the NASA Wind Tunnel Revitalization Program.

First, relative to the Aeronautical Policy Review Committee, it is our view that this Committee provides a unique forum to address broad aeronautical R&D issues at the highest levels. The Committee membership and charter serve to strengthen the effectiveness of this partnership and enhance the understanding of the critical issues at the highest policy levels in the Administration and Congress. The two OSTP publications enunciating the national aeronautical goals and action plan provide a well thought out, cohesive framework for coordinated action by the government, academia, and industry. In the future, the Committee should assess status and progress towards implementing the action plan at the national level and report their findings to you at least once a year in support of possible Congressional testimony. In addition, I believe that the Committee should assess the key technology areas at a more detailed level. This would require the development of "technology roadmaps" indicating specific activities and/or products that are necessary to achieve the national goals. Although some of this has been done previously, it could be refined and extended to include schedules, resource requirements, and government/industry responsibilities.

With respect to membership on the Aeronautical Policy Review Committee, I believe that we should modify the current membership to raise the sights of the Committee and its stature. Some suggested candidates for membership are:

Donald Fuqua, President, Aerospace Industries Association;
Sanford McDonnell, Chairman & CEO, McDonnell Douglas Corp;
T. A. Wilson, Chairman, The Boeing Company;
Malcomb Stamper, Vice Chairman, The Boeing Company;
John McLucas, Chairman, QuesTech, Inc.;
Irwin Mendelson, President Engr. Div., United Technologies Corp;
Albertus D. Welliver, V.P. Engr. and Tech., The Boeing Company;
Jack Kerrebrock, Associate Dean of Engineering, M.I.T.; and
Eugene Buckley, President, Sikorsky Aircraft Company.

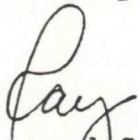
Any of the first three proposed candidates for membership would make an excellent chairman. Given their current positions and responsibilities, I believe Don Fuqua is the most appropriate candidate.

Second, with respect to the Wind Tunnel Revitalization Program, we have prepared a comprehensive 5-year program for rehabilitation and modernization of NASA's major wind tunnels. This program has been carefully structured in conjunction with the industry and the DoD and is endorsed by the NASA Advisory Council, Aeronautics Advisory Committee and the National Research Council, Aeronautics and Space Engineering Board. The budget has been submitted to the Office of Management and Budget for initiation in FY 1989. We are just completing preparation of a descriptive report on the Wind Tunnel Revitalization Program and will send you a copy within the next few weeks.

Third, with respect to the NASA Wind Tunnel Testing Reimbursement Policy, we have initiated an internal assessment of alternatives to the current NASA cost reimbursement policy as well as an independent review by the Aeronautics and Space Engineering Board of the National Research Council. The policy assessment will examine this issue objectively in terms of what is best for the country in the operation of this national resource to support full-scale development and aeronautical research consistent with the NASA Charter and the Aeronautics and Space Act. Enclosed is a white paper that provides back-ground on the current NASA policy and the NASA Management Instruction that enunciates the current policy.

If there is anything that we can do to supply further clarification of our views or plans in any of these areas, please let me know.

Sincerely,

A handwritten signature in cursive script, appearing to read "Ray", written in dark ink.

Raymond S. Colladay
Associate Administrator for
Aeronautics and Space Technology

Enclosure

JOHN E. STEINER

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(206) 453-8802

VICE PRESIDENT CORPORATE
PRODUCT DEVELOPMENT
THE BOEING CO.
RETIRED

October 12, 1987

The Honorable William R. Graham
Science Advisor to the President
Executive Office of the President
Office of Science and Technology Policy
Old Executive Office Building
Room 358
Washington, DC 20506

Reference: Letter: J.E. Steiner to Dr. Graham,
dated August 10, 1987

Dear Dr. Graham:

Aeronautics (both civil and military) is a major employer (over one million jobs), a major tax base and a major generator of favorable balance of trade. Relationships between government and industry are complex. The generation of required long term research is also complex and involves the major three forces: Government, Industry, and Academia, all of which are also complex. This letter is submitted for your consideration per the reference.

1. Historical Note

Your organization made an in-depth investigation of the subject in 1981/82 under the able Chairmanship of Victor Reis, assisted by Louis Montulli. Two non-government persons were selected to participate in that effort: myself representing the industry, and Eugene Covert (MIT) representing Academia. The result of the effort was a document "Aeronautical Research and Technology Policy" dated November 1982. It received, and still receives, wide distribution.

Subsequently, in 1983, the Aeronautical Policy Review Committee was chartered with myself as Chairman. In November, 1983 the Committee delivered its first report to your office recommending that technology horizons for both military and non-military were too short and should be extended to ten years or more. The report was distributed to Congressional Committees, NASA, DOD and Industry and requested answers from DOD and NASA. Such answers were prepared and were, I believe, constructive toward National objectives.

In April 1985 "National Aeronautical R&D Goals" (Bird Book I) was released, recommending three goals: Subsonic, Supersonic and Trans-atmospheric, and some 7000 copies were distributed. This initiated the NASA - Industry Supersonic study program (Phase I now being completed) and aided in securing funding for the X-30 program. It also served notice on Industry, Government, and Academia that a very substantial effort would be required to retain U.S. leadership.

In February 1987 the booklet entitled "National Aeronautical R&D Goals; Agenda for Achievement" (Bird Book II) was released, including your personal inputs. Again, about 7000 copies were distributed to Government, Industry, and Academia, with favorable response by other Committees and Boards and with some increased National emphasis on work toward meeting the Goals.

2. Committee Futures

As Chairman, I was asked to chart the future of the Committee, and the reference letter to you and a same date memorandum to Committee members was generated. Returns from all members have now been received and, in addition, I have discussed the subject with members of other groups such as ASEB, NASA - AAC, AIA Technical Council, etc. Results are voluminous and can be summarized as follows:

- a. The aeronautics industry is of great importance to the nation (both civil and military). The U.S. position is currently threatened by rapidly increasing foreign competition and by inadequate long term research in such areas as composite structure and propulsion.
- b. The Committee is viewed as unique in that it is independent of other organizations and commands a position of stature led by your office. There is universal agreement that the Committee with some re-structure, should be continued. Quoting from one informed Committee member: "The Committee provides a unique forum to address broad aeronautical R&D issues at the highest levels and in a constructive manner."
- c. The next objective should be a report to you, submitted next spring or early summer, on the status of response to Bird Book II and specifically, on certain confusing elements such as long range high speed flight, composite research, propulsion research, the U.S. world competitive situation and what must be done to enhance it, and others. This report might or might not form a Bird Book III report. An objective, among others, might be to pass along the accomplishments and needs-analyses of the Administration to transition teams for the next Administration and to minimize the chances of "reinventing the wheel". Accomplishment of the above would require a part or full time aeronautics staff member at OSTP (possibly borrowed from NASA).
- d. There is essentially universal support for Dr. Covert as the next Chairman. However, I have listed some other options in the attachment and you may have your personal inputs as well.

3. Attachments

- A. A discussion and list of items the Committee should address between now and next spring or early summer.
- B. A list of Committee members (one page summary and more extensive detail) with recommendations as to replacement for those that require it.

In closing, it has been my great privilege to serve your office for over four years in the capacity of Chairman, Aeronautical Policy Review Committee. I believe the Committee's work has been constructive to the Nation and to your office, and I stand ready to assist in whatever action you may direct.

Sincerely,



John E. Steiner
Chairman, Aeronautical Policy and Review Committee

Items Committee Should Address

1. Status of "Agenda for Achievement"

The document (Bird Book II) released in February 1987 was widely distributed (7000 copies) and contained an Action Plan summarized in eight items: (1) Increase industry R&D effort, (2) Aggressively pursue the National Aero-Space Plane, (3) Develop technology, design and business foundation for a High Speed Civil Transport, (4) Expand domestic R&D collaboration as required by global competition, (5) Encourage government research in long term emerging technology areas promising high payoff, (6) Strengthen American universities for science education using enhanced government and industry support, (7) Improve development and integration process using computer technology to make U.S. products affordable, and (8) Enhance the safety and capacity of the National Airspace System.

U.S. leadership is being gradually eroded by aggressive foreign efforts in many fields. One of the last areas where it still exists is aeronautics. At stake are U.S. jobs, tax base, balance of trade and in the long term (and considering all industries) a substantial erosion of the U.S. standard of living. Economic security is as important as military security, and the two are closely related. The situation is very complex and relatively unrelated items may add up to form a trend.

The Committee members feel that the office of the Science Advisor to the President should have at least a yearly review of the status of the Agenda as viewed by the Committee that prepared it. Circulation that might be given to such an annual review would depend on judgment at the time, but Committee members feel that at least a first review next spring should be attempted.

2. The High Speed Civil Transport (HSCT)

Phase I reports from Boeing and McDonnell Douglas are in preparation. If, as many believe, a machine could be developed which would cross the Pacific in three hours with economics equal to those of a 747, then an immense future market is at stake, plus a position of industrial leadership for the nation that achieves it. We know that Europe is working on such a program and that there are really four national elements, Europe, U.S. Japan, and U.S.S.R. We must not be complacent about the potential impact of a foreign success. Several members of the Committee felt that certain research tasks were not being addressed with enough effort,

and that these must be identified and research strengthened. The entire system must be addressed, since productivity required for economic objectives requires rapid turn-around and other factors and could affect related developments in airways and airports. One Committee member felt so strongly that he would use the Committee in this area to the exclusion of many others.

3. The HSCT vs. An Aerospace Plane Derivative

This subject is delicate, since we want the best for both programs. One, however, has a much greater economic forcing function than the other. The Committee felt that a careful rationalization would be needed and that the office of the Science Advisor to the President should develop it before a change in Administration politicizes the whole subject and hurts the national interest in the process.

4. Development of a "Body of Technology" for Composite Structure

Considering all elements including temperature, longevity, cost, and performance we certainly do not have an adequate base at present. The subject involves Academia as well as Government and Industry, and Committee members felt an overview of progress and potential consideration of all phases including technology transfer (of several kinds) and including the required (but only the required) input of national security.

5. Potential Impact of Civil Tilt Rotor

The V-22 military tilt rotor airplane will fly in 1988. With two technology demonstrators behind it the program will probably be technically successful. Boeing/Bell are considering a single civil demonstrator probably using the DHC-8 body, but decisions will await the V-22's success. If economically viable, what impact could this have on the Air Traffic Control System as it finally develops. Several ATC questions were raised by Committee members, this being only one.

6. Progress Toward Goals of Bird Book I

The Committee felt this was not quite the same subject as item 1. above. For example, what did we mean by Trans-Century Renewal in Subsonics. Some members feel that the U.S. world position is eroding, not advancing. What can be done about it? It is not solely a technical problem and that is why a "Productivity" specialist is recommended in Attachment B as the Department of Commerce representative.

7. Items Aiding Administration Transition

The Administration will wish to summarize its accomplishments preparatory to the coming transition. Just handing out Bird Book copies and the 1982 Policy will not be adequate. This Administration, through your office did something very unusual in the creation of the Policy and of the Committee. The result is envied by other industries and even by some involved in Space activities. Members felt that appropriate use of the Committee during this period would be beneficial and that the new Administration should determine if it wishes to use the Committee structure. The base on which it is built required a great effort. The result is unique. We should attempt to use it to improve the transition to keep the goals front and center and to build on the Agenda for Achievement, not re-create it.

Note: Many other items were suggested by Committee members. Some, like an overview of actions toward Air Traffic Control are both controversial and could be redundant. Others, such as dissatisfaction on the subject of propulsion development, would be passed on to the new Chairman when he is selected.

Aeronautical Policy Review CommitteeSummary of Members

1.	Brubaker	D.O.C.	Requires Replacement
2.	Cashen	Northrop	OK
3.	Colladay	NASA	OK
4.	Cooper	USAF	Replaced by Paiewonsky OK
5.	Covert	MIT	OK
6.	Fleming	ATA	OK
7.	Hello	Rockwell	Recommend Replacement
8.	Hopps	ex Lockheed	Recommend Replacement
9.	Husick	ex Fairchild	May be OK
10.	Kerber	D.O.D.	OK
11.	Krebs	ex G.E.	OK
12.	Luffsey	FAA	OK
13.	Lynn	Bell Textron	OK
14.	Sams	MDC	OK
15.	Swihart	Boeing	OK
16.	Chairman Steiner	ex Boeing	Recommend Replacement

Summary:

16 Members, 4 to 5 considered for replacement

Aeronautical Policy Review Committee

1. Crawford F. Brubaker
Deputy Assistant Secretary
for Aerospace
Department of Commerce

Mr. Brubaker is retiring and recommended Ms. Sally Bath to me. However, I would recommend Dr. Bruce Merrifield, Asst. Sec. for Productivity, Department of Commerce to emphasize the technology of productivity and its relationship to the technology of performance. Engineers tend to emphasize the latter, sometimes at the expense of the former.
2. John F. Cashen
Vice President, Advanced
Projects
Northrop Corporation

Mr. Cashen is excellent and should stay on as is
3. Raymond S. Colladay
Associate Administrator
for Aeronautics and Space
Technology
NASA

Dr. Colladay is able, supportive and a great contributor
4. Thomas E. Cooper
Assistant Secretary of the
Air Force for Research,
Development and Logistics

Dr. Cooper was replaced (after retirement) by Dr. Paiewonsky Deputy for Advanced Technology, Office of the Assistant Secretary of the Air Force for Procurement. Dr. Paiewonsky attended several meetings during the release of BBII and appeared competent and satisfactory. However, Dr. Cooper's replacement with same title should also be considered
5. Eugene E. Covert
Head, Depart. of Aeronautics
and Astronautics
Massachusetts Institute of
Technology

Dr. Covert has been excellent. If he becomes Chairman I would recommend Dr. Jack Kerrebrock of MIT as the Academia representative. Dr. Kerrebrock would also qualify as a candidate for Chairman but might prefer to be a member due to Dr. Covert's long term experience with the Committee. Several other academicians would also qualify, e.g. Dr. Holt Ashley of Stanford.

6. J. Roger Fleming
Senior Vice President,
Technical Services
Air Transport Association

Mr. Fleming is able, supportive,
and a contributor. He should
continue as is.
7. Bastian Hello
Senior Vice President,
Government Relations
Rockwell International

Mr. Hello is able, a contributor
and has the advantage of living in
the area of Washington, DC.
However, when appointed to the
committee he had a different job,
closer to Rockwell Aeronautics. He
should be considered for
replacement.
8. Russell L. Hopps
Vice President,
Engineering (Ret.)
Lockheed Corporation

Mr. Hopps is retired and has not
recently been a contributor. I
would recommend that he be replaced.
9. Charles B. Husick
Senior Vice President
Fairchild Industries (Ret.)

