BY THE COMPTROLLER GENERAL 112985

Report To The Congress

OF THE UNITED STATES

A Look At NASA's Aircraft Energy Efficiency Program

Four years ago the National Aeronautics and Space Administration (NASA) initiated the Aircraft Energy Efficiency program to provide by 1985 the technology for making future transport aircraft up to 50 percent more fuel efficient than today's aircraft. Thus far, NASA has helped the aircraft industry to improve its current and derivative aircraft, and the program offers continued promise that future aircraft will be significantly more fuel efficient.

The original goals of the program were highly optimistic. Several technologies offering significant fuel efficiency opportunities probably will not be ready for several years after 1985, and estimated costs have risen significantly.

There is a need for

- NASA to adopt a standard format for concisely and consistently reporting the status of major aeronautical programs to the Congress and
- an aeronautics policy which would clarify its role.

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COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-199365

To the President of the Senate and the
Speaker of the House of Representatives

This is our report on a major effort by the National Aeronautics and Space Administration to provide new technology for improving aircraft fuel efficiency. It examines the status of the program, 5 years into a 10-year planned effort, and discusses why the agency should improve its reporting to the Congress on major aeronautical programs and renew efforts with the Office of Science and Technology Policy to establish a U.S. aeronautics policy.

This review was made as part of our continuing effort to examine aeronautical research and technology activities and apprise the Congress of the status of major research programs and assist it in exercising its legislative and review functions.

We are sending copies of this report to the Director, Office of Management and Budget; the Administrator, National Aeronautics and Space Administration; the Secretary of Defense; and the Director, Office of Science and Technology Policy.

Elmer B. Staats

Comptroller General
of the United States

COMPTROLLER GENERAL'S REPORT TO THE CONGRESS

A LOOK AT NASA'S AIRCRAFT ENERGY EFFICIENCY PROGRAM

D I G E S T

The Aircraft Energy Efficiency program is a 10-year effort of the National Aeronautics and Space Administration (NASA) to accelerate the development of various aeronautical technologies which could make future transport aircraft up to 50 percent more fuel efficient than today's aircraft. The program, which began in 1976, was originally estimated to cost $670 million and was to be completed by the end of 1985. (See pp. 2 and 6.)

It is a collection of six distinct but interrelated projects, each managed separately--Engine Component Improvement, Energy Efficient Engine, Advanced Turboprop, Energy Efficient Transport, Laminar Flow Control, and Composite Primary Aircraft Structures. (See pp. 3 and 7.)

The program, now in its 5th year of funding, has had some successes in demonstrating technical advances applicable to existing and derivative aircraft. Some of these advances, which include improved engine components, lighter materials for aircraft structures, and wing modifications, moved the industry into earlier applications for realizing potentially significant fuel savings. (See pp. 5, 15, and 34.)

Three of the projects--those with the highest risk and highest potential for fuel savings--will not be completed before the 1987-89 time frame, primarily because of funding constraints, the need to acquire more basic data before proceeding with the technology development, and a special problem concerning possible adverse environmental effects of composite material. Since these three projects--Advanced Turboprop, Laminar Flow Control, and Composite Primary Aircraft Structures--are crucial to the ultimate goal of improving aircraft fuel efficiency, it is difficult to predict whether the program will meet its projected fuel savings. (See pp. 5 to 9, 12, and 15 to 20.)

NASA's internal estimates of program costs total $984 million, over $300 million more than originally estimated. (See p. 5.)

NASA AND DOD COORDINATION

NASA and the Department of Defense (DOD) have established several formal and informal means of coordinating their composite materials and propulsion research activities. This coordination has helped to prevent duplication. Although intended as a formal activity, the DOD/NASA composites interdependency program was never formalized. GAO believes that to ensure its continuity and future benefits, the program should be formalized. (See pp. 20 and 21.)

PROJECT STATUS REPORTS TO THE CONGRESS

Through the existing budget and hearing records, NASA has attempted to inform congressional committees of the status of the program. Such presentations are voluminous and only generally explain the significance of changes. Using a standard format for reporting on the status of this multimillion dollar program and similar future programs that span many years could provide necessary information to track changes in the cost, schedule, and performance requirements originally presented to the Congress. This would provide the Congress with meaningful, consistent, and concise information which would avoid misunderstandings and improve committee preparation for annual hearings. (See pp. 22 to 24.)

NASA'S ROLE IN AERONAUTICS

NASA's role in aeronautics has centered around basic research and technology work which provides the foundation for future advances in aeronautics and which gives rise to focused accelerated development programs such as this fuel efficiency program. NASA has been encouraged to increase emphasis on these focused efforts that have nearer term payoff, while also being encouraged to increase long term, basic research work. Without a significant increase in resources, NASA cannot satisfy both of these demands. There is a need for the development of policy guidance and direction to maintain a balanced aeronautical research and technology program that will be responsive to national needs. (See pp. 25 to 27.)

In 1978 the President's Office of Science and Technology Policy and NASA had begun formulating a policy statement to clearly define NASA's role in aeronautics, but higher priorities forestalled their efforts. A policy statement would provide NASA management with improved guidance for more effective application of its resources to national needs. (See pp. 27 and 28.)