Mr. Husick is retired from
Fairchild. However, he is a
contributor. I recommend he remain
until a representative from the
General Aviation Community can be
identified.
10. Ronald L. Kerber
Deputy Under Secretary of
Defense for Research and
Advanced Technology

Dr. Kerber has been an able
contributor and should remain as is
11. James N. Krebs
Vice President and General
Manager (Ret.)
General Electric Company

Mr. Krebs is still very well
informed and a contributor. Some
have recommended him as Chairman,
but he will refuse. I recommend he
continue unless the new Chairman
wished to replace him with a person
active in industry. In that case,
I recommend Dr. Irving Mendelsson
of Pratt and Whitney
12. Walter S. Luffsey
Director, Adv. Aviation
System Design Team
Federal Aviation
Administration

Mr. Luffsey is satisfactory but not
a great contributor at this time.
I recommend he be continued but
reviewed by the new Chairman

13. Robert R. Lynn
Senior Vice President of
Research and Engineering
Bell Helicopter Textron
14. Hershel Sams
Vice President, Engineering
Technology
McDonnell Aircraft Company
15. John M. Swihart
Vice President, International
Affairs
The Boeing Company
16. John E. Steiner
Chairman

New Industry Member

Mr. Lynn is a great contributor and should continue, especially in view of the potential Civil Tilt Rotor development and its potential impact

Mr. Sams is an active, able contributor. He is an alternate choice for Chairman. Unless that were to happen I recommend he continue as is

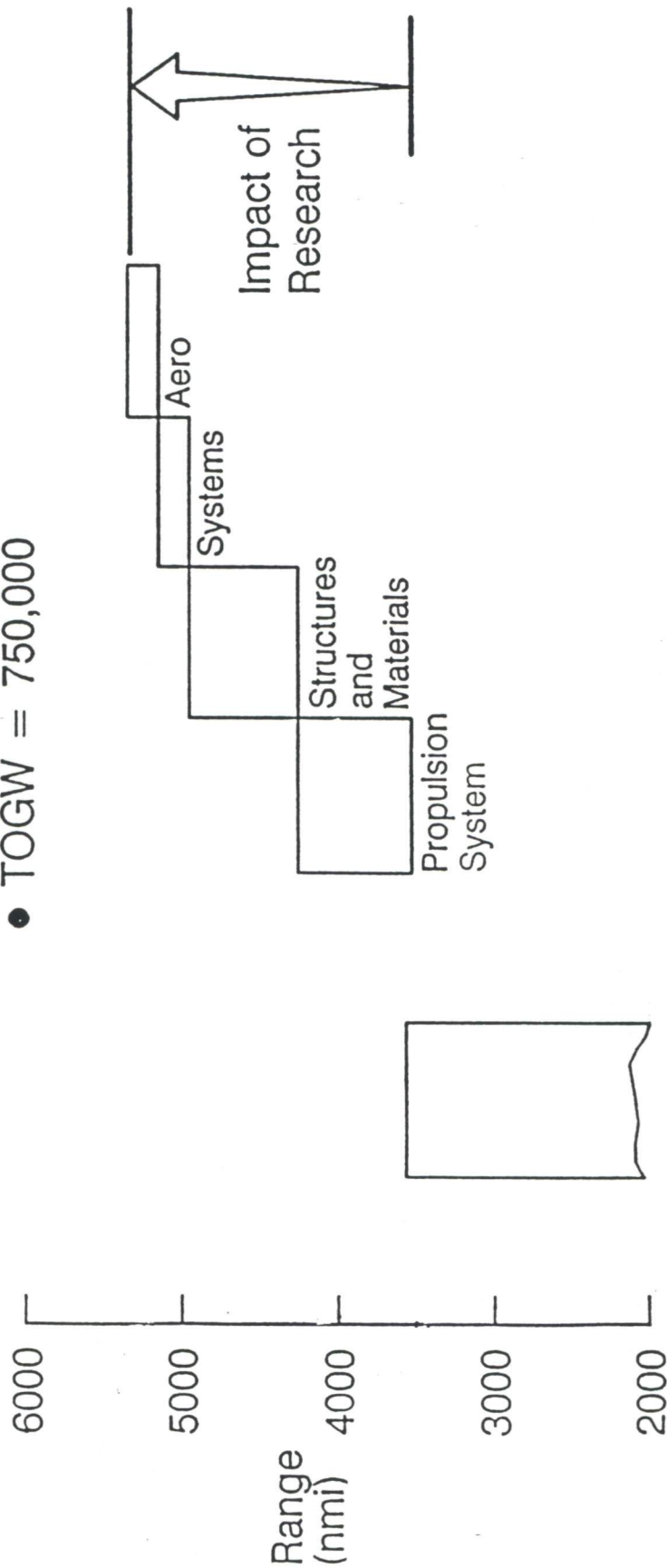
Mr. Swihart is an active, able contributor. I recommend he continue as is

I believe it is time for a new Chairman. I recommend Eugene E. Covert. If he refuses there are two alternates, Mr. Hershel Sams of McDonnell and Mr. Robert B. Ormsby, a former member of the Committee (See BBI). He currently serves as Chairman of NASA's Advisory Committee but has advised that he will be available next spring and could overlap in the meantime. Other recommendations of Committee members are Al Flax, John Swihart and Jim Krebs.

There are many persons who qualify. Recommendations have included Mike Ciminera, Vice President of Grumman, Bob Patton, Vice President of Vought, and, as noted above, Irving Mendelsson, Vice President of Pratt and Whitney

Technology Projections

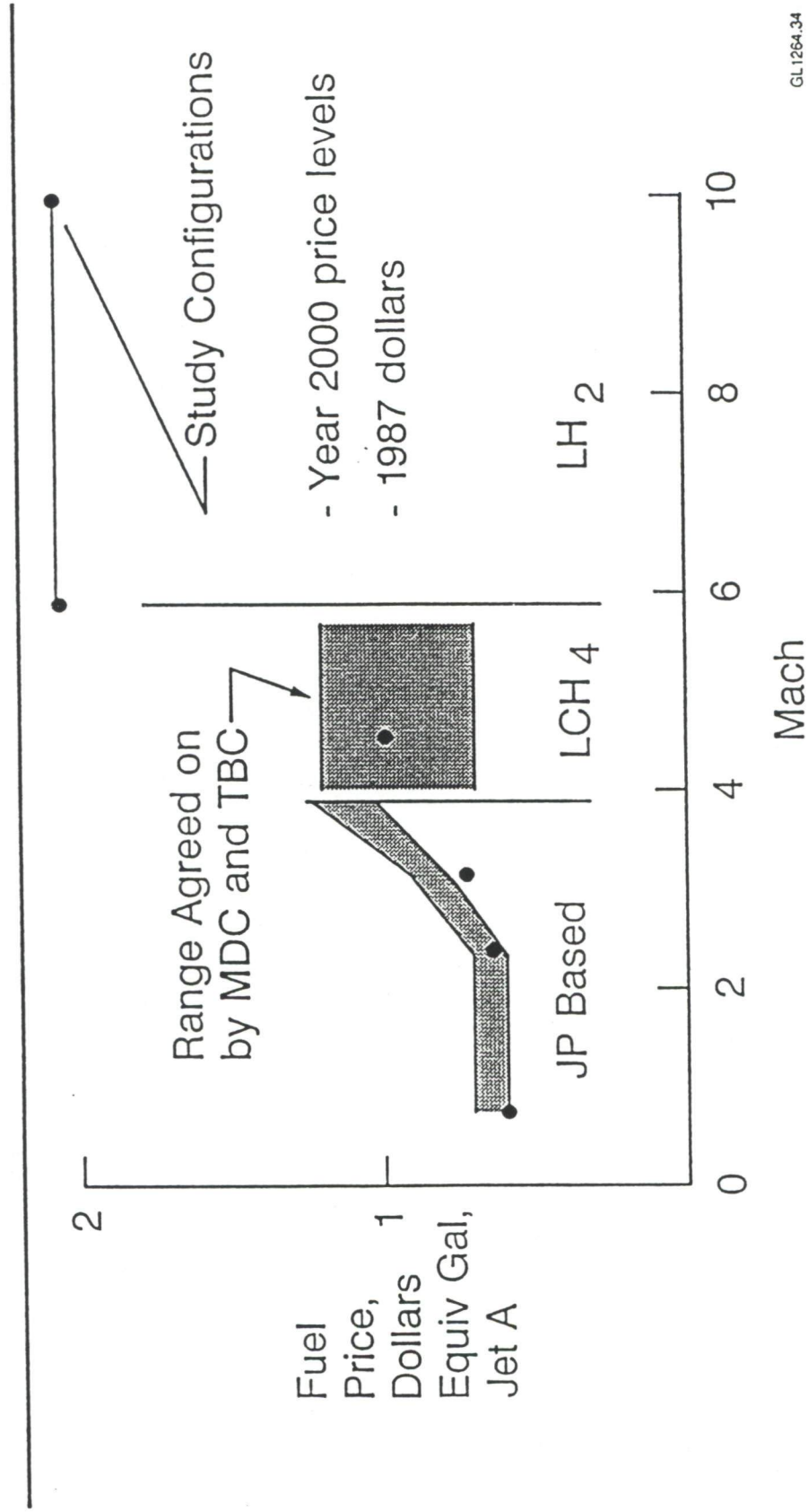
- Mach = 2.4
- 250 passengers
- TOGW = 750,000



Current Technology

Year 2000

Economics Study Fuel Prices



THE CASE FOR NASA'S AERONAUTICAL RESEARCH AND TECHNOLOGY

The Administration's Policy for Aeronautical Research and Technology, announced in November 1982, established challenging national goals for aeronautics and aeronautical research and technology (R&T) recognizing that major aspects of the long term economic and defense security of this nation are linked to the preservation of U.S. preeminence in aeronautics. Evidence of this importance can be measured by the fact that fully one-third of our defense budget is for procurement, maintenance, or operation of aeronautical systems and by the large positive contribution of civil aeronautics to transportation, employment, balance of trade and national prestige. While U.S. aeronautics still maintains a broad base of technological advantage, the margin of difference has narrowed dramatically in recent years.

The highest leverage opportunity for securing U.S. aeronautical leadership and industrial competitiveness lies in America's traditional area of strength: pioneering new technology. The potential exists for military and civil aircraft of such clearcut superiority that their technical excellence would overshadow any numerical or non-technical competitive factors. Exploiting these opportunities through continuation of a vigorous aeronautical R&T program is essential to the preservation of U.S. leadership.

Why Aeronautics If Not Other Industries?

The federal government investment in aeronautical R&T has been an efficient and effective mechanism for bringing the best skills of the nation to bear on the most pressing needs of one of our most successful industries. Several characteristics of the aeronautics industry dictate that it be continued. In addition to its primary responsibility for defense, the federal government has responsibilities for safety certification, management of the airspace and environmental protection which require continued R&T to meet changing requirements and needs. The primary benefits of R&T in these areas accrue to the government.

There is a strong common base of aeronautical R&T that underlies all future military and civil aeronautical system developments. While civil and military aircraft configurations often differ greatly, both benefit from diverse aeronautical R&T advances, providing a unique opportunity to compound the value of this research. Historically, civil aircraft have benefited from military technological advances in both airframes and propulsion. Increasingly, a reverse flow has been important, e.g., improved fuel efficiency, flight management systems, and lightweight structures.

At the production level, highly constructive synergies affecting preeminence are centered in the sophisticated 15,000 company supplier base which supports the airframe builders and other

major aerospace firms. Civil work constitutes approximately 60% of the aviation business base for these companies which provide a pool of engineering talent and highly skilled labor that is available for military needs and a modern production base for wartime surge capacity that is maintained by the private economy. Due to the common industrial base, a weakening of the civil industry will impact the entire aeronautics industry, and will ultimately result in more expensive military systems.

Some additional factors which distinguish aeronautics as a candidate for federal R&T are: the extensive research facilities required with a replacement cost of approximately \$6 billion; the large disincentives for private sector investment in long term, generic aeronautical R&T stemming from the inability to capture the benefits from private research efforts; the length of the R&D cycle for aircraft and the great length of the payback period; the extensive breadth and depth of technologies required to produce superior aircraft; and the size of the investment, on the order of \$2-3 billion, to develop an aircraft.

The OSTP report entitled "Aeronautical Research and Technology Policy" acknowledged these factors in concluding:

"While the study group recognizes the urgent need to reduce government spending to achieve the objectives of the Economic Recovery Program, it unanimously concludes that a continued strong, government-budgeted program of aeronautical R&T is consistent with overall government priorities and should be maintained."

Why NASA?

One of the important tenets of the recent federal policy for Aeronautics is the reaffirmation of the key role that NASA has played in the development of aeronautical R&T. NASA has acted as a catalyst and has provided a central technological resource for the successful partnership that has evolved over 70 years with industry, other federal agencies and the university community (which is the source of newly trained scientists and engineers).

The vast majority of NASA's aeronautical research and technology activities are long-term, high-risk and generic in nature. In 1982 and again in 1984, the GAO reviewed NASA's Aeronautics Program in depth and concluded (references MASAD-82-33 and NSIAD-84-120) that there was a very significant degree of commonality (97%) for the applicability of NASA's research to military and civil aircraft, that only 1% was purely civil in nature and only 2% purely military. Further, the OSTP report on aeronautical R&T policy included a comparison of DoD and NASA support for aeronautical R&T. The resources for FY 1982 were noted to be: DoD, \$400M and 1900 people; and NASA, \$480M and 3800 people. In view of this analysis, NASA contributes roughly 65% of the manpower and 55% of the federal R&D funding required to provide the technology base for future military

aircraft, with DoD resources focused primarily on R&T closely related to identified military weapon systems.

The Administration's Policy for Aeronautical R&T also recognizes that the independence of NASA is an asset to the Nation that enables the free transfer of information among government and industry and provides a long term R&T perspective, free from nearer term development, production, and operational pressures. These latter factors which are primary concerns in industry and DoD dilute their emphasis on the long-term, high-risk research which ultimately leads to superior aircraft.

NASA also provides the essential research data base to assist the FAA in regulatory activities and can contribute significantly to the development of a true aerospace capability as aeronautics and space technology are rapidly merging.

The critical components of NASA's research establishment are its facilities and research manpower. NASA's facilities are considered by industry to be central to the development of future military and civil aircraft. The value of facility operations is enhanced by the large experienced work force with significant research expertise which exists at the NASA Centers. This aeronautical research manpower represented by the NASA Centers and their research contractors (including universities), is a unique national asset which must be shared for optimum results.

Both of these elements have required decades to develop, and have been invaluable to the nation. They cannot be disestablished and reconstructed in a short time. Long-term stability is absolutely essential to their continued viability. They are seriously threatened by the current atmosphere of doubt.

The National Academy of Engineering in a Report to be released in January 1985 entitled "The Competitive Status of the U.S. Civil Aviation Manufacturing Industry" summarized the importance of NASA's role in the following manner:

"The bedrock of U.S. leadership in civil aircraft is technology--its development and incorporation into new designs. That leadership need not be threatened provided that the U.S. maintains a vigorous program of research and development. The National Aeronautics and Space Administration (NASA) is the focal point of aeronautical R&D for both Civil and Military applications. The high cost of R&D and the massive facilities required for aeronautical R&D preclude any private enterprise from performing NASA's central role."

JOHN E. STEINER

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VICE PRESIDENT, CORPORATE
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October 12, 1987

The Honorable William R. Graham
Science Advisor to the President
Executive Office of the President
Office of Science and Technology Policy
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Sincerely,



John E. Steiner
Chairman, Aeronautical Policy and Review Committee

Items Committee Should Address

1. Status of "Agenda for Achievement"

The document (Bird Book II) released in February 1987 was widely distributed (7000 copies) and contained an Action Plan summarized in eight items: (1) Increase industry R&D effort, (2) Aggressively pursue the National Aero-Space Plane, (3) Develop technology, design and business foundation for a High Speed Civil Transport, (4) Expand domestic R&D collaboration as required by global competition, (5) Encourage government research in long term emerging technology areas promising high payoff, (6) Strengthen American universities for science education using enhanced government and industry support, (7) Improve development and integration process using computer technology to make U.S. products affordable, and (8) Enhance the safety and capacity of the National Airspace System.

U.S. leadership is being gradually eroded by aggressive foreign efforts in many fields. One of the last areas where it still exists is aeronautics. At stake are U.S. jobs, tax base, balance of trade and in the long term (and considering all industries) a substantial erosion of the U.S. standard of living. Economic security is as important as military security, and the two are closely related. The situation is very complex and relatively unrelated items may add up to form a trend.

The Committee members feel that the office of the Science Advisor to the President should have at least a yearly review of the status of the Agenda as viewed by the Committee that prepared it. Circulation that might be given to such an annual review would depend on judgment at the time, but Committee members feel that at least a first review next spring should be attempted.

2. The High Speed Civil Transport (HSCT)

Phase I reports from Boeing and McDonnell Douglas are in preparation. If, as many believe, a machine could be developed which would cross the Pacific in three hours with economics equal to those of a 747, then an immense future market is at stake, plus a position of industrial leadership for the nation that achieves it. We know that Europe is working on such a program and that there are really four national elements, Europe, U.S. Japan, and U.S.S.R. We must not be complacent about the potential impact of a foreign success. Several members of the Committee felt that certain research tasks were not being addressed with enough effort,

and that these must be identified and research strengthened. The entire system must be addressed, since productivity required for economic objectives requires rapid turn-around and other factors and could affect related developments in airways and airports. One Committee member felt so strongly that he would use the Committee in this area to the exclusion of many others.

3. The HSCT vs. An Aerospace Plane Derivative

This subject is delicate, since we want the best for both programs. One, however, has a much greater economic forcing function than the other. The Committee felt that a careful rationalization would be needed and that the office of the Science Advisor to the President should develop it before a change in Administration politicizes the whole subject and hurts the national interest in the process.

4. Development of a "Body of Technology" for Composite Structure

Considering all elements including temperature, longevity, cost, and performance we certainly do not have an adequate base at present. The subject involves Academia as well as Government and Industry, and Committee members felt an overview of progress and potential consideration of all phases including technology transfer (of several kinds) and including the required (but only the required) input of national security.

5. Potential Impact of Civil Tilt Rotor

The V-22 military tilt rotor airplane will fly in 1988. With two technology demonstrators behind it the program will probably be technically successful. Boeing/Bell are considering a single civil demonstrator probably using the DHC-8 body, but decisions will await the V-22's success. If economically viable, what impact could this have on the Air Traffic Control System as it finally develops. Several ATC questions were raised by Committee members, this being only one.

6. Progress Toward Goals of Bird Book I

The Committee felt this was not quite the same subject as item 1. above. For example, what did we mean by Trans-Century Renewal in Subsonics. Some members feel that the U.S. world position is eroding, not advancing. What can be done about it? It is not solely a technical problem and that is why a "Productivity" specialist is recommended in Attachment B as the Department of Commerce representative.

7. Items Aiding Administration Transition

The Administration will wish to summarize its accomplishments preparatory to the coming transition. Just handing out Bird Book copies and the 1982 Policy will not be adequate. This Administration, through your office did something very unusual in the creation of the Policy and of the Committee. The result is envied by other industries and even by some involved in Space activities. Members felt that appropriate use of the Committee during this period would be beneficial and that the new Administration should determine if it wishes to use the Committee structure. The base on which it is built required a great effort. The result is unique. We should attempt to use it to improve the transition to keep the goals front and center and to build on the Agenda for Achievement, not re-create it.

Note: Many other items were suggested by Committee members. Some, like an overview of actions toward Air Traffic Control are both controversial and could be redundant. Others, such as dissatisfaction on the subject of propulsion development, would be passed on to the new Chairman when he is selected.

Attachment B

Aeronautical Policy Review Committee

Summary of Members

1.	Brubaker	D.O.C.	Requires Replacement
2.	Cashen	Northrop	OK
3.	Colladay	NASA	OK
4.	Cooper	USAF	Replaced by Paiewonsky OK
5.	Covert	MIT	OK
6.	Fleming	ATA	OK
7.	Hello	Rockwell	Recommend Replacement
8.	Hopps	ex Lockheed	Recommend Replacement
9.	Husick	ex Fairchild	May be Ok
10.	Kerber	D.O.D.	OK
11.	Krebs	ex G.E.	OK
12.	Luffsey	FAA	OK
13.	Lynn	Bell Textron	OK
14.	Sams	MDC	OK
15.	Swihart	Boeing	OK
16.	Chairman Steiner	ex Boeing	Recommend Replacement

Summary:

16 Members, 4 to 5 considered for replacement

Aeronautical Policy Review Committee

1. Crawford F. Brubaker
Deputy Assistant Secretary
for Aerospace
Department of Commerce

Mr. Brubaker is retiring and recommended Ms. Sally Bath to me. However, I would recommend Dr. Bruce Merrifield, Asst. Sec. for Productivity, Department of Commerce to emphasize the technology of productivity and its relationship to the technology of performance. Engineers tend to emphasize the latter, sometimes at the expense of the former.

2. John F. Cashen
Vice President, Advanced
Projects
Northrop Corporation

Mr. Cashen is excellent and should stay on as is

3. Raymond S. Colladay
Associate Administrator
for Aeronautics and Space
Technology
NASA

Dr. Colladay is able, supportive and a great contributor

4. Thomas E. Cooper
Assistant Secretary of the
Air Force for Research,
Development and Logistics

Dr. Cooper was replaced (after retirement) by Dr. Paiewonsky Deputy for Advanced Technology, Office of the Assistant Secretary of the Air Force for Procurement. Dr. Paiewonsky attended several meetings during the release of BBII and appeared competent and satisfactory. However, Dr. Cooper's replacement with same title should also be considered

5. Eugene E. Covert
Head, Depart. of Aeronautics
and Astronautics
Massachusetts Institute of
Technology

Dr. Covert has been excellent. If he becomes Chairman I would recommend Dr. Jack Kerrebrock of MIT as the Academia representative. Dr. Kerrebrock would also qualify as a candidate for Chairman but might prefer to be a member due to Dr. Covert's long term experience with the Committee. Several other academicians would also qualify, e.g. Dr. Holt Ashley of Stanford.

6. J. Roger Fleming
Senior Vice President,
Technical Services
Air Transport Association

Mr. Fleming is able, supportive,
and a contributor. He should
continue as is.
7. Bastian Hello
Senior Vice President,
Government Relations
Rockwell International

Mr. Hello is able, a contributor
and has the advantage of living in
the area of Washington, DC.
However, when appointed to the
committee he had a different job,
closer to Rockwell Aeronautics. He
should be considered for
replacement.
8. Russell L. Hopps
Vice President,
Engineering (Ret.)
Lockheed Corporation

Mr. Hopps is retired and has not
recently been a contributor. I
would recommend that he be replaced.
9. Charles B. Husick
Senior Vice President
Fairchild Industries (Ret.)

Mr. Husick is retired from
Fairchild. However, he is a
contributor. I recommend he remain
until a representative from the
General Aviation Community can be
identified.
10. Ronald L. Kerber
Deputy Under Secretary of
Defense for Research and
Advanced Technology

Dr. Kerber has been an able
contributor and should remain as is
11. James N. Krebs
Vice President and General
Manager (Ret.)
General Electric Company

Mr. Krebs is still very well
informed and a contributor. Some
have recommended him as Chairman,
but he will refuse. I recommend he
continue unless the new Chairman
wished to replace him with a person
active in industry. In that case,
I recommend Dr. Irving Mendelsson
of Pratt and Whitney
12. Walter S. Luffsey
Director, Adv. Aviation
System Design Team
Federal Aviation
Administration

Mr. Luffsey is satisfactory but not
a great contributor at this time.
I recommend he be continued but
reviewed by the new Chairman

13. Robert R. Lynn
Senior Vice President of
Research and Engineering
Bell Helicopter Textron
14. Hershel Sams
Vice President, Engineering
Technology
McDonnell Aircraft Company
15. John M. Swihart
Vice President, International
Affairs
The Boeing Company
16. John E. Steiner
Chairman

Mr. Lynn is a great contributor and should continue, especially in view of the potential Civil Tilt Rotor development and its potential impact

Mr. Sams is an active, able contributor. He is an alternate choice for Chairman. Unless that were to happen I recommend he continue as is

Mr. Swihart is an active, able contributor. I recommend he continue as is

I believe it is time for a new Chairman. I recommend Eugene E. Covert. If he refuses there are two alternates, Mr. Hershel Sams of McDonnell and Mr. Robert B. Ormsby, a former member of the Committee (See BBI). He currently serves as Chairman of NASA's Advisory Committee but has advised that he will be available next spring and could overlap in the meantime. Other recommendations of Committee members are Al Flax, John Swihart and Jim Krebs.

New Industry Member

There are many persons who qualify. Recommendations have included Mike Ciminera, Vice President of Grumman, Bob Patton, Vice President of Vought, and, as noted above, Irving Mendelsson, Vice President of Pratt and Whitney

SUMMARY

Key Points:

- o The aerospace industry is comprised of a few large integrated producers that draw from an extensive, varied, and increasingly international supplier base.
- o Aerospace has run consistent trade surpluses in the post-World War II period. 1989 was another record breaking surplus year at \$22.1 billion. Civilian aircraft-related exports have been particularly strong in the current business cycle, whereas the declining emphasis on military products has signaled less robust demand in that sector of the industry.
- o Aerospace is the user/driver of multiple advanced product and process technologies. The industry also draws on a broad variety of basic goods and services.
- o The aerospace industry is both capital and R&D intensive. In 1987 aerospace R&D funding was \$19.2 billion, the highest of any industry in absolute terms. Aerospace industry funding for R&D amounted to 3.9 percent of net sales, compared to a 3.3 percent average for all U.S. manufacturing industries.
- ✓ o The magnitude of risk and enormous staying power required until break-even distinguishes commercial aviation from virtually any other industry.
- o Aerospace makes up the largest sector of the defense industry. Recent cuts in the defense budget have decreased demand for aerospace products, and an anticipated further decline in defense spending is expected to signify major structural shifts in the aerospace industry.
- o There is increasing divergence between defense and civil aerospace mission needs, resulting in a major decrease of military to civil direct technology transfers. While civil aerospace focuses on efficiency and safety, the military has emphasized ultra-high performance.
- o Foreign producers are becoming increasingly competitive with U.S. firms and are gaining market share in both intermediate and final aerospace products. The U.S. share of world markets in aerospace products declined from a high of 79 percent in 1970 to 62 percent in 1988.
- ✓ o U.S. component and subsystem contractors -- the backbone of the aerospace industry -- are most affected by foreign competition. The primes continue to benefit from a comparative international advantage in systems integration.

- Task 1: Introduction*
- o In addition to an ever growing base of foreign suppliers in the aerospace industry, globalization has also occurred through an increasing use of joint ventures, particularly in civil aircraft parts production. In civil aircraft production, joint ventures have moved away from co-production towards earlier, more participative stages of product development. In military aircraft production, however, internationalization is less characterized by joint ventures than by offset arrangements.

Factors Supporting the Competitiveness of the U.S. Aerospace Industry:

- o High levels of R&D spending.
- o Superior systems-integration capability.
- o Long-term thinking.
- o Aerospace industry's restructuring efforts and awareness of challenge.
- o Strong public support.

Factors Weakening the Competitiveness of the U.S. Aerospace Industry:

- o Uncertainty about process and materials.
- o High costs.
- o R&D funding problems.
- o Fiscal policy not conducive to long-term investment.
- o Insufficient intra-industry interaction.
- o Weakness at the technology validation stage of the R&D process.
- o Foreign government targeting and subsidies.
- o Changes on the demand side.
- o Burden of own success.
- o Lack of qualified engineers and/or technicians.
- o Outdated trade policy.

Insights from the Aerospace Industry for the National Technology Strategy:

- o Strong capital investment and R&D spending is critical to the success of innovative, high tech industries.

- o When industries are knowledge- and capital-intensive, have high barriers to entry and are critical to national prestige and defense, governments will support their development. U.S. government policies should take this reality into account.
- o First-rate regulatory agencies are often key to an industry's competitiveness.
- o Technology transfer from the military to the civilian sector is no longer as relevant as it once was, given diverging mission requirements.
- o A strong, consistent, cost-effective and innovative supplier base is vital to original equipment manufacturers.
- o A trade policy which does not unduly restrict exports and which encourages exports is critical to the success of high tech industries.
- o High tech industries such as aerospace yield broad, cross-cutting benefits to the nation in terms of security, technological innovation, and social welfare.
- o A sufficient source of well trained scientific, engineering, and technical personnel is essential to the success of high tech industries.

Critical Technologies:

- o Advanced Composite Materials
- o Advanced Sensors
- o Airbreathing Propulsion
- o Artificial Intelligence
- o Computational Science
- o Optical Information Processing
- o Rocket Propulsion
- o Software Development
- o Superconductivity
- o Ultrareliable Electronic Systems
- o Very Large Scale Integrated Circuits

I. STRUCTURE OF THE INDUSTRY

Basic Information on the Industry

Definition:	The Commerce Department's "Aerospace Industry" basically includes those industries in SIC categories 372 and 376: Aircraft (3721), Aircraft Engines and Engine Parts (3724), Aircraft Auxiliary Equipment, n.e.c. (3728), Guided Missiles and Space Vehicles (3761), Space Propulsion Units and Parts (3764), and Space Vehicle Equipment, n.e.c. (3769). To a lesser extent, aerospace also includes Radio and Television Communication Equipment (3663); Search, Detection, Navigation, Guidance, Aeronautical Systems, Instruments and Equipment (3812); and Measuring and Controlling Devices, n.e.c. (3829). ¹
Total Sales:	(1988) \$114,562.2
Employment:	(1988) 1,313,000, of which 435,000 were production workers. ³
After tax profit:	(1988) 4.3% of net sales. ⁴

Key Segments of the Industry

The industry can be described in terms of a three-tiered supplier network pyramid⁵ that includes about 15,000 companies in the United States. Airframe Assembly and Sales is the end-category. On-Board Avionic Systems; Propulsion Systems; and Airframe Structures, Subassemblies, and Subsystems as suppliers to Airframe Assembly make up the next tier. On-Board Avionics are in turn fed by Electronic and Electrical Components and Parts, and by Electronic Systems and Subsystems. Propulsion Systems are fed by Engines and Components, Engine Accessories, and Starting Systems and Electrical Power Sources. Airframe Structures are fed by Fuselage and Structures, Interior Cabin Systems, Environmental Control Systems, Fuel Systems, Landing Gear Systems, and Hydraulic Systems.

¹1989/1990 Aerospace Facts and Figures, Aerospace Industries Association of America, Inc. Washington, DC, 1989. p. 12.