RECOMMENDATIONS

GAO recommends that the NASA Administrator prepare semiannual project status reports for the Aircraft Energy Efficiency program and similar large future aeronautical programs which show original and current estimated costs, schedule, technical characteristics, and reasons for any variances experienced. (See p. 24.)

GAO recommends that the Director of the Office of Science and Technology Policy and the NASA Administrator renew their efforts and propose an aeronautics policy statement to the President and the Congress. This statement should give special attention to the conflicting pressures on NASA to do more basic, long term work and more focused, near term work at the same time and should draw the distinction between NASA's role and industry's role in developing aeronautical technology. (See p. 28.)

GAO recommends that the NASA Administrator and the Secretary of Defense formalize the organization and responsibilities of the two agencies in the composites interdependency program. (See p. 21.)

AGENCY COMMENTS

NASA and the Office of Management and Budget's comments have been included in the report where appropriate and are included in their entirety in appendixes III and V. GAO worked closely with program officials during its review, and their viewpoints have been given complete consideration. The draft report had been closely coordinated with program officials before being sent to NASA for official comment.

NASA and the Office of Management and Budget believed the draft report had a negative tone was overly critical of the program, and did not fully recognize the uncertainties involved. GAO carefully reevaluated its presentation and made appropriate adjustments where it might be construed that the tone was unnecessarily negative or the data misleading. The Office of Management and Budget generally agreed with the GAO recommendation concerning the need for an aeronautics policy statement. That Office and NASA disagreed with the recommendation for semiannual status reports. GAO believes such reports are needed to clearly show the programs' status and progress.

The Office of Science and Technology Policy was asked to comment on the draft report, but GAO had not received its comments at the time the report went into final processing. DOD did not provide written comments, but the DOD cochairman of the Aeronautics Panel of the Aeronautics and Astronautics Coordinating Board agreed with GAO's recommendation.

Contents

ABBREVIATIONS

ACEE	Aircraft Energy Efficiency
ATP	Advanced Turboprop
CPAS	Composite Primary Aircraft Structures
DOD	Department of Defense
ECI	Engine Component Improvement
EEE	Energy Efficient Engine
EET	Energy Efficient Transport
GAO	General Accounting Office
LFC	Laminar Flow Control
NASA	National Aeronautics and Space Administration
OMB	Office of Management and Budget
PSR	project status report
R&D	research and development

GLOSSARY

Turbofan engine	A turbojet engine in which additional propulsive thrust is gained by extending a portion of the compressor blades outside the inner engine case. These extended blades are commonly referred to as the fan. The air accelerated by the fan tips forms a secondary airstream which bypasses the rest of the engine and is either directed overboard or to the exhaust section of the engine. The air which passes through the center of the fan is the primary airstream through the engine itself. The secondary or bypass air is not combusted but does provide additional thrust caused by the propulsive effect imparted to it by the fan. (A turbojet engine is a gas turbine engine relying entirely upon jet thrust to develop propulsive force.)
Turboprop engine	A gas turbine engine with the turbine shaft coupled to the propeller and the compressor. A portion of the net energy drives the propeller.
High-bypass turbofan engine	A turbofan engine incorporating a large fan which increases the amount of air which bypasses the rest of the engine.
Core engine	The core consists of the high-pressure compressor, combustor, and high-pressure turbine.
High spool	The high pressure stages of the compressor and the high pressure stages of the turbine.
Low spool	The low pressure stages of the compressor and the low pressure stages of the turbine.
Nacelle	The structure which encases an engine when installed on an aircraft.
Specific fuel consumption	The weight of the fuel consumed per pound of thrust per hour.

Thermodynamics	The study of heat flow and heat exchange.
Propeller slipstream	The stream of air discharged backward by a rotating propeller.
Supercritical, high-aspect ratio wing	A supercritical wing refers to a thicker, advanced shape which offers less wind resistance than conventional wings. This advanced shape allows the use of "high-aspect ratio" wings, which have a greater ratio of wing span to average wing width than conventional wings. The supercritical, high-aspect ratio wings also have less sweep and offer more lift than conventional wings.
Surface-airstream friction	Wind resistance caused by air rubbing against the airplane surface or skin while in flight.
Winglets	Wing tip extensions which are slanted upward and are nearly perpendicular to the wing.
Basic research and technology	Although there is no generally accepted definition for basic research and technology in aeronautics, it refers to the development of basic knowledge for enabling the growth of new aeronautical products. Basic research and technology activities are long term efforts which are not focused on specific aircraft types or specific end products. Rather, these activities cover research and technology which is exploratory in nature, whose results advance the state of the art in all aeronautical disciplines, and have wide applicability to all types of aircraft.
Composite material	A material formed by imbedding filaments (for example, graphite or boron) in an epoxy (plastic-like) medium.
Derivative aircraft and engines	Variations of existing aircraft and engine models, to be distinguished from all-new aircraft and engine designs.

Rotorcraft	Aircraft that maintain flight through the use of large rotating blades rather than stationary wings. Helicopters are the most familiar type of rotorcraft.