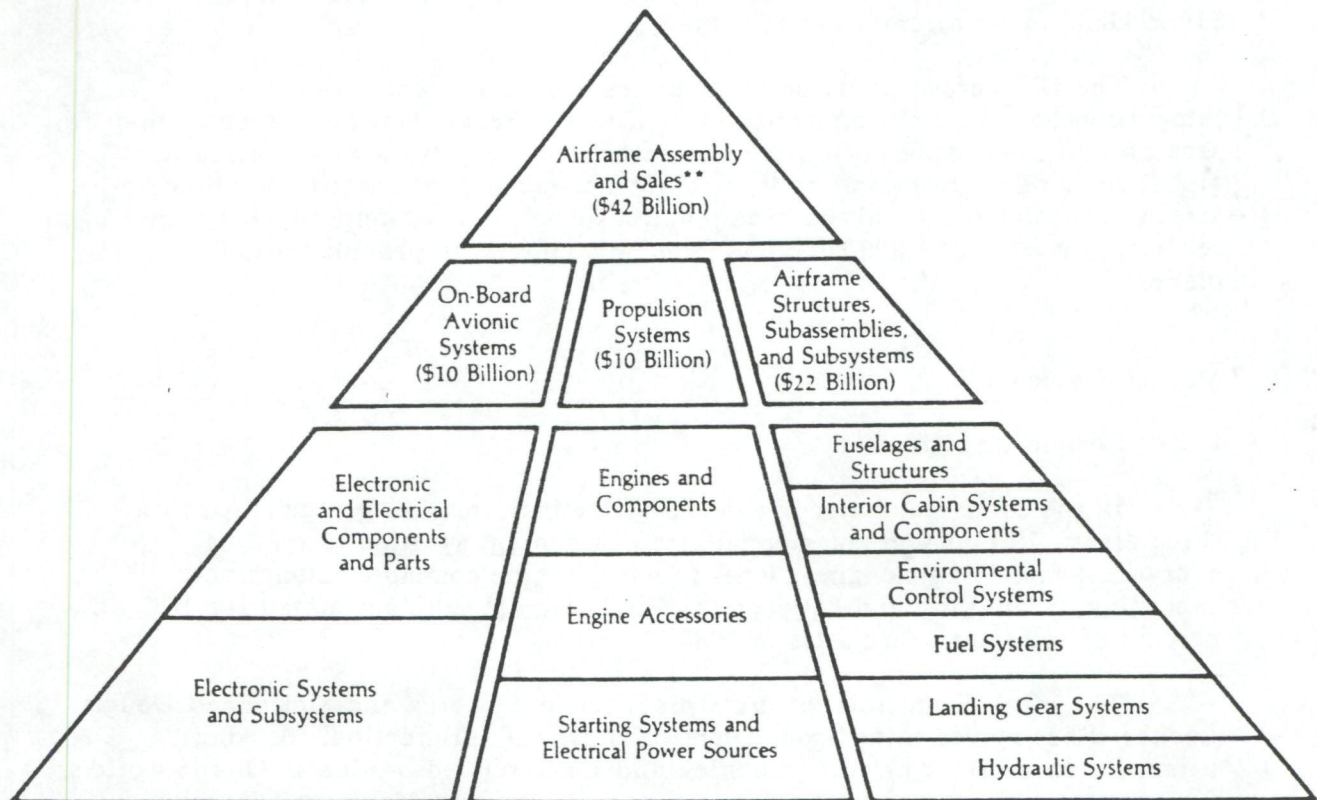
²Ibid., p. 15.

³Ibid., p. 141.

⁴Ibid., p. 156.

⁵SRI International, Changing Markets for Aircraft Products, Report No. 740, Fall 1986.

The Aircraft Industry Pyramid*



SOURCE: SRI International, *Clinging Markets for Aircraft Products*,
Report No. 740, Fall 1986.

* This pyramid illustrates three layers of the complex structure of the aircraft industry, which includes about 15,000 companies in the United States.

**1984 sales.

Size Distribution of Companies

The aerospace industry is highly concentrated at the top -- the original equipment manufacturers (OEMs), but spreads into a base of thousands of subcontractors that are increasingly international.⁶ In 1987, about 10,000 supplier firms provided engines, sub-assemblies, components and parts or provide other goods and services for civil aircraft manufacturing.⁷ According to research done for 1987, the company of final assembly accounts for 44 percent (\$7,135,000 of \$16,298,000) of an aircraft's total value.⁸

The U.S. aerospace industry continues to lead the world in systems integration both in the commercial and military spheres. However, even in this area of traditional superiority, the U.S. aerospace industry faces an increasing global challenge. On the micro level, aerospace component parts production is already considered a highly international business. For example, Boeing planes reportedly use about 3,800 suppliers from 33 countries to provide parts for its planes.⁹

Market Segments

Commercial Aircraft

In the commercial aircraft industry, the main market is segmented into three areas: 70 plus seat commercial aircraft; general aviation (including everything from single-engine planes to multi-engine commuter planes not exceeding 33,000 lbs.); and helicopters. Civil aircraft sales accounted for 16.7 percent of total aerospace sales in 1988.¹⁰

The large commercial aircraft producers are Boeing and McDonnell Douglas. Lockheed has moved away from commercial aircraft production, focusing primarily on military aircraft, missiles, and space-related products. Of the world's five commercial jet transport manufacturers, Boeing and McDonnell Douglas maintain leading positions in systems integration. Boeing remains in first place and controls more than half the world's market. McDonnell Douglas vies with Europe's Airbus Industrie for second place. Airbus held 24% of the world's unfilled unit orders in 1989 and 1989, versus McDonnell Douglas' 17%.¹¹

There are about a dozen fixed wing aircraft, or general aviation, producers in the United States and fewer than ten helicopter-producing companies.

⁶March, Artemis. "The U.S. Commercial Aircraft Industry and its Foreign Competitors," in The Working Papers of the MIT Commission on Industrial Productivity, Vol. 1, Cambridge, MA, MIT Press, 1989, p. 11.

⁷Economic Impact of Civil Aviation on the U.S. Economy, Wilbur Smith Associates, June 10, 1989, p. 6-2.

⁸Survey of U.S. aircraft and engines manufacturers, Wilbur Smith Associates, 1989.

⁹Stokes, Bruce. "Come Fly with Me," National Journal, March 31, 1990, p. 778.

¹⁰1989/90 Aerospace Facts and Figures, p. 15.

¹¹The European Aerospace Industry Trading Position and Figures 1990.

Aside from airframe manufacturers, the second significant OEM category in commercial aviation is engine-producing firms. There are three principle engine manufacturers in the free world that can independently design and build engines for large commercial aircraft. United Technology Corp.'s Pratt & Whitney division leads the field, followed by General Electric and Rolls-Royce, LTD. Other smaller international players, however, are developing engine production capabilities. This is a trend which will likely bring about an increase in the number of joint-ventures in the engine field. SNECMA/GE is an example of such a cooperative arrangement, as is the Pratt & Whitney, Rolls-Royce, Japanese Aero Engines, MTU and Fiat Aviazone in International Aero Engines venture.

Military Aircraft and Missiles

Military aircraft and missile sales accounted for 45.5 percent of total aerospace sales in 1988.¹² The principal commercial passenger aircraft producers also have defense-oriented production lines, and produce military aircraft and missile systems as well. A number of other aerospace prime contractors do not produce commercial passenger aircraft but concentrate primarily on military aircraft, missiles, and related systems. The prime military aircraft/missile producers are supported, as are commercial aircraft producers, by major systems subcontractors who provide propulsion systems, and guidance, flight control and communications systems, usually termed avionics. Avionics suppliers represent a cross-section of high-tech electronics and computer firms.

Space

Space products accounted for 21 percent of total aerospace sales in 1988.¹³ The space program draws on basically the same producer base as military aircraft and missile programs. Much of space is defense-related; 60 percent of Federal spending outlays are for the Department of Defense (DOD). General production categories include spacecraft and satellites, launch vehicles, space and ground networks, communications and data systems.¹⁴

¹²1989/90 Aerospace Facts and Figures, p. 15.

¹³1989/90 Aerospace Facts and Figures, p. 15.

¹⁴1989/90 Aerospace Facts and Figures, pp. 72-73.

Relationship between National Defense and the Aerospace Industry

Aerospace is closely related to national defense; it is the largest sectoral component of the defense industry.¹⁵ Of DOD's Top 100 Contractors for 1989, aerospace firms accounted for most of the top 20 in terms of dollar value of contracts. In 1988 military aircraft sales alone accounted for about 69 percent of the industry's total annual aircraft sales and about 37 percent of total aerospace sales. Missiles accounted for 9 percent of total aerospace sales.¹⁶

✓ Even after defense spending began to taper off in the late 1980s, approximately 40 percent of U.S. government R&D for aerospace was directed into aeronautical research in 1988 with DOD accounting for 77 percent of that. (In comparison NASA contributed 9 percent and the FAA 14 percent.)¹⁷

Despite a projected slowdown of defense-contracted aerospace products with anticipated defense budget cuts, a sizeable backlog, on-going modernization, and a focus on smaller, tactical aircraft may keep production lines busy at least for the near term.

In the post-World War II period, the civil aircraft industry benefited from military aircraft innovations. Some of the best examples of direct military to commercial transfers include the Boeing 707 aircraft (based on the C-97 and the B47 bomber) and the CF-6 and CFM56 engines (based on the TF-39 and the F101 engines, respectively). However, this early relationship has changed over the years:

- o Direct military to commercial transfers have declined during the past 20 years with a divergence in mission requirements.¹⁸ Some would refute this assertion by citing the potential for commercial transfer in DOD's air-breathing engine improvements program and DOD's aerospace plane program. Nonetheless, the military has focused increasingly on ultra-high performance, whereas the civil industry has emphasized reliability, safety, maintainability, and economy over an extended period of time.
- o Different mission requirements appear to be reducing the amount of generic technology validation useful to commercial producers. (Validation is the lengthy and expensive process by which generic systems or subsystems are tested under actual or simulated operating conditions so as to understand their performance limits and risks.)¹⁹
- o Shrinking military contracts and funding incentives under the ManTech and IMIP programs²⁰ and restrictive government-imposed ceilings on reimbursement for defense-related IR&D, have acted to

¹⁵Campaign '88: Aerospace Perspective: A Leading High-technology Industry Looks at the Issues, Aerospace Industries Association, Washington, DC, 1988, p. 2.

¹⁶1989/90 Aerospace Facts and Figures, p. 15.

¹⁷1989/90 Aerospace Facts and Figures, p. 108.

¹⁸Working papers: MIT Commission, p. 16.

¹⁹Working Papers: MIT Commission, p. 16-17.

²⁰ManTech and IMIP are the DOD's Manufacturing Technology and Industrial Modernization Incentives Program, in which DOD provides capital investment to industry.

dampen private sector aerospace capital investment and R&D funding. Engine producers have been more affected by these changes than the airframers, as the engine producers had received substantial reimbursements. While military-to-commercial transfer is already marginal, the contraction of DOD financial support contributes even further to the decline of such transfers.

Relationship to NASA

NASA maintains both civil and military aerospace interests. Over the past 25 years, NASA has increasingly emphasized space over aviation. NASA does provide direct funding for some technology development in civil aviation, but NASA's focus is on generic technology research and not product development. NASA contracts, for example, have accounted for less than 5 percent of Boeing's commercial R&D over the past 10 years. Boeing and McDonnell Douglas' effort to look at key technologies and the economic viability of a high-speed civil transport is an example of a NASA-funded civil aircraft project.

Military and civil space programs have been closely linked, although some experts believe that the DOD/NASA relationship has been eroding over the last few years. Nonetheless, a large majority of space industry output is government-contracted, and much of this is, in turn, defense-related. The DOD-NASA relationship is apparent via the frequency of military payloads on Shuttle missions or the interchangeable use of NASA and pure military facilities and test sites for missile development and trial deployment. NASA and DOD also have significant data exchange on weather, communications, and navigation, especially where NASA and DOD employ different types of operational satellites to gather data.

Key Relationships with Other Industries:

The U.S. aerospace industry is a major purchaser of goods and services. Aside from purchases of electrical machinery, primary and fabricated metals, chemicals, and other transportation equipment, the aerospace industry's demand for business services, retail, foods and beverages, utilities, real estate and health services, is considerable.

Aerospace is traditionally regarded as a "trickle down" industry, which is one of the reasons it is regarded as both a prestigious and strategic sector of the economy in developed and developing countries alike. As a "pioneer" industry, aerospace is a driver of technology. Its innovations have often generated lower-cost adaptations for other product markets, benefiting the entire economy. Some concrete examples include turbochargers, fiber-reinforced plastics, and computer-aided design and manufacturing (CAD/CAM).

There are numerous direct and indirect spin-off applications from aerospace technology in the areas of health and medicine, capital equipment production, energy, industrial productivity, safety and the environment, transportation,

construction, consumer/home/recreational products, digital image processing, computer processing and technology, and communications.²¹

Regulations

Because the government is a primary customer - largely through the Defense Department and NASA, aerospace is one of the most regulated of industries. How aerospace does business is governed by literally thousands of statutes and by the extensive Federal Acquisitions Regulations, supplemented by directives, instructions, procedures, manuals, reports, management systems, and data requirements. The government keeps close control of the industry at every step of the contracting process, including how much profit can be earned on government work, and what costs may be considered allowable (charged to the government).

Commercial aircraft manufacturing is regulated primarily by the Federal Aviation Administration's airworthiness requirements, which are designed to ensure public safety.

In addition, there are environmental regulatory limitations such as the Stage 3 noise regulations.

Export controls define which aerospace products or technologies can be exported and to which countries they may be exported. Because exports are a large and growing component of the U.S. aerospace business, export controls can be burdensome. This is especially true if imposed unilaterally by the United States and not by other countries, or if they restrict sales of products available from competitor nations.

Competitive Position of Aerospace

Trade

U.S. firms have dominated the aerospace industry since World War II. Boeing alone accounts for about 2 percent of U.S. export revenues. The aerospace industry is the leading exporter among U.S. manufacturing industries and has consistently run surpluses in the post-war period.²² Aerospace exports totaled about \$32.1 billion in 1989, for a \$22.1 billion U.S. aerospace trade surplus. Export volume is three-quarters civil products and one-quarter military, with a recent over-all trend showing declines in military exports and increases on the civil side.

The principal customers for U.S. aerospace exports are the United Kingdom, Japan, France, Canada, Germany, Australia, and Brazil.

Aerospace has a strong position in world markets, but its share is shrinking because of increased foreign competition. Between 1970 and 1988, the U.S. share of world aerospace markets declined from 79 percent to 62 percent. Heavy defense spending in the early to mid-1980s pushed U.S. world market share up to 73

²¹Technology Diffusion -- The Movement of Technology Between Aerospace and Other Industries, Aerospace Industries Association, Washington, DC, October 1985, p. 8.

²²1989/90 Aerospace Facts & Figures, p. 119.

percent in 1985, but the more recent decline in DOD spending coupled with increased foreign spending has resulted in the shrinking of U.S. percent of world market share.²³

While global production of both final products (complete aircraft, engines, spare parts) and intermediate products has increased, the number of U.S.-based suppliers has shrunk dramatically, despite a booming market. U.S. exports of aerospace parts are still more than triple the value of parts imported, but in recent years, parts imports have been rising relatively more rapidly.²⁴

Growth and Profits

Despite occasional cyclical downturns, aerospace has been one of America's most successful enterprises. It is healthy and profitable. Aerospace sales reached about \$120 billion in 1989. As an industry, aerospace is profitable. Profit as a percent of sales is, however, less than for all manufacturing and has consistently been so.²⁵

Despite a slow-down in defense spending and the reduced demand for military aircraft, aerospace is booming because of strong commercial demand. Trade in commercial jet aircraft, sub-systems and components has surged. According to major aerospace company reports to the Bureau of Census, the U.S. aerospace industry's total backlog reached \$191.5 billion in 1988.²⁶

Outlook

After record spending in the early and mid-1980s, demand for military aircraft contracted by about 25 percent in the late 1980s, according to some sources. Impending cuts in the defense budget will probably mean even further reductions in demand for military aircraft, missile systems, and military space projects. Research and production may, however, continue in small, agile tactical planes that incorporate technologically advanced equipment.²⁷ Defense lines may be kept busy through modernization of existing aircraft with up-to-date electronics and some major new projects, including the Advanced Tactical Fighter, the Advanced Tactical Aircraft, and the LHX helicopter. Further down the road, the defense community has set its hopes on the Aerospace Plane (Transatmospheric Vehicle).

Demand for commercial aircraft is likely to continue to rise. Air travel is expected to double by 2005. The market could see between 9,600 and 9,900 aircraft deliveries between now and 2005.²⁸ The market for new planes over the next 15

²³1987/1988 Aerospace Facts and Figures, p. 15.; 1983/1984, p. 15; and Facts and Perspectives, June 1988, p. 1;

Aerospace Industries Association, Washington, DC.

²⁴1989/90 Aerospace Facts and Figures, p. 119.

²⁵Ibid., p. 18.

²⁶Bureau of the Census, "Aerospace Industry (Orders, Sales, and Backlog)," Series MA37D (Annually).

²⁷AIA President Don Fuqua in "AIA Predicts Gradual Downturn, Shift to Civil Technologies for Defense Industry," New Technology Week, Dec. 18, 1989, p. 2.

²⁸Don Fuqua in New Technology Week, Dec. 18, 1989, p.2.

years is expected to average \$38 billion a year, compared with \$14 billion a year from 1970-89.²⁹ A change in the political climate may also create market opportunities in Eastern Europe and other centrally planned economies.

Despite increasing demand, however, to meet the foreign challenge the U.S. aerospace industry will need to develop competitive new products. Launching a new generation of commercial aircraft costs \$2-\$4 billion, and a company must sell roughly 600 units to break even. Developing a new engine costs \$1-\$1.5 billion and requires sales of 2,000 units to break even. The industry estimates break-even to occur after 14 years for a new aircraft and after 10 years for a new engine. These slow rates of return can be prohibitive. Foreign producers, often assisted by supportive governments, do not have the burden of such high risk.

New efforts at commercialization of the space industry could signify an upward trend in this area. However, high costs and a vaguely defined national space policy have tended to deter commercialization.

Trends

The market for commercial aircraft is expected to expand through the mid-1990s. The future of defense aircraft production is less certain.

Foreign competition will increase. Developing countries, such as Brazil and Indonesia, perceive aerospace as a strategic and prestigious industry that serves as technology-driver for the rest of the economy. Furthermore, the Europeans and, more recently the Japanese, have been building up their respective technological capabilities over the post-war period and now feel ready to assume a competitive position in the market.

Currently, the U.S. commercial jet transport aircraft industry's chief competitor is the EC's Airbus-Industrie, which has been marketing its products aggressively. Airbus has been successful in selling its A-320.

A further challenge comes from (the almost entirely government-funded) French Aerospatiale and (the now private) British Aerospace. They have recently announced plans to study a more commercially viable, next-generation Concorde that would feature an approximate doubling of both distance capability and speed, as well as offering significant fuel and noise reduction.

The Japanese represent a more long-term challenge. They are currently attempting to establish links with both the American and the European aerospace industries, presumably to move up the learning curve in terms of both technology and marketing. The recent Mitsubishi-Daimler Benz pact is one such arrangement. Although it would be somewhat premature to speculate, the Japanese may be gearing up for a future in aerospace that will leapfrog over current technology. In commercial aircraft, they have directed their efforts at hypersonic and supersonic trans-Pacific capability. Estimates for production of such a product range from 10 to 15 years. In the more near-term future, the Japanese will be active participants in the market - in engines, subsystems, parts, etc. and will probably draw heavily on their electronics and materials expertise. They will be part of various cooperative agreements and will undoubtedly have a growing presence in the space market.

²⁹National Journal, p. 780.

In general, the key to obtaining market share in the next century will be in creating competitive new products that incorporate efficiency-, safety- and performance-improving technologies.

Dual use technologies are becoming increasingly important in the aerospace industry. This has come about through a variety of reasons. National defense budgets are now largely devoted to gathering and processing information, improving communications on the field of battle as well as worldwide, and testing and supporting complex military equipment. Because military systems are often produced in many countries, using imported materials, components, and software - many of which are based on civil products and technology - the distinction between military and civil use has been blurred. This is likely to continue as collaboration increases, as defense budgets decline and military planners look for ways to get the most from research and development and procurement dollars. In the United States as in Europe, there is growing interest in buying commercial products "off the shelf" for defense applications, where possible. This will further contribute toward a graying of the line between civil and defense technology.

Internationalization

In response to the rise in foreign technological innovation, the imperative of retaining marketshare, and in some cases, obtaining needed financial backing, U.S. original equipment manufacturers like Boeing and McDonnell Douglas have adopted an increasingly global production strategy.

1. Licensing and Foreign Direct Investment

U.S. primes have engaged in various forms of foreign partnership. Licensing has been used extensively by U.S. manufacturers. Know-how, patents, or trademarks are transferred in return for licensing fees or royalties, which help offset the high cost of research and development. Licensing is an arrangement that has been used in military aircraft production. U.S. aerospace foreign direct investment is still marginal with isolated examples primarily in Canada and Europe. There has been no need for an off-shore transfer of aerospace capabilities. In some instances, U.S. labor is actually cheaper than labor in some foreign countries; industry productivity has been high. The complex nature of aerospace products allows original equipment manufacturers to purchase systems or components offshore when and where desirable. The OEMs are essentially systems integrators and the U.S. still retains a technological edge in this capability.

2. Foreign Suppliers and Off-sets

Nonetheless, while OEMs themselves have not moved off-shore, parts and subassemblies are coming from abroad with increasing frequency. In many cases these are simple business decisions, reflecting a need for cheaper subcontracted parts than are available domestically. In the case of defense aircraft production, there are often elaborate offset arrangements which are designed to gain OEMs market share.

It has been argued that it will not be the primes so much as domestic subcontractors -- the backbone of the U.S. aerospace industry -- that will be the big losers in the aerospace shake-out. The number of U.S.-based suppliers has shrunk dramatically, despite a booming market. Mostly, this has come as a result of

increased competition. In the case of defense aircraft production, procurement policy has limited profits and cash flow as well as the allowability of independent research and development (IR&D) spending with the result of squeezing investment and thereby reducing competitiveness.

3. Civil and Military Joint-Ventures

Joint ventures are very attractive because they are designed so that both costs and risks (for equity investments, research, and product development) are shared, as well as providing market access. The integrated producers argue that the era of a U.S. monopoly in aerospace is over and that the industry can no longer operate in isolation. If Boeing doesn't make a deal with the Japanese, Airbus-Industrie will. While certain technologies should remain secret, select process and material exchanges can benefit the industry as a whole. It is also argued that because it is the Japanese and the Europeans who are the biggest purchasers of U.S. products, cooperative agreements are a logical way to gain market access.

On the other hand, some have expressed a fear that the big producers are entering into Faustian pacts -- selling core technology in exchange for market share. These critics argue that once competitors have the technology, they will leave U.S. producers behind.

Civil joint ventures are becoming increasingly prevalent. Some examples of international partnerships in which U.S. firms are involved include the Boeing 767 jet aircraft project with Boeing (U.S.), Japan Commercial Aircraft Corporation (Japan), and Aeritalia (Italy). CFM International is a joint venture with General Electric (U.S.) and SNECMA (France) to build the CFM56 jet engine. International Aero Engines involves the construction of V2500 jet engines by Pratt & Whitney (U.S.), Rolls Royce (U.K.), Japanese Aero Engines Corp. (Japan), Motoren-und-Turbinen-Union (Germany), and Fiat Aviazione (Italy). A fourth example involves GE and Rolls Royce for production of each other's engines (the GE CF6-80C2 and the Rolls Royce RB211-535E4).

Defense aerospace cooperations have tended to move increasingly away from mere licensing or coproduction arrangements to joint ventures, but defense cooperation has not proceeded at the same pace, or as successfully, as cooperation in the civil sector. There have been outstanding success, and cooperation will undoubtedly continue but the failure or poor performance of some programs, a shrinking defense market, and technology transfer concerns, indicate a continuing rocky road for partnerships in this sector of the industry.

Restructuring

On the micro level, individual firms have made several changes to meet increased competition.

In general, major U.S. firms are in the process of reorganizing their operations. There have been great efforts to step up early manufacturing involvement in the design and development process and to initiate new processes, automation, and computerization. Finally, airframe and engine companies are

pressing their suppliers and subcontractors for higher quality and at reduced costs.³⁰

The Aerospace Industries Association of America has attempted to develop a strategic corporate vision for the industry, selecting critical technologies and seeking industry, academic and government cooperation in technology planning.

AIA established the National Center for Advanced Technologies (NCAT), which was designed to coordinate and integrate the Key Technologies efforts of AIA. The objective is to keep aerospace from meeting the same fate as the U.S. steel, auto, and commercial electronics industries. NCAT's goals are to cut in half the time it takes to get new technologies from idea to application and to double the productivity of available resources. The NCAT technologies are generic in nature, and it is hoped the spillover into other sectors of the economy will be substantial.

II. IMPACT OF TECHNOLOGY IN THE INDUSTRY

The fact that the U.S. aerospace industry has historically maintained high levels of R&D spending gives some indication of the significance of new technology to the industry. In 1987, the aerospace industry allocated 3.9 percent of net sales to R&D.

Innovation has traditionally come both from the supply and the demand side. Acting as a kind of "supply-side" push, U.S. aircraft companies have had a strong tradition of commitment to their products and the continued need for innovation.

For most of the post-war period, a strong customer base had backed producers on the "demand side." The demand pull from customers originally came from three sources: civil regulators, commercial airlines, and the military.

o CAB regulation prevented price competition and focused on performance competition instead. Manufacturers were able to push the costs of adding new technology through to the customer via CAB-approved fare increases. With deregulation, this cost-transferral to the end-user was lessened. Deregulation did, however, perhaps contribute to some improvements in cost efficiency.

o The major American commercial carriers often prompted and supported the development of new aircraft products (e.g., Pan Am, which encouraged production of the first commercial jet, new engines, and the 747). Airlines employed their own teams of engineers who worked closely with aircraft and engine manufacturers in product development. After deregulation, the airlines took a less technical, more business/profit-directed approach, which weakened this close R&D working relationship. The rise of leasing companies (now representing over a third of all new jet orders) furthered the focus on profits, placing the onus for technology development and funding on the manufacturer.

³⁰Working Papers: MIT Commission, pp. 45- 50.

- o Military demand for performance pushed the development and early application of many technologies (e.g., jet engines), as well as providing the test beds for the technology used in early commercial jet aircraft.

Critical Technologies and Technology-Related Skills

The Aerospace Industry Association's Technical and Operations Council has singled out ten key technologies based on highest leverage, potential payoff and broadest application.³¹ In 1988, the aerospace industry was channeling 40 percent of its total technology spending on these 10 technologies. Half of that was from IR&D and half was from government contracted research.

The 10 key technologies identified by the AIA are the following: advanced composites, advanced sensors, airbreathing propulsion, artificial intelligence, computational science, optical information processing, rocket propulsion, software development, superconductivity, and ultrareliable electronic systems. The aerospace industry has also supported research and investment efforts in very large scale integrated circuits (VLSI). The 11 critical technologies are discussed below.

³¹Key Technologies for the 1990s: An Industry Study of High-Leverage, Enabling Aerospace Technologies and Roadmaps to Attain Them, Aerospace Industries Association of America, Inc., November 1987.

CRITICAL TECHNOLOGY: Advanced Composite Materials

DESCRIPTION: Advanced composite materials are high-performance, environmentally durable advanced materials. They include metal matrix, ceramic matrix, carbon/carbon, resin matrix, and hybrid composites.

WHY IS IT A CRITICAL TECHNOLOGY: These materials represent the potential for major improvements in the integrity of aerospace structures, including both high-speed aircraft and missiles (supersonic and hypersonic), high temperature engine components; and ultralightweight structures. Lower structural weight translates into true performance enhancements: increased range, payload, velocity, or maneuverability. High performance composites will provide advanced aircraft competitiveness.

U.S. POSITION RELATIVE TO RoW:

	Lag	Par	Lead
1990		J	E
2000	J	E	

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:

Costs are significant in securing and processing raw materials. (Traditional aluminum costs \$1 a pound, fiberglass \$5/lb, and graphite composites cost \$50-\$60/lb) Conventional materials used in aerospace products and systems remain more cost-effective. The manufacturing process is complicated and still evolving. Certain areas need further study, e.g., the effects of oxidation on high temperature composite materials and the development of repair and replacement techniques applicable to composite materials. Furthermore, there is a shortage of skilled engineers trained in advanced composites.³²

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:

Advanced material production requires low-cost, innovative manufacturing methods; advanced automated design techniques; and unified technical data bases.

³²The Leading Edge: Key Technologies for the 1990s (Series Reprinted from the AIA Newsletter Vol 1 No 1 - Vol 2 No 7), Aerospace Industries Association, Washington, DC,

CRITICAL TECHNOLOGY: Advanced Sensors

DESCRIPTION: Sensors are extensions of man's limited senses of sight and hearing and also perceptions of forces or motions such as acceleration, pressure, and vibration. Active sensors are most common, such as radar. Passive sensors have become important for stealth technology. Advanced sensors go beyond current state-of-the-art sensors.

WHY IS IT A CRITICAL TECHNOLOGY: Development of advanced sensors offers both improvements to individual sensor systems and the possibility of combining information to enhance performance to match ever-increasing requirements and challenges. Applications will be for commercial and military aircraft and helicopters, missiles, space vehicles, and ships and ground vehicles. Benefits would include much improved detection and recognition capability; computer-integrated sensor systems; capability for autonomous detection-reaction operation; greatly reduced life-cycle costs; and stealth and counter/stealth technology and systems. Overall, the payoff is better product performance at a lower price.

U.S. POSITION RELATIVE TO RoW:

	Lag	Par	Lead
1990	J,E		
2000	J,E		

The Europeans have the technological edge in sensor technology involving measurement of vibration, noise, and displacement. The French and British have made advances in infrared and radar sensor technologies. The Japanese lead in solid-state video imaging technologies.

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:

The U.S. no longer holds the lead amongst NATO countries in sensor technology. The Soviets and several Central European countries are known to have made significant advances in sensor technology. U.S. space and civil aircraft also could lose future commercial sales, if advanced sensor capabilities are not incorporated into next-generation products. Cost is the overriding inhibitor to sensor technology development: Raw materials and current manufacturing methods are expensive. A small customer base does not encourage supplier investment; currently only the government needs or can afford sophisticated sensor systems.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:

Some sensors incorporate semiconductor materials. Dependence on foreign semiconductors could have severe ramifications on the domestic ability to develop and produce sensor devices. More generally, sensor technology development also requires expert material and device processing, CAD tools, and automated manufacturing.

CRITICAL TECHNOLOGY: Airbreathing Propulsion Systems

DESCRIPTION: Airbreathing propulsion systems describe the type of engine technology used in aircraft and missiles, as well as in possible future applications to the space plane (NASP) and high-speed commercial transport (HSCT).

WHY IS IT A CRITICAL TECHNOLOGY? New propulsion technology developments in airbreathing engines will provide major gains in propulsion system capability for a wide range of potential applications. Within 20 years, advancements in propulsion technology could result in the design of subsonic transports requiring 30 percent less fuel; fighter aircraft with greater agility and survivability; sustained Mach 3+ flight speed capability and/or V/STOL capability; and rotorcraft with 100 percent greater range and payload. Generally, the payoffs include improved affordability, enhanced operability, increased thrust/weight, increased maneuverability and expanded payload/range without compromise to reliability/supportability.