CHAPTER 1

INTRODUCTION

The National Aeronautics and Space Administration (NASA) and its predecessor, the National Advisory Committee for Aeronautics, have been the focal point for aeronautical research and development (R&D) in the United States since 1915. The National Aeronautics and Space Act of 1958, as amended, gives NASA the responsibility for improving the safety and performance of aircraft, conducting long term aeronautical research for peaceful purposes, preserving the role of the United States as a leader in aeronautical science and technology, and ensuring close cooperation with other agencies and other nations in the field of aeronautics.

The objectives of NASA's aeronautics program are to advance aeronautical technology to ensure safer, more economical, efficient, and environmentally acceptable air transportation systems which are responsive to current and projected national needs; to maintain the strong competitive position of the United States in the international aviation marketplace; and to support the military in maintaining the superiority of the Nation's military aircraft.

A major effort in NASA's aeronautics program is the Aircraft Energy Efficiency (ACEE) program. This report examines the status of ACEE, the coordination effectiveness between NASA and the Department of Defense (DOD), the need for periodic reporting to the Congress on efforts such as ACEE, and NASA's role in aeronautical R&D.

The ACEE program accounts for over one-third of NASA's aeronautical budget for fiscal year 1980 and will decrease to 29 percent in fiscal year 1981. NASA's internal cost estimate to complete ACEE was $984 million, excluding personnel costs. Details on ACEE costs and funding for NASA's aeronautical research and technology program are contained in appendix I.

ORIGIN AND CONTENT OF ACEE

In January 1975 NASA was requested by the Senate Committee on Aeronautical and Space Sciences 1/ to develop a program for improving the fuel efficiency of commercial

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1/New title is Committee on Commerce, Science and Transportation.

aircraft. The request referred to the current efforts aimed at achieving NASA's objective of preserving the role of the United States as a leader in aeronautics and specifically highlighted those projects which would enable the U.S. industry to provide a new generation of fuel efficient commercial aircraft. This came at a time following the Middle East oil embargo, when the aviation industry was unable or unwilling to make the kind of intensified investment required to develop, demonstrate, and apply new technology for improved aircraft fuel efficiency. The specific request was that NASA, in consultation with industry, should consider establishing a clearly defined goal of demonstrating the technology necessary to make possible a new generation of fuel efficient aircraft by a stated date. Such aircraft were to have the same general operating characteristics as at present, would meet safety and environmental requirements, would be similar in cost, could be flying in the 1980s, and have a large improvement in fuel efficiency. The program was to be developed in such a fashion that technology transfer was facilitated, and the program plan would specify major milestones and fuel savings percentages and describe the planned efforts and costs.

In response to the committee request, NASA assembled a task force to identify the technological advancement opportunities that could result in improved aircraft fuel efficiency. The task force consisted of Government scientists and engineers from NASA, the Department of Transportation, the Federal Aviation Administration, and DOD. Also, the task force worked with the major engine and aircraft manufacturers, major airlines, and several advisory boards and councils.

The task force prepared a report outlining a technical plan for improving aircraft fuel efficiency, the estimated resources required, and the expected benefits. The plan was submitted to the committee in special hearings conducted in September, October, and November 1975. The committee endorsed the plan and recommended that NASA implement the program described in the plan. NASA initiated the program in fiscal year 1976.

Basically, NASA's task force report identified six aeronautical technology elements involving propulsion, aerodynamics, and structures where accelerated and expanded Government R&D efforts along with industry efforts could provide the technology to improve fuel efficiency by up to 50 percent. The total NASA costs over 10 years were estimated at $670 million including adjustments for inflation. The report projected potential savings of about 2 billion barrels of fuel (84 billion gallons) for U.S. airlines from

1980 to 2005. These savings represented the difference between an estimated 12.8 billion barrels of fuel that would be used with available technology and 10.9 billion barrels of fuel to be used with the improved technology. The report cited other benefits such as investing in U.S. technology development rather than purchasing foreign oil, continuing air travel at a reasonable cost, and continuing U.S. dominance of the world transport aircraft market.

NASA's approach for improving fuel efficiency involves expanding or accelerating ongoing research, initiating new efforts on known potential technological improvements, and accomplishing most of this effort through contracts with major aircraft and engine manufacturers. The research goal for each project in the program is to demonstrate a state of technology readiness (for example, the point at which industry could incorporate the improvements into aircraft design). The planned efforts were outlined by priority and were generally to be conducted in phases. Funding requests were to be part of the annual budget process and subject to overall budget priorities.

The six projects in ACEE are Engine Component Improvement (ECI), Energy Efficient Engine (EEE), Advanced Turboprop (ATP), Energy Efficient Transport (EET), Laminar Flow Control (LFC), and Composite Primary Aircraft Structures (CPAS).

NASA MANAGEMENT RESPONSIBILITY

NASA's Office of Aeronautics and Space Technology is responsible for the overall management of the ACEE program, which includes approving plans, allocating funds, and providing technical and program direction. The Langley Research Center is responsible for program implementation of three ACEE projects: EET, LFC, and CPAS. The Lewis Research Center is responsible for program implementation of the other three ACEE projects: ECI, EEE, and ATP.