U.S. POSITION RELATIVE TO RoW:

	Lag	Par	Lead
1990			x
2000			x

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:

Specifically, there has been an absence of sustained national plans for supersonic commercial aircraft propulsion development which will require substantial research and development to achieve an economically viable and environmentally acceptable system. More generally, and related to the above, there have been insufficient resources applied to the development and production of highly advanced materials which are critical to advancing propulsion technology.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:

Airbreathing propulsion technology is linked to development in such areas as turbomachinery; combustors/augmentors; inlets and exhaust systems; controls, accessories and mechanical systems; advanced automated methods; and especially advanced high temperature and lightweight materials.

CRITICAL TECHNOLOGY: Artificial Intelligence

DESCRIPTION: AI is the investigation of reasoning capabilities using computers. AI technology is the development of an evolving set of software concepts and technologies directed at practical imitation of perception and reasoning. The process of integration, or intelligent systems engineering, is key to the use of AI in practical systems to provide real solutions to challenging mission needs.³³ AI covers the range of intelligent behavior necessary to achieve an action: interpret, assess, plan, and act.

WHY IS IT A CRITICAL TECHNOLOGY? Application of artificial intelligence will result in revolutionary productivity improvements for man/machine systems. Payoffs include viable access to the large amount of data increasingly available from space and other systems; national knowledge base assets (e.g., design and engineering, crisis response plans, etc.); autonomous systems for inaccessible environments, long duration missions, and minimum maintenance environments (e.g., Space Station Freedom); collaborative work environments for large software/hardware design, development, and maintenance; and reduced operator load in dealing with complex systems.

Artificial intelligence is already being applied in areas such as fault diagnosis, machine maintenance, satellite telemetry monitoring, robotic systems, and planning and scheduling.

U.S. POSITION RELATIVE TO RoW:

	Lag	Par	Lead
1990			
AI Hardware	J		E
AI Software			J,E
2000			
AI Hardware	J		E
AI Software		J,E	

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:

Research in AI has been funded primarily by DARPA, with relatively small additional contributions from industry and NASA. The level of funding from all of these sources is declining dramatically in comparison with the investment being made in Japan and Europe. The continuing Japanese lead in advanced hardware development and deployment will give them a significant advantage in the future.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:

AI is primarily a software technology, and thus both contributes to and places requirements on software development technology. In addition, AI increasingly requires large scale parallel computation; software development environments for large scale parallel hardware are critical to long-term progress.

³³The Leading Edge, p. 20.

CRITICAL TECHNOLOGY: Computational Science

DESCRIPTION: Computational science is the linking of software and hardware capability for human use. Improvements in computational science yield multifold increases in both speed and scope of computation.

WHY IS IT A CRITICAL TECHNOLOGY? Advances in computational science will mean significant increases in computational scope and capacity. The benefits will permeate all aspects of the aerospace industry including technologies development, product design, and systems maintenance.

U.S. POSITION RELATIVE TO RoW:

	Lag	Par	Lead
1990			
2000			

The U.S. position is difficult to assess, much less predict. While the U.S. is the current leader in computational science, the Japanese and Europeans are gaining on U.S. capabilities.

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:
Current U.S. supercomputing is under severe threat from Japan.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:
Computer science is dependent upon software, manufacturing processes, and computer operation/programming skills.

CRITICAL TECHNOLOGY: Optical Information Processing

DESCRIPTION: Optical information processing is concerned with the storage and manipulation of data by optical devices. This technology includes signal, image, numerical data, and symbolic data processing. The key to this new technology is the use of light as opposed to the charged electron flow used in conventional electronics.

WHY IS IT A CRITICAL TECHNOLOGY?

Innovation in optical information processing could lead to a thousandfold improvement in information processing performance (real-time speed) and reliability. There would be an order-of-magnitude reduction in the number and size of component interconnections. In addition, optical information processing could result in less maintenance and a longer life for inaccessible systems.

U.S. POSITION RELATIVE TO RoW:

	Lag	Par	Lead
1990		x	
2000	x		

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:

Technical maturation is slow. Materials and process are still evolving and customers are slow to accept it. With the exception of fiber optics, optical information technology has yet to demonstrate clear advantages over electronics for any application. Technology transfer is slow both on the inter-industry level and from DoD to industry. High costs are incurred because of the use of expensive specialized material compounds and the construction of clean room facilities.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:

Optical Information Processing would require the developing of specialized material compounds with nonlinear optical properties; innovative, low-cost manufacturing methods; and new, innovative device/component designs.

CRITICAL TECHNOLOGY: Rocket Propulsion Systems

DESCRIPTION: Rocket Propulsion Systems refers to the type of engine technology employed for use with space launch vehicles, orbit transfer vehicles, ballistic and tactical missiles, space intercepts, and on-orbit planetary.

WHY IS IT A CRITICAL TECHNOLOGY? Rocket propulsion technology advances could include increased reliability and safety, order-of-magnitude reductions in cost-to-orbit, and reductions in engine costs with improved performance. The prospect of lower costs and heavier payloads will promote commercial involvement in the space effort.

U.S. POSITION RELATIVE TO RoW:

	Lag	Par	Lead
1990			
2000			

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:

The belief that rocket propulsion is a mature technology has eroded U.S. leadership in this technology.³⁴ There is growing foreign competition. In addition to insufficient funding, inadequate test facilities, and a shortage of skilled engineers, the lack of sustained, specific, long-range U.S. space goals has inhibited the continued development of rocket engines.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:

Critical areas involved in rocket engine technological development include advanced automated operational check out, improved materials, and improved manufacturing methods.

³⁴Ibid., p. 30.

CRITICAL TECHNOLOGY: Software Development

DESCRIPTION: Software is the language and logic of computer operation. "Software" has been defined as the algorithms (procedural or mathematical approaches to problem solving) and instructions which cause computers to process data correctly in support of operational mission needs.³⁵ As the complexity of weapon systems increases, the demands for sophisticated and complex software is experiencing exponential growth. Since historically software development costs increase rapidly with program size and complexity, system costs are rising rapidly. Without improvements in software development methodologies, the availability of computer hardware of improved performance and reduced cost will become a liability rather than an asset.

WHY IS IT A CRITICAL TECHNOLOGY? Improvements in software development methodology could lead to an order-of-magnitude increase in software productivity with corresponding decreases in cost and error rates. Among other things, this could mean ultra-survivable military aircraft, long-life affordable space systems, fail-safe air-traffic-control, cost-effective air defense systems, and ultra-low cost brilliant weapons.

U.S. POSITION RELATIVE TO RoW:

	Lag	Par	Lead
1990			X
2000			X

While the United States is in the forefront of this technology because electronic computers were first developed here and because there is a wider base of companies in this country than elsewhere, major foreign consortia already exist. The Europeans are currently leading the U.S. in certain areas of software development.

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY: Development of advanced software technology is currently inhibited by the level of funding. A second fundamental problem is the lack of formal understanding and focus in research efforts. Current efforts are fragmented between government, industry, and academia, whereas a more interdisciplinary approach is needed. There is also considerable concern about the availability of trained personnel.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES: Software development is dependent upon software engineering, mathematics, and computer programming.

³⁵Ibid., p. 12.

CRITICAL TECHNOLOGY: Superconductivity

DESCRIPTION: Current high-temperature superconductors are ceramic-like materials that, when cooled somewhat below minus 200 degree Fahrenheit suddenly show a number of remarkable properties that include zero resistance to DC electrical currents.

WHY IS IT A CRITICAL TECHNOLOGY? These ceramic-like materials should provide order of magnitude improvement over copper microstrip and antenna elements at the same temperature. While aerospace applications will probably precede other applications, these applications will include superconducting analog/digital convertors, infrared detectors, superconducting transistors, as well as high-performance superconducting motors and generators, energy storage systems, and structural isolation systems.

U.S. POSITION RELATIVE TO RoW:

	Lag	Par	Lead
1990			
2000			

The Japanese are advancing their historical efforts in superconductivity and ceramic technology. The U.S. currently leads basic research in superconductivity but the real challenge lies in practical, commercial application.

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY: Aggressive research programs and commercialization efforts overseas, as well as strong manufacturing capacity by foreign competitors all present a challenge to U.S. semiconductor producers.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES: Progress in superconductivity innovations is closely related to materials related research.

CRITICAL TECHNOLOGY: Ultrareliable Electronics Systems

DESCRIPTION: URES refers to the ensurance of provably correct designs. URES involves the employment and blending of key technologies and methodologies to enhance the reliability of complex electronic systems.

WHY IS IT A CRITICAL TECHNOLOGY? Ultrareliable electronics enable improved performance, integrity, availability and affordability of platform and vehicle systems. It is primarily a focus on reliability with payoffs including fundamentally failure free lifetime systems and significantly reduced life cycle costs.

URES require development of such supporting technologies as packaging and manufacturing, and development of systems and architectures such as intelligent sensors and actuators, self-healing systems, distributed systems, high-speed, fault-tolerant fiber optic data bases. Verification methodologies such as designed-in testability are needed.

U.S. POSITION RELATIVE TO RoW:

	Lag	Par	Lead
1990			
2000			

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:
The erosion of the U.S. position in electronic components poses a threat to U.S. prominence in URES.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:
Related areas include methods for designing and testing error-free systems and environmental screening; hardware and software failure models and system reliability prediction methodology; and advanced CAD tools for simulation.

CRITICAL TECHNOLOGY: Very Large Scale Integrated Circuits

DESCRIPTION: VLSI refers to compact circuitry which will provide computers with an even greater computational ability, while at the same time, being smaller, more reliable and easier to maintain. VLSI stands to benefit from the expertise gained through electronics microminiaturization, the emergence of new materials such as gallium arsenide, and advances made in superconductivity.

WHY IS IT A CRITICAL TECHNOLOGY: In addition to providing computers with greater computational capacity and reliability, VLSI will give unprecedented performance in aerospace and many other fields, providing "brains" for aircraft, satellites and weapons. They will also play a pivotal role in the development of other newly emerging fields, such as artificial intelligence, and will be applied broadly throughout the civil economy.

U.S. POSITION RELATIVE TO RoW:

	Lag	Par	Lead
1990			
2000			

THREATS TO U.S. RETAINING/GAINING PROMINENCE IN TECHNOLOGY:

Although the U.S. pioneered integrated circuits, foreign manufacturers now dominate production of commercial semiconductor devices and have rapidly implemented new technology, including VLSI.

TECHNOLOGICAL INTERDEPENDENCIES - RELATED TECHNICAL ISSUES:

Major areas of emphasis include improved design simulation; submicron scale device fabrication; enhanced aerospace attributes such as ruggedness, testability, and radiation hardness; advanced semiconductor materials; and interconnecting and packaging.

III. THREATS TO U.S. LEADERSHIP IN CRITICAL TECHNOLOGIES:

Process/Materials uncertainty: Advanced materials and process are by their very nature risky. Unproven in terms of both efficiency and safety, manufacturers and commercial buyers are understandably reluctant to invest in R&D that could result in failure. This is especially true in times of economic uncertainty -- ironically, usually the time it is most critical to develop competitive, new products.

High Costs: "New" materials and processes are usually expensive for reasons of resource scarcity, poor economies of scale, and usually lengthy maturation. The high insurance costs associated with new technology products is of particular relevance to aerospace.

R&D Funding: Because aerospace is technology-driven and on the forefront of (expensive) innovation, it requires large amounts of R&D investment. The government funded about 40 percent of aerospace R&D in 1988. DOD accounted for 77 percent of that sum, directed to military programs at the development stage. The FAA contributed another 14 percent in 1988, geared to air traffic control and air safety. NASA's work in high-risk civil aviation R&D programs (targeting basic and applied research activities) accounted for another 9 percent. U.S. manufacturers provided about 20 percent of aerospace R&D funding.

R&D investment and commitment is difficult to attain for a variety of reasons, among them the high cost of capital (on the private side) and various recent procurement revisions (on the military side). Limits on the aggregate amount of IR&D/B&P costs that DOD could negotiate with industry has led to lower IR&D spending in defense because of lower recovery costs.

o **Fiscal Policy Inconducive to Long-term Investment:** Single-year procurements and single-year budgets thwart long-term planning for defense-related aerospace. Because the R&D tax credit is not permanent, is only applied to an increase in expenditure above a company's historical outlays, and only applies to incremental, early program costs, it fails to stimulate the aerospace industry's long-term investment in R&D.

The high cost of capital can be traced to high Federal budget deficits. High cost of capital acts as a strong disincentive to borrow monies; investment in R&D suffers as a consequence.

o **Insufficient Intra-Industry Interaction:** Like many other U.S. industries, aerospace suffers under the "Lone Ranger" syndrome. A microsystem management philosophy versus a systems approach has led to limited inter-industry communication. Antitrust legislation has contributed to this restrictive behavior. This approach exists even at the intra-industry level.

o **Weak Links in the R&D Chain -- Validation:** Because aerospace products are expensive, sophisticated, and face critical requirements in terms of performance and safety, they are necessarily subject to a lengthy and expensive process of validation. Unfortunately, validation is one of the weakest links in the U.S. aerospace industry's R&D chain. Not only is there a shortage of test-facilities for validation (NASA and military facilities are not used directly for commercial

purposes), the process itself has become prohibitively expensive and time-consuming. The U.S. aerospace industry must work to expedite the validation process or risk losing the competitive edge to its international competitors who are becoming increasingly adept at transferring experimental prototypes to commercially feasible product.

o **Foreign Competition -- Targeting and Subsidies:** Foreign governments, particularly in Europe and Japan, but also in Indonesia and Brazil, have deliberately targeted aerospace as a critical industry. These foreign governments support their aerospace industries in the form of generous loan conditions and policies that mitigate risk. As a result, these foreign industries have been able to develop highly advanced aerospace technologies for commercial application with limited concern about cost.

o **Changes on the Demand-Side:** Deregulation and aircraft leasing in the U.S. airline industry have contributed to a shift in aircraft customer preoccupation from performance to profits. Costs can no longer be passed as easily to the passenger and airlines are not as ready to buy expensive new technologies that do not enhance economic performance significantly more than periodic upgrades of older machines.

In the space sector, 90 percent of the manufacturers involved in product development are government contracted. These companies are unwilling to invest in R&D because of a fear of being second on the market. Poor intellectual property protection and a sense that subsidized foreign industries have an advantage, combine to dissuade technology development.

Defense budget cuts signify a relative decline in significance of military customers to the aerospace industry. Those aerospace producers that currently maintain a military focus will need to meet the challenge of conversion -- most obviously to commercial aerospace production. Such a conversion will need to occur both on the technology/product level, as well as on the financial level. No longer dependent on regular government contracts, these "converts" will have to be able to compete on the open market.

o **Burden of own Success:** Currently, the major American producers have their hands full with a recordbreaking backlog of orders. In the meantime, unburdened by the current short-term sales boom, the Japanese for example can take the time to develop technology for the next generation of aircraft and aerospace products.

o **Lack of qualified engineers/technicians:** The average age of aeronautical/astronautical engineers has risen more sharply than that for all engineers over the decade. Between 1976 and 1986, the proportion of aeronautical/astronautical engineers over age 50 rose from 26 percent to 49 percent; the proportion of all engineers in this age group increased from 24 to 34 percent.³⁶ The education pipeline is not providing sufficient numbers of highly trained scientists and technicians to fill future ranks, especially in advanced areas. There are fewer and fewer American students studying math and science,

³⁶"Profiles -- Aeronautical/Astronautical Engineering: Human Resources and Funding," Special Report, NSF 89-314, National Science Foundation, Washington, DC, 1989, p. 15.

especially at the graduate level. Forty percent of science/engineering graduate students at American universities are foreigners.

- o **Outdated Trade Policy:** U.S. export controls for certain "critical" technologies have hindered U.S. aerospace exports. Some of these controls may need to be updated. Insufficient protection of intellectual property has also acted as a disincentive to aerospace firm investment in new technologies. In addition, U.S. policy on procurement (including "Buy American") has been called restrictive by some cost-conscious industry members.

IV. OPPORTUNITIES

- o **High levels of R&D spending:** The industry has one of the highest levels of R&D spending of any U.S. industry, both in terms of government spending (mostly DoD, but also NASA and the FAA) and private industry spending (known as independent R&D). In 1987 company and government R&D funding combined amounted to 15 percent of net sales, compared with the all-industry average of 4.7 percent. Private industry spending was 3.7 percent of net sales, compared to a 3.3 percent average for all manufacturing.

- o **Superior Systems-Integration Capability:** The American aerospace industry is particularly adept in systems-integration and is, in fact, considered the world's leader in this critical area.

- o **Long-term thinking:** While arguably not as forward-looking and as eager a risk-taker as it once was, the U.S. aerospace industry continues to draw on a tradition of greater patience than most other industries in the country.

- o **AIA restructuring efforts/awareness of challenge:** With the decline of several key U.S. manufacturing industries as poignant warnings to other industries, the U.S. aerospace sector has made a concerted effort on both the micro and the macro level to address the growing foreign challenge.

- o **Public support:** For the same reasons that other countries view aerospace as a strategic and prestigious industry, the U.S. stands strongly behind it. NASA and DoD programs support aerospace both directly and indirectly, reflecting a high national political priority.

A. Scott Crossfield
CROSSFIELD ASSOCIATES
12100 Thoroughbred Road
Herndon, Virginia 22071
(703) 860 4223/9360

November 16, 1988

Dr. William R. Graham
Science Advisor to the President and
Director, Office of Science and Technology Policy
Room 358, Old Executive Office Building
Washington, DC 20506

Dear Bill:

As requested by your office I have reviewed the strawman REPORT OF THE AERONAUTICAL REVIEW COMMITTEE, August 1988.

First, I still think it is a fundamental flaw to artificially sever a generic technology family. I have to reiterate my often argued persuasion that it lacks sophistication to attempt to specify "aeronautical" and "space" policy of an "aerospace" technology. Even this report has problems to wit:

The first paragraph on page 2 refers to "-- aeronautics --- strong balance of trade ---" and "aviation --- competitiveness."

On page 3, paragraph 1 it refers to "--- aeronautics ---" and its "\$15 billion per year --- balance of trade ---"

On page 6, paragraph 1 it is "--- aerospace ---" that has a "--- \$15 billion ---" trade balance.

On page 7, paragraph 5, in the same vein, it is again "--- aerospace sales ---" because the author could not intelligently separate aeronautics and space with relevant arguments.

These specious cults (aeronautics and space) have cost us dearly in diluting our talent and resources and will continue to do so if we persist. For example: in a way, this has made the X-30 neither fish nor fowl, disdained by the space types and reluctantly abided by the aero types. How long do we perpetrate going into the game burdened by our failure to first simply engineer the definition of the arenas?

I am well aware that the foregoing is not a valid response to your specific request. Now to the report at hand:

Page 1, par. 1: When did France secede from Europe?

Page 4, par. 1: After "--- 1915." it may be appropriate, here, to quote the full extent of NACA's legal policy: "To study the problems of aeronautics with a view to their practical solution." which is a classic for a policy statement.

A. Scott Crossfield
CROSSFIELD ASSOCIATES
12100 Thoroughbred Road
Herndon, Virginia 22071
(703) 860 4223/9360

November 18, 1988

Dr. William R. Graham
Science Advisor to the President and
Director, Office of Science and Technology Policy
Room 328, Old Executive Office Building
Washington, DC 20506

As requested by your office I have reviewed the statement report
OF THE AERONAUTICAL REVIEW COMMITTEE, August 1988.

First, I still think it is a fundamental flaw to not really
review a generic technology family. I have to reiterate my often
stated position that it lacks sophistication to attempt to
specify "aeronautical" and "space" policy of an "aerospace" tech-
nology. Even this report has problems to will.

The first paragraph on page 2 refers to "aeronautics"
along balance of trade "and aviation" -- competitiveness.

On page 3, paragraph 1 it refers to "aeronautics"
and its "\$15 billion per year" balance of trade --

On page 6, paragraph 1 it is "aerospace" -- "that has a
"\$15 billion" trade balance.

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your specific request. Now to the report at hand:

Page 1, par. 1: When did France succeed from Europe?
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here to quote the full extent of NASA's legal policy: "To study
the problems of aeronautics with a view to their practical
solution," which is a classic for a policy statement.

Page 6, par. 4: "In the last 15 years, the United States has lost one-third of a world market that it once dominated as European competitors moved toward technological parity ---." The loss of that market, as with many others, cannot be attributed to technical issues.

Page 7, par. 3 & 4: Technology policy should recognize that it is inappropriate to spend research funds on market surveys.

Page 8, par. 2: "It is too early to tell, however, if it will be possible to fully meet the ambitious objectives of this program" is an opinion not agreed with in many reputable quarters, and an inappropriate caveat in this document that can come back to haunt.

Page 8, par. 3, sentence 2: "---, if realized, ---" same kind of weak willed hedge as above that belies the aggressive, competitive, positive theme intended in the report.

Page 9, par. 2: "--- U.S. technological superiority." What U.S. technological superiority? This is head in the sand stuff that repudiates objective authorship and is the self deluding conceit that brought us to the problem of lack of sustained technological growth in the first place.

Page 9, "RECOMMENDATIONS:", it may be appropriate to add: "f. Establish a minimum level of DOD far term aerospace hardware basic research investment."

Page 10, b. at the bottom of the page: Here, "aviation" should really be "aerospace" to avoid risk of contaminating the academic world with trade school definitions of disciplines.

Page 11, "4." Running a jet engine on hydrogen in no way is the measure of "a major technology milestone."

Page 11, "RECOMMENDATION:" it should be made known that, by its very nature, the X-30 research program has already paid for its investment to date in technological returns and will continue to pay in kind for its entire life.

and, "c." should clearly reflect that the "--- start of a technology line ---" is the epitome of the competitive, aggressive theme of the report.

Page 12, par. 3: after "Foreign success" it would be appropriate to insert: ", without concerted and competent U.S.response,"

Page 6, par. 4: "In the last 15 years, the United States has lost one third of a world market that it once dominated as European competitors moved toward technological parity. The loss of that market, as with many others, cannot be attributed to technical issues."

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Page 12, par. 3: after "Foreign success" it would be appropriate to insert "... without concerted and competent U.S. response."

Page 13, par. 1: Perhaps a recommendation "d." should "encourage U.S. participation in global consortiums ---" in keeping with Page 10, first b. The GE Snecma arrangement is a precursor to 21st century reality.

Page 13, "RECOMMENDATIONS: a." Does this mean application of government research funds to a commercial demonstrator? What did we learn from the old VSTOL Office and the SST Office? It will be a very bureaucratic and unproductive effort. The technology developed for VSTOL went to Canada (Dash 7) and the SST to France and England. Conversely the industry beat the government to the punch with the "unducted fan" because they saw the market. If our industry does not step up initially it probably won't at all.

Page 13, par. 4: "The current product liability situation which faces the U.S. General Aviation Industry has resulted in costs which price products out of the market." perpetrates a fraudulent cop out. It has contributed but not nearly as much as claimed and that mostly because of pay off techniques that corrupted the justice system. The FAA regulations, ATC requirements, the industry overpricing, and ignorance of the marketplace are the primary causes of the problem; similar factors to those that drove the automobile market to Japan.

Page 14, par. 1, sentence 2: The claims of foreign subsidization, are made by virtually every industry, and are often a matter of bookkeeping gadgetry in the manner of how the piper is paid, and he must be. It still comes out of the country's economy somewhere. Just as with the liability thing our policy should reflect how to beat the game not protest it.

Page 14, last par.: The Act was also modified and re-enacted also in 1982 and 1987.

Page 15, par. 1: "\$1.2 billion" should be "\$12 billion."

And: The last two sentences don't make sense to me.

Page 15, par. 2: How would a Russian duplicate of GPS lead to "--- U.S. and free world dependency ---?"

Page 15, "RECOMMENDATION:" (should be plural) are good but the only way the U.S. will get global cooperation is by proving its good faith and leadership by being allowed to pursue the National Air Space Plan aggressively with the dedicated funding taxed for it without the unrelated budgetary equivocation. The Plan and its demonstration is drawing intense attention around the world and no study will subjugate that influence.

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Page 16, last par., last sentence: "--- under the general heading of composites." should be deleted as an untrue restriction.

Page 18, "Supersonics" Sonic boom and ozone are more in need of research policy than "quiet wind tunnels."

Page 19, par. 2: flight research with research aircraft is, in fact, fundamental technical aeronautical research and not validation. The research airplanes and the X-30 were and will almost always be in areas unavailable to the groundling researcher's tools. The whole research airplane program that wrote the books was cheaper than one wind tunnel.

Page 20, "Supersonics" Gas generator driven compressor techniques for high speed aircraft have been abandoned by the U.S. but the Brits and Japanese are exerting large and ingenious efforts to this development which is critical.

Page 20, last 3 par.: Here the Japanese have declared that they intend to become the world's supplier of high tech propulsion in the future and claim to have committed \$18 billion in the next ten years to this end.

The entire Appendix A, in general, and particularly from "C. Structures and Materials" to the end is idiosyncratic and too detailed. That is significant only because of what is left out which thus defeats the purpose of policy guidance

Bill, I concede that this is free ranging and lacks the months of thought that went into the original. But it does represent reaction in areas that I think I have more than cursory understanding. Also, I find its reasoning more faddish than intellectual or philosophical. I hope this is responsive.

Regards,

cc Tom Rona, Alan Chambers

Page 16, last part, last sentence: "under the general heading of composite," should be deleted as an undue restriction.

Page 18, "Superconducting" and "acoustic" are more in need of research policy than "quiet wind tunnels."

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Bill, I concede that this is long ranging and lacks the punch of thought that went into the original. But it does represent research in areas that I think I have more than cursory understanding. Also, I find the reasoning more logical than intellectual or philosophical. I hope this is responsive.

Regards,

cc: Tom Rouse, Alan Chambers

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

November 4, 1988

Dear Mr. Crossfield:

Enclosed is a copy of the Report of the OSTP Aeronautical Policy Review Committee for 1988. As we discussed on the phone the report is not intended to be a repeat of the earlier Birdbooks, but rather an analysis of where the US aeronautical R&T is today relative to achieving the goals stated in the previous reports. In addition, where appropriate the report attempts to highlight issues and make recommendations relative to these findings.

Dr. Graham would like to have you review the report. Any comments would be greatly appreciated, by Dr. Graham and the committee.

I suggest that your comments be forwarded directly to Dr. Graham with a copy to the Executive Secretary of the Aeronautical Policy Review Committee.

Sincerely,



Alan Chambers

Mr. Scott Crossfield
12100 Thoroughbred Road
Herndon, VA 22071

encs: Report of the Aeronautical Policy Review
Committee, August 1988

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

November 4, 1988

Dear Dr. Kupperman:

Enclosed is a copy of the Report of the OSTP Aeronautical Policy Review Committee for 1988. As we discussed on the phone the report is not intended to be a repeat of the earlier Birdbooks, but rather an analysis of where the US aeronautical R&T is today relative to achieving the goals stated in the previous reports. In addition, where appropriate the report attempts to highlight issues and make recommendations relative to these findings.

Dr. Graham would like to have you review the report. Any comments would be greatly appreciated, by Dr. Graham and the committee.

I suggest that your comments be forwarded directly to Dr. Graham with a copy to the Executive Secretary of the Aeronautical Policy Review Committee.

Sincerely,



Alan Chambers

Dr. Charles Kupperman
McDonnell Douglas
1550 Wilson Ave., Suite 550
Arlington, VA 22209

encs: Report of the Aeronautical Policy Review
Committee, August 1988

Scotty Crossfield

Charlie Kepperman - Sp. ASST TO PRES.

Crossfield, Scott (TECH Consultant)
RHOB room 2321
phone 225-8103

Subcommittee on Trans, Av & Materials

Charles Kepperman
McDonald Douglas
1550 Edison Ave
Arlington, Va 22204

12-9-50

Suite 550

phone 276-4612

Sent x
11/4/88

REVIEW. TXF

CROSBY, William D., Jr., minority counsel, House Committee on Rules. Home, 920 Mackall Ave., McLean, VA 22101. Born September 1, 1943 in Louisville, KY to Dr. William Duncan and Lucille (Edwards) Crosby. Married June 2, 1973 to Constance Elaine Frederick. Children: William Duncan, III and Lelia Margaret. Yale Univ., 1961-65, B.A.; Columbia Law School, 1965-68, LL.B. Enlisted as officer candidate, U.S. Navy in 1968; released as LTJG in 1971 after service on the *USS Shangri-la* and in Naval Investigative Service Office. Member: American, Kentucky, DC and Federal Bar Assns.; Capitol Hill Club.

CROSSFIELD, A. Scott, tech. consultant, Subcom. on Transportation, Aviation and Materials, House Com. on Science & Technology. Home, 12100 Thoroughbred Rd., Herndon, VA 22071. Born Oct. 2, 1921 in Berkeley, CA to Albert Scott and Lucia (Dwyer) Crossfield. Univ. of Washington, 1949, B.S. in aero. engineering and 1950, M.S. in aero. science; FL Inst. of Tech., 1982, D.Sc. (hon.). Married April 21, 1943 to Alice Virginia Knoph. Children: Becky Lee, Thomas Scott, Paul Stanley, Anthony Scott, Sally Virginia and Robert Scott. U.S. Naval Reserve service, 1942-46. Career record: 1946-50, wind tunnel operation staff, Univ. of Washington; 1950-55, aerodynamicist, project engineer and research airplane pilot, NACA; 1955-61, design specialist, chief engineering test pilot, 1961-66, dir. of test and quality assurance, Space and Information Systems Div., 1966-67, tech. dir. of research and engineering, Space and Information Systems Div., all with North American Aviation, Inc.; 1967-71, vice pres., Flight Research and Devel. Div. and 1971-74, staff vice pres. of trans. systems devel., Eastern Air Lines; 1974, senior vice pres., Hawker Siddeley Aviation, Inc.; 1977—, current position. Author: *Always Another Dawn*, 1960. Recipient: Lawrence Sperry Award, 1954; Octave Chanute Award, 1957; David C. Shilling Award, 1961; Ivan C. Kincheloe Award, 1960; Godfrey Cabot Award, 1961; Intl. Harmon trophy, 1961; Collier trophy, 1962. Fellow, Society of Experimental Pilots, co-founder; Amer. Inst. of Aeronautics & Astronautics. Member: Amer. Society for Quality Control; Flying Physicians Assn.; Experimental Aircraft Assn.; former president, Natl. Aviation Club, 1983-85; Episcopal Church.