SCOPE OF REVIEW

The review was performed at NASA Headquarters, Washington, D.C.; Langley Research Center, Hampton, Virginia; Lewis Research Center, Cleveland, Ohio; and Wright-Patterson Air Force Base, Dayton, Ohio. We also visited and held discussions with officials of the three major airframe companies and two major jet engine companies.

We reviewed the data compiled by NASA in developing the ACEE program; analyzed the task force report; reviewed and analyzed the status of the program as to cost, schedule, and performance; discussed the program's status with Lewis and Langley Research Centers and NASA Headquarter officials; reviewed related engine and composite material research efforts in the Air Force, and interviewed Air Force officials. Our review work was essentially completed as of July 1979.

Our objective was to review and report on the status of the ACEE program, with particular emphasis on (1) the impact of the program on NASA's aeronautical research and technology base, (2) the likelihood that the technology being developed will be applied on derivative or new aircraft, and (3) the effectiveness of coordination between NASA and DOD in the composite materials and propulsion research areas.

The program's progress was measured against the original goals in the task force report because it provided a common starting point, and the program received its congressional endorsement based on the plan set out in the report. However, chapter 2 and appendix II explain the revisions to the task force plan which were made as the phases of each project progressed.

We coordinated this review with the Office of Technology Assessment, since that Office was involved in an assessment entitled "Impact of Advanced Air Transport Technology."

CHAPTER 2

PROGRAM STATUS

The ACEE program, which is in its 5th funding year, has experienced some technological successes which will be applied on new and derivative airplanes built in the early 1980s. Examples are improved engine components, lighter airframe components, and improved wings.

It is unlikely that ACEE will reach its fuel savings goals within the estimated time frame and at the original estimated costs. As NASA officials proceeded with the program, they gained better information which caused them to restructure three projects with high fuel savings potential. As a result, technology readiness dates have slipped several years on these projects. NASA's internal cost estimates for the entire program total $984 million, over $300 million more than originally estimated. 1/

PROGRAM ASSUMPTIONS AND APPROACH

The approach laid out in the task force report for advancing fuel conservation technology relies on several key assumptions about the successful development and application of the ACEE technologies. These assumptions, together with the intangible results of the program, make it difficult to assess how well ACEE is progressing and whether its fuel savings goal will be met in its entirety.

The ACEE goal of providing by the end of 1985 the technology necessary to improve aircraft fuel efficiency by up to 50 percent was arrived at by comparing aircraft designs of the 1990s with aircraft of the 1970s. These savings can only be achieved with aircraft designs which incorporate all the appropriate technology advances from the six ACEE projects, assuming they are completely successful and there is 100-percent application. Further, the decisions on whether to apply new technology depend on market demand for new aircraft, Government regulations, financial condition of the aviation industry, foreign competition, and the length of time required to incorporate the technology on new aircraft.

1/In commenting on a draft of this report, NASA and OMB said that it had a negative tone and was overly critical. We carefully evaluated its presentation and made appropriate adjustments where it might be construed that the tone was unnecessarily negative or the data misleading.

The ACEE program was not intended to develop more fuel efficient aircraft. Rather, ACEE will advance fuel conservation technology to the point of technology readiness (the point at which industry could incorporate the various technical advances in their design of new and derivative aircraft). For example, technology readiness for an engine component may be achieved after obtaining successful results through ground testing. On the other hand, the advanced turboprop may not be technologically ready until it has been placed on an aircraft and flight tested. After NASA has developed the various ACEE technologies to a state of technology readiness, industry will require up to 8 years to apply the technology to new aircraft, depending on development costs, risks, and technical complexity.

The NASA approach to ACEE made use of certain techniques that it believes enhances the probability of success and promotes transfer of technology throughout the industry. One technique was the use of parallel contracts with the major manufacturers in the particular industry. For example, NASA awarded contracts to both manufacturers of large commercial turbofan engines on the ECI and EEE projects. NASA used this technique to assure that the broadest range of technology improvements is considered, which enhances the probability of meeting program objectives. Further, NASA believes the use of parallel contracts will maintain a viable, strong, and competitive high technology industry and will serve to retain the U.S. manufacturers in a dominant position in the world commercial market.

Another technique was to involve the airlines even though they do not directly develop the technology. The airlines provided NASA management with input on airline needs, future air transportation markets, views on the technology being developed based on past experiences, and factors they consider when determining whether advanced technology should be incorporated into commercial aircraft. NASA believes that involvement by all parties in the aviation industry enables project management to recognize and address the need of the total industry which should enhance the probability that the technology developed will eventually be incorporated into future aircraft.

Another technique was cost sharing by manufacturers. On the ACEE contracts in effect at the time of our review, NASA required contractors to contribute 10 percent of costs on efforts with obvious commercial payoff such as ECI, EET, and EEE. Since NASA has the authority to require cost sharing of 50 percent or more, it is possible for NASA to free up some of its own resources in the future by requiring contractors to share more than 10 percent of the costs on efforts with commercial payoff. Increased sharing would depend upon financial conditions in the industry and NASA's ability to negotiate a higher cost-sharing rate. 1/

ACEE goals and benefits will be realized to the extent that all six technology projects are successful, the technologies are further developed by industry, and new aircraft are designed around these technologies.

STATUS OF ACEE

The ACEE program is really a collection of six distinct but interrelated projects, each managed separately. Each of the six concerns a different technology area and involves a different level of NASA involvement because of the differences in the time and money needed to reach a state of technology readiness. NASA's work under ACEE ranges from basic aerodynamics work for aircraft of the 1990s to product improvement of existing engines.

Although they are interrelated, each project has distinct cost, schedule, and performance goals. A concise picture of the status of the total ACEE program is shown on pages 8 and 9. The total program cost estimate of $984 million shown in the chart is a combination of approved budget estimates and internal NASA estimates. It represents a best estimate of program costs at the time of our review. A brief summary of the status of the six individual projects follows. Details are contained in appendix II.

1/In our draft report, we suggested that the sharing percentage be increased. Based on NASA's and OMB's comments, we believe the suggestion is not necessary. (See apps. III and V.)

ACEE Status Chart--Part 1 Costs

July 1979

	Total estimates			Estimates and approved funds through FY 1979		
	Task force plan	Detailed project plans	Estimates as of July 1979	Task force plan through FY 1979	Detailed project plans through FY 1979	Approved funds through FY 1979
	(millions)					
ECI	$ 40	$ 40	$ 39.5	$ 33	$ 33	$ 33.4
EEE	175	198.5	199.7	85	70.7	70.8
ATP	125	a/125	a/125	22	a/22	5.2
EET	50	75	85.7	25	41	35.3
LFC	100	100	b/227	20	20	11.3
CPAS	180	c/164.5	b/308	107	107.7	65.7
Total	d/$670	$703.0	d/$984.9	$292	$294.4	$221.7

a/A project plan was being prepared at the time of our review. In absence of a project plan, we used the task force estimate.

b/See pages 54 and 60 for details explaining these estimates.

c/This estimate reflects a significantly restructured effort and excludes development of a fuselage structure which was included in the task force estimate at $70 million.

d/Adjusted for inflation, except for portions of the July estimates for LFC and CPAS as explained on pages 54 and 60.

ACEE Status Chart - Part 2 Schedule and Performance

July 1979

	Technology readiness		Fuel savings (percent)		Planned applications		Proposed technology concepts	Project changes	Accomplishments
	Org. est.	Current est.	Org. est.	Current est.	Time	Range			
ECI	1981	1981	5	1.8-5.6	1982 1982 1983 1985	Short Med. Long Med.	Improved engine components and performance retention	None	Demonstrated savings on selected components Mfgers committed selected components to production
EEE	1983	1983	10-15	14.5	1990 1995	Long Med.	New engine design with new components	Deleted experimental engine phase Added more component development and testing	Selected preliminary new engine designs
ATP	1985	1987-88	15-20	15-20	1988 1995	Short Med.	Quiet, efficient performance at Mach .8 at 30,000 ft.	Delayed implementation due to insufficient data base	Efficiency demonstrated in model testing
EET	1983	1983	10-20	10-20	1983 1985 1988 1990 1995	Long Med. Short Long Med.	New aircraft design incorporating supercritical wings and active controls	Increased active controls effort	Demonstrated some savings through wing modifications
LFC	1985	1989	20-40	20-40	1990	Long	Develop system for smoother airflow over wings and tails	Completion date extended because of insufficient data base	Evaluated cleaning systems Identified wing characteristics and suction requirements
CPAS	1983	1987-89	10-15	10-15	1985 1988 1990 1995	Med. Short Long Med.	Reduce weight by extensive use of new composite materials, particularly fuselage and wing	Deleted efforts specifically related to wing and fuselage Reduced manufacturing technology efforts Added efforts on secondary components	Demonstrated potential significant weight reduction by using composites Use of some composites in new aircraft design Current fuel savings estimate at 1.5% through use of secondary composite components

ECI

The ECI project primarily involves improving the performance of selected components on General Electric and Pratt & Whitney aircraft engines. It also involves a diagnostics effort to identify areas where an engine deteriorates and the causes thereof. The original plan envisioned costs of $40 million, a technology readiness date of 1981, fuel savings of 5 percent, and application of the technology beginning in 1982.

To date, several components have been improved and are being incorporated into production for current engines. The predicted fuel savings now range from 1.8 percent to 5.6 percent, depending upon the specific engine involved and the factors included in computing the percentages. High development risk, questionable retrofit potential, and time and money constraints prevented the selection of enough components to reach an average fuel savings of 5 percent. The two major engine manufacturers have nevertheless projected future engine models with a 6-percent reduction in fuel consumption, a portion of which is attributable to this project. NASA also contends that its efforts stimulated fuel savings competition between the two major manufacturers.

When we completed our review, NASA estimated the project cost would be $39.5 million. The ultimate cost to the Government will be less because General Electric and Pratt & Whitney will pay NASA a percentage of their revenue from sales of improved components.

For details on the ECI project, see page 33.

EEE

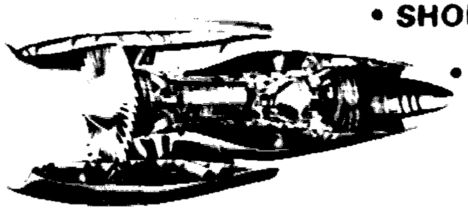
The EEE project planned to make future engines more fuel efficient by increasing the engine bypass and pressure ratios and operating temperatures, improving component efficiencies, and reducing engine weight. It was envisioned that the costs would approximate $175 million, the technology readiness date would be 1983 for achieving the 10- to 15-percent reduction in fuel usage, and the application of the technology could begin in 1990.