CROW, James A., field rep. to Rep. Ed Jones, 8-TN. Home, 4630 Bateman, Millington, TN 38053. Born Dec. 29, 1934 in Memphis, TN to Adron Doyle and Nelma (Kelly) Crow. Married Nov. 25, 1960 to Shirley Roberts. Children: James A., Jr. and Elizabeth Ann. U.S. Army service, 1957. Recipient of Civic Award from International Harvester, 1976. Member: Exchange Club; Moose; Presbyterian Church. Interests: hunting, swimming.

CROW, Stephen L., prof. staff member, Subcom. on Energy and Water Development, Senate Com. on Appropriations. Legal res., Portland, OR. Home, 225 9th St., NE, Washington, DC 20002. Born Dec. 27, 1946 in Portland, OR to Louis M. and Jacquelin (Wolfer) Crow. Married to Vicki L. McKee. Child, Kelly L. Oregon State Univ., 1965-69, B.S.; Univ. of Oregon, 1969-72, J.D. Career

record: 1973, attorney-private practice; 1973-75, legis. asst. to Rep. Wendell Wyatt, OR; 1975-78, exec. asst. to Sen. Mark O. Hatfield, OR; 1978, minority counsel, Senate Committee on Rules & Administration; 1979-81, minority counsel, Senate Com. on Energy & Natural Resources. Admitted to OR Bar, 1972; DC Bar, 1978.

CRUMB, Duane J., special asst. to Rep. William E. Dannemeyer, 39-CA. Home, 7008 Austin Court, Riverside, CA 92503. Born Dec. 10, 1945 in Wauertown, NY to Donald J. and Helen P. (Coulter) Crumb. Married May 11, 1974 to Joyce E. Harmon. Children: Danita Jo and Danae Joy. Pasadena City Coll., 1963-65, A.A.; Univ. of Redlands, 1965-67, B.A. Career record: 1970-77, bank loan officer; 1977-84, church business admin.; 1985, crusade assoc., Billy Graham; 1985—, current position.

CRUMP, Bill (William Bell, III), chief of staff to Rep. Connie Mack, 13-FL. Legal res., Schlater, MS. Home, 6626 Medinah Lane, Alexandria, VA 22312. Born Sept. 19, 1953 in Leflore County, MS to William Bell, Jr. and Joyeanne (Peeples) Crump. Married June 6, 1976 to Margaret Jane Gerrard. Child, William Bell IV. Delta State Univ., 1972-76, B.S.E.; Pi Kappa Alpha, president of Student Body, senator, dir. of Union Entertainment. Career record: 1972-76, Alderman and 1976-82, Mayor, Town in Schlater, MS; 1976-80, teacher, Pillow Academy; 1980-82, sales rep., Lanier Business Products; 1982, campaign mgr., Webb Franklin Congressional Campaign; 1982-86, admin. asst. to Rep. Webb Franklin, MS; 1986—, current position. Selected an Outstanding Young Man of America; recipient, American Legion Citizenship Award. Deacon, First Presbyterian Church, Greenwood, MS. Interests: snow skiing, photography, history.

CUADERES, John D., legis. asst. to Rep. Dave McCurdy, 4-OK. Legal res., Norman, OK. Home, 4809 W. Braddock Rd., No. 201, Alexandria, VA 22311. Born July 6, 1962 in Oklahoma City, OK to Eduardo Flores and Rilla Maria (Jones) Cuaderes. Univ. of Oklahoma, 1980-84, B.A. and 1985-86, M.P.A., dean's list, Honor Role, president's list, Phi Kappa Psi. U.S. Army service; Parachutist Badge; 1LT, U.S. Natl. Guard.

CUBIE, James M., professional staff member, Subcom. on Foreign Operations, Senate Com. on Appropriations and legis. asst. to Sen. Patrick J. Leahy, VT. Home, 116 12th Street, NE, Washington, DC 20002. Born Nov. 4, 1946 in Haverhill, MA to the Rev. James M. (deceased) and Grace (Allen) Cubie. Child, James Ferguson. Eastern Nazarene College, 1964-68, B.A. (valedictorian); Princeton Theological Seminary, 1968-70; Univ. of Maryland Law School, 1971-74, J.D. Career record: 1974-75, staff, Congress Watch; 1975-76, staff, New Direction; 1976-79, staff, Union of Concerned Scientists; 1979-81, majority counsel, Subcom. on Energy, Joint Economic Committee; 1981-84, prof. staff member, Subcom. on the District of Columbia, 1985-87, prof. staff member, Subcom. on HUD and Independent Agencies, Senate Com. on Appropriations; 1987—, current position. Admitted to Maryland and District of Columbia Bars.

CULPEPPER, Ray, 3-GA. Home, 22311. Robert Lee and con Junior Coll. 84, B.A.; Georgia record: 198 GA; 1987—, c

CUMMINGS, tee on Environ Arbovale, WV. and Verna Pet June 30, 1965 dren: Matthew University, 1967-70, LL.B. ian Church.

CUNNINGHAM, Charles E. Gra IA. Born Nov. 3 and Darlyne (L lege, 1973-77 dent's list, de farm operator analyst for GOF staff asst., Tau 81, legis. asst current position woodworking.

CUNNINGHAM, Joseph R. Bids Wilmington, D West Chester (Ranck) Cunnir Margaret Sim beth, Michael Walter Hecke 1952-55, B.A 1955-56, Fu 1956-57. Ent service in 195 record: 1957 educ.; 1962 teacher, radio rector, adverti 78, hospital ics, hunting,

CURRAN, Do Congress, L Chestnut Ave May 26, 193 and Dorothy 25, 1960 to Ann, Matthev Junior Coll., and 1957-59 ton Univ., 19 in public adm Career record Old Age Sup 1961-69, ad

**EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY**

TO:

2	THOMPSON		MARKS		OTHER:
3	GRAHAM		VAN CLEAVE		
1	RONA		WINCE		
	BERGER				
	DESUTTER				
	ENGLISH				
	Action		Correction	X	Signature
	Approval		File		Urgent
	As Requested		Information		Revise
	Circulate		Prepare Reply		Testimony
	Comment		Reply		Speech
	Concurrence		See Me		Decision
	Prepared by:		Prepared by:		Prepared by:
	Cleared by:		Cleared by:		Cleared by:

DATE DUE:

FROM ABC Chambers	DATE 9-26-88	PHONE NO. x 7710
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Remarks:

Donna

Revised
November 1987

Document Originally
Attached to
Following Page

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

September 26, 1988

MEMORANDUM FOR WILLIAM R. GRAHAM

FROM: THOMAS P. RONA 
SUBJECT: REPORT FROM THE AERONAUTICAL POLICY REVIEW
COMMITTEE

We recently received the completed 1988 Report of the Aeronautical Policy Review Committee (Tab A). John Cashen, acting as Jack Steiner's deputy while Jack has been on travel, forwarded the report to this office (Tab B).

The report follows the format of the 1983 report to Dr. Keyworth in providing an assessment of the aeronautical research and technology status in the U.S. It also identifies major achievements and in specific areas cause for concern.

The Committee's intent is not to have the report published in a manner similar to the Birdbooks, but rather to continue to provide this office and yourself with the annual assessment of the status of achievement of the U.S. National Aeronautical R&D Goals proposed by the Committee in 1985 and 1987 Birdbooks.

I suggest the following action:

- o Accept the report with a letter thanking the committee members for their work and comments. (Tab C). This will complete the required actions outlined by the Notice of Renewal of the Committee (P.L. 92-463).
- o Add as appendix the supporting data you requested in your note (9/14/1988).
- o Send the report out for comments to individuals of your choice (e.g. Scott Crossfield) - (Action: Chambers).
- o On basis of comments and other considerations, if desired, issue the material, modified as appropriate, as an OSTP report.

This process will provide for desired reviews and, still, respond to the Aeronautical Policy Review Committee members in a prompt manner.

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

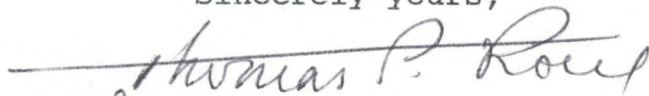
September 26, 1988

Dear Dr. Cashen:

I have received the 1988 report from the Aeronautical Policy Review Committee. It will be of great help in further developing national aeronautical R&D implementation strategies.

I personally want to thank you, Jack Steiner, and all the members of the Committee for the effort expended in assessing the current programs and developing a thoughtful and comprehensive report. I appreciate that these activities require an effort over and above the normal call of duty. Please extend my appreciation to all members and staff that assisted.

Sincerely yours,

A handwritten signature in dark ink, appearing to read "Thomas P. Roup". The signature is written in a cursive style with a horizontal line extending to the left.

for William R. Graham,
Science Advisor to the President

Dr. John Cashen
Vice President, Advanced Projects
Northrop Advanced Systems Division
8900 East Washington Boulevard
Pico Rivera, CA 90660-3737

cc/J. Steiner

Vice President
Advanced Projects

NORTHROP

24 August 1988

Advanced Systems Division
Northrop Corporation
8900 East Washington Boulevard
Pico Rivera, California 90660
Telephone 213 942-3000

Mr. John E. Steiner
3425 Evergreen Point Road
Bellevue, Washington 98004

Dear Jack;

Enclosed is the latest and, we intend, final version of the CY 1988 report of the Aeronautical Policy Review Committee.

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Sincerely,


John Cashen
Deputy Chairman

enc:
Distribution list attached

Vice President
Advanced Projects

NORTHROP

24 August 1988

Advanced Systems Division
Northrop Corporation
8900 East Washington Boulevard
Pico Rivera, California 90660
Telephone 213 942-3000

Mr. John M. Swihart
Vice President, International Affairs
The Boeing Company
P.O. Box 3707
M/S 14-52
Seattle, Washington 98124

Dear John;

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NORTHROP

24 August 1988

Advanced Systems Division
Northrop Corporation
8900 East Washington Boulevard
Pico Rivera, California 90660
Telephone 213 942-3000

Mr. Hershel Sams
Vice President, Engineering Technology
McDonnell Aircraft Company
P.O. Box 516
St. Louis, Missouri 63166

Dear Hershel;

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Advanced Projects

NORTHROP

24 August 1988

Advanced Systems Division
Northrop Corporation
8900 East Washington Boulevard
Pico Rivera, California 90660
Telephone 213 942-3000

Dr. Bernard Paiewonsky
Office of the Assistant Secretary of the
Air Force for Acquisition
Deputy for Advanced Technology
The Pentagon, Room 4D977
Washington, D.C. 20330-1000

Dear Bernie;

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Deputy Chairman

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NORTHROP

24 August 1988

Advanced Systems Division

Northrop Corporation

8900 East Washington Boulevard
Pico Rivera, California 90660
Telephone 213 942-3000

Mr. Robert R. Lynn
Senior Vice President, Research and Engineering
Bell Helicopter Textron
P.O. Box 482
Fort Worth, Texas 76101

Dear Bob;

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Vice President
Advanced Projects

NORTHROP

24 August 1988

Advanced Systems Division
Northrop Corporation
8900 East Washington Boulevard
Pico Rivera, California 90660
Telephone 213 942-3000

Mr. Walter Luffsey
Director
Advanced Aviation Systems Design Team
Room 222
Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, D.C. 20591

Dear Walt;

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Vice President
Advanced Projects

NORTHROP

24 August 1988

Advanced Systems Division
Northrop Corporation
8900 East Washington Boulevard
Pico Rivera, California 90660
Telephone 213 942-3000

Mr. James N. Krebs
84 Harbor Avenue
Marblehead, Massachusetts 01945

Dear Jim;

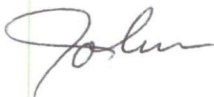
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Deputy Chairman

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NORTHROP

24 August 1988

Advanced Systems Division
Northrop Corporation
8900 East Washington Boulevard
Pico Rivera, California 90660
Telephone 213 942-3000

Mr. Charles B. Husick
4973 60th Avenue S.
St. Petersburg, Florida 33715

Dear Chuck;

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Vice President
Advanced Projects

NORTHROP

24 August 1988

Advanced Systems Division

Northrop Corporation

8900 East Washington Boulevard

Pico Rivera, California 90660

Telephone 213 942-3000

Mr. Russell L. Hopps
618 Island View Circle
Port Hueneme, California 93041

Dear Russ;

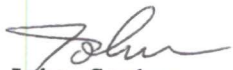
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Vice President
Advanced Projects

NORTHROP

24 August 1988

Advanced Systems Division
Northrop Corporation
8900 East Washington Boulevard
Pico Rivera, California 90660
Telephone 213 942-3000

Mr. Bastian (Buz) Hello
Senior Vice President, Government Relations
North American Aircraft Operations
Rockwell International Corporation
1745 Jefferson Davis Highway
Arlington, Virginia 22202

Dear Buz;

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Vice President
Advanced Projects

NORTHROP

24 August 1988

Advanced Systems Division
Northrop Corporation
8900 East Washington Boulevard
Pico Rivera, California 90660
Telephone 213 942-3000

Mr. J. Roger Fleming
Sr. Vice President, Technical Services
Air Transport Association
1709 New York Avenue N.W.
Washington, D.C. 20006

Dear Roger;

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24 August 1988

Advanced Systems Division

Northrop Corporation

8900 East Washington Boulevard

Pico Rivera, California 90660

Telephone 213 942-3000

Professor Eugene E. Covert
Department Head, Aeronautics and Astronautics
Room 33-207
Massachusetts Institute of Technology
70 Massachusetts Avenue
Cambridge, Massachusetts 02139

Dear Gene;

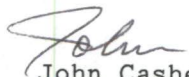
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24 August 1988

Advanced Systems Division

Northrop Corporation

8900 East Washington Boulevard

Pico Rivera, California 90660

Telephone 213 942-3000

Dr. Raymond S. Colliday
Director
Defense Advanced Research Projects Agency
1400 Wilson Boulevard
Arlington, Virginia 22209

Dear Ray;

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Vice President
Advanced Projects

NORTHROP

24 August 1988

Advanced Systems Division
Northrop Corporation
8900 East Washington Boulevard
Pico Rivera, California 90660
Telephone 213 942-3000

Mr. William F. Ballhaus, Jr.
Associate Administrator for
Aeronautics & Space Technology
National Aeronautics and Space Administration
600 Independence Avenue
Code R
Washington, D.C. 20546

Dear Bill,

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Deputy Chairman

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Vice President
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NORTHROP

24 August 1988

Advanced Systems Division
Northrop Corporation
8900 East Washington Boulevard
Pico Rivera, California 90660
Telephone 213 942-3000

Dr. John F. Cashen
Northrop Corporation
Advanced Systems Division
T000/1N
8900 E. Washington Blvd.
Pico Rivera, California 90660

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Northrop Corporation
8900 East Washington Boulevard
Pico Rivera, California 90660
Telephone 213 942-3000

24 August 1988

The Honorable William R. Graham
Science Advisor to the President
Room 358
Old Executive Office Building
Washington, D.C. 20506

Dear Dr. Graham:

Transmitted herewith is the 1988 report from the Aeronautical Policy Review Committee.

The Committee intends this report provide a current assessment of the U.S. industry/government progress made toward achieving the National Aeronautical R&D Goals identified in "Birdbook I". We have also highlighted some specific "Issues and Recommendations" which we believe are of major importance. And, as an addendum, we have provided a technical discipline assessment as an adjunct to the above.

Current R&T efforts in the U.S. are providing strong support for attainment of the central objective -- U.S. preeminence in aeronautics. Nevertheless, foreign competition is becoming much stronger and in this environment we believe it is critical that the aeronautical R&T activities continue to receive close review by yourself and the appropriate persons in the Executive Office.

Sincerely,



John Cashen
Deputy Chairman