NASA's projections indicate that the technology being developed will be sufficient to demonstrate the feasibility of producing an engine capable of a 14.5-percent reduction in fuel usage and meet the other technical goals such as emission standards. The technology readiness date was still firm for 1983 at the completion of our review.

ENGINE COMPONENT IMPROVEMENT

PERFORMANCE IMPROVEMENT

CF6

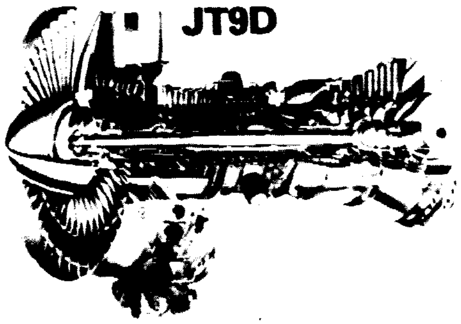


- SHORTENED CORE NOZZLE
- IMPROVED TURBINE
- NEW FRONT MOUNT
- NEW FAN

JT8D

- IMPROVED COMPRESSOR/TURBINE
- REDUCED NACELLE DRAG

JT9D



- NEW FAN
- IMPROVED CLEARANCE CONTROL
- HIGH TEMPERATURE SEALS/COATINGS

- HISTORICAL DATA ANALYSIS
- GROUND/FLIGHT TESTS
- COMPONENT SENSITIVITY ANALYSES
- DESIGN TOOLS/ANALYTICAL MODELS

ENGINE DIAGNOSTICS

Source NASA

As of July 1979, NASA estimated the project would cost $199.7 million, or about $25 million more than the task force estimate. The cost increase is primarily attributed to a change in the approach for achieving technology readiness. The revised plan provided for more extensive use of the two major engine manufacturers and a change in the method of testing the research products.

For details on the EEE project, see page 39.

ATP

The ATP project involves designing and developing propellers capable of quiet and efficient operation when installed in commercial aircraft operating at 540 miles per hour and above 30,000 feet. The original plan envisioned costs of $125 million, a technology readiness date of 1985, fuel savings of 15 to 20 percent over turbofan engines employing the same levels of engine core technology, and application of the technology beginning in 1988.

The project is about 3 years behind schedule, due primarily to a delayed start because NASA decided to demonstrate the feasibility of achieving the desired propeller efficiency before requesting ACEE funds. The initial potential application date of 1988 probably will be missed and the second potential application date of 1995 still seems uncertain. However, its use has gained support since the task force report was published.

NASA was preparing a detailed project plan at the completion of our review which will include a revised cost estimate. While this plan had not been completed, NASA officials believe the original estimate of $125 million may still be reasonable. The Office of Management and Budget (OMB) approved funding the second phase beginning in fiscal year 1981. OMB had refused funding for this phase in the 1980 budget because it was not approving any new starts.

For details on the ATP project, see page 43.

EET

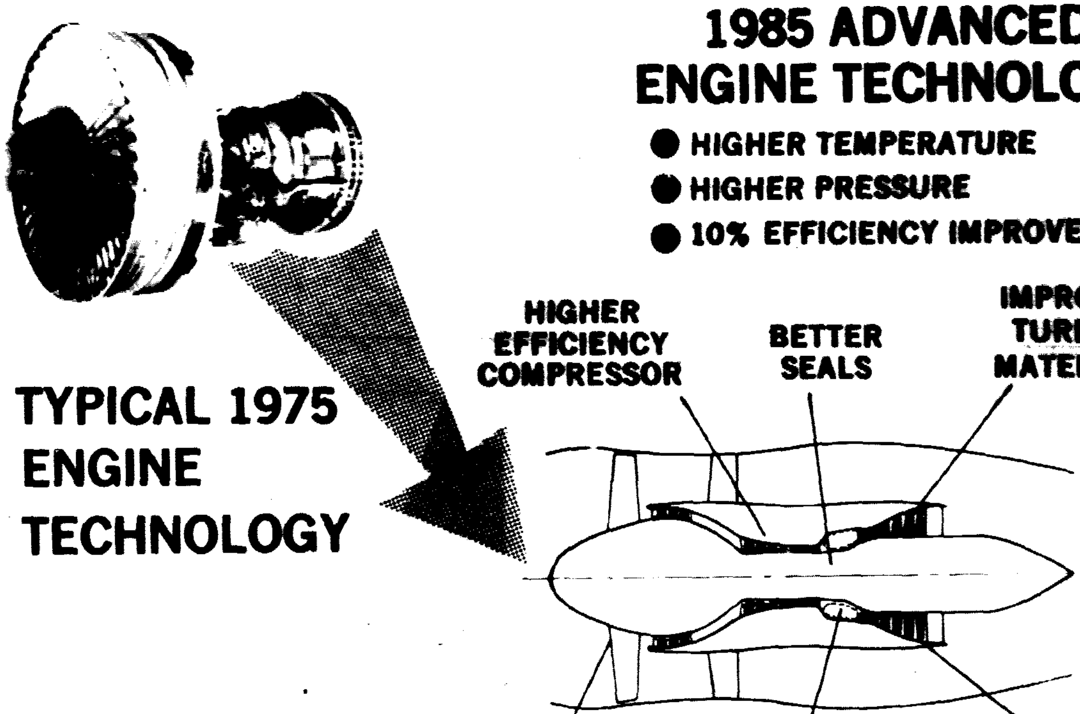
The EET project involves demonstrating new aircraft designs using advanced wings, improved integration between engines and airframes, and active (automatic) flight controls. NASA estimated that this technology would provide 10- to 20-percent fuel savings and that technology readiness would be achieved in 1983 at a cost of $50 million. Newly designed aircraft incorporating most of these advances were expected to be in service by 1988.

ENERGY EFFICIENT ENGINE

1985 ADVANCED ENGINE TECHNOLOGY

- HIGHER TEMPERATURE
- HIGHER PRESSURE
- 10% EFFICIENCY IMPROVEMENT

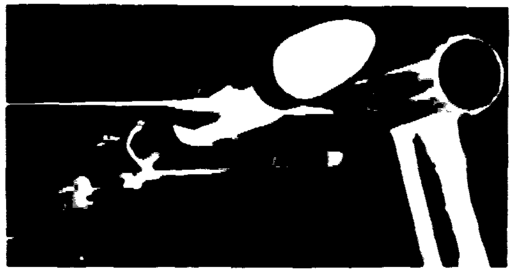
TYPICAL 1975 ENGINE TECHNOLOGY



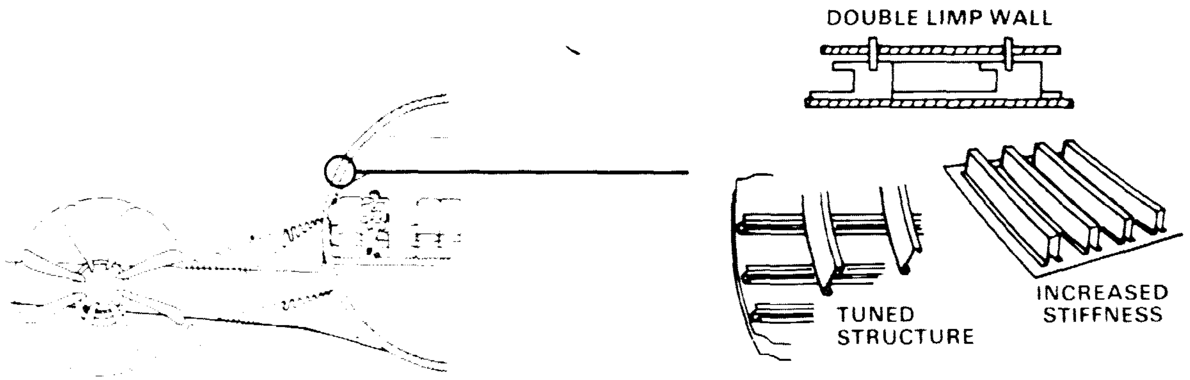
Source NASA

ADVANCED TURBOPROP

• AERODYNAMICS, ACOUSTICS, STRUCTURES



• INTERFERENCE DRAG



• FUSELAGE NOISE ATTENUATION

Source NASA

The project is scheduled for completion by 1983, and the advances in supercritical aerodynamics and active controls have been identified and verified which, if incorporated in newly designed aircraft, could achieve the estimated fuel savings. Also, one airframe manufacturer already has incorporated wing tip extensions with limited active controls on derivative production models. These derivatives are being sold with a guaranteed 3 percent increased fuel efficiency.

Unlike the other ACEE projects, these concepts are not being developed in parallel by the major aircraft manufacturers. NASA maintains that such parallel development is not necessary in this case because the technology is relatively easy to transfer. Since only one of the three major aircraft manufacturers is working on the high aspect-ratio, supercritical wing, which accounts for most of the estimated fuel savings, we are uncertain whether the other two manufacturers will be in as good a position to maximize the benefits of supercritical aerodynamics.

At the time of our review, the project cost estimate was $85.7 million. The increase over the original estimate is attributed to incorporating ongoing work into the project and adding active controls work.

For details on the EET project, see page 47.

LFC

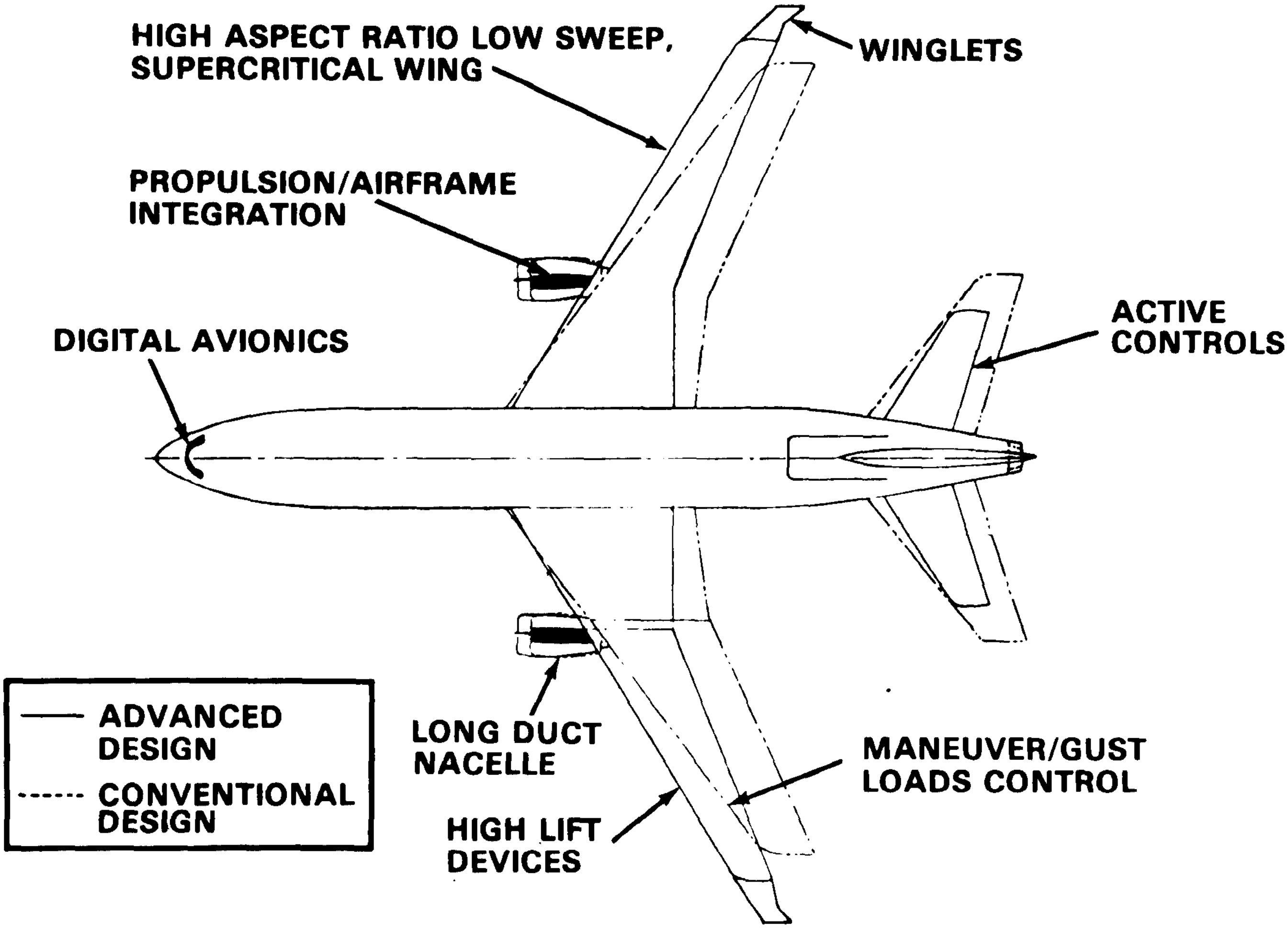
The LFC project involves improving the flow of air over airplane surfaces by developing and demonstrating a practical, reliable, and maintainable suction system that reduces the surface to airstream friction. The plan estimated a cost of $100 million to demonstrate this system by 1985. The fuel savings were estimated to be 20 to 40 percent on aircraft expected to be in service by 1990. However, a LFC system is only practical for long range aircraft, and maximum fuel savings will occur only on flights of over 5,000 miles.

At the time of our review, the project was approximately 4 years behind schedule because it was restructured to allow more time and effort on phase I wing model tests and other tests later on in the project. With the completion of the project still 10 years away, it is difficult to determine how much closer NASA is to developing a practical LFC system which will enable 20 to 40 percent fuel savings to be achieved.

The estimated costs were $227 million at the time of our review. This estimate includes future phases which have not been officially approved by NASA nor submitted to

ENERGY EFFICIENT TRANSPORT

ADVANCED TECHNOLOGY FEATURES



Source NASA

OMB. This anticipated cost increase of $127 million is due to restructuring the program to allow more time to conduct a broader scope of activities.

For details on the LFC project, see page 49.

CPAS

The CPAS project basically involves substituting a lighter weight material which if used in the wing, fuselage, and tail, could reduce aircraft weight by 25 percent and fuel usage by 10 to 15 percent. It was planned to spend $180 million to design, build, fly, and gather manufacturing experience on the primary aircraft structures. The technology readiness date was 1983, with extensive use anticipated on newly designed airplanes which could be introduced in 1990.

NASA has deferred efforts on the composite wing and fuselage, which constitute the major share of potential weight and fuel savings. As a result, the project as planned at the time of our review will offer potential fuel savings of at best 1.5 percent. NASA estimates that if it can obtain additional funds for the proposed new fuselage and wing efforts, technology readiness may be possible in the 1987-89 time frame. There have been successes in the composites area since each of the three major airframe manufacturers is applying some composites to its aircraft structures.

The fuselage, wing, and some inservice flight experience were deferred primarily because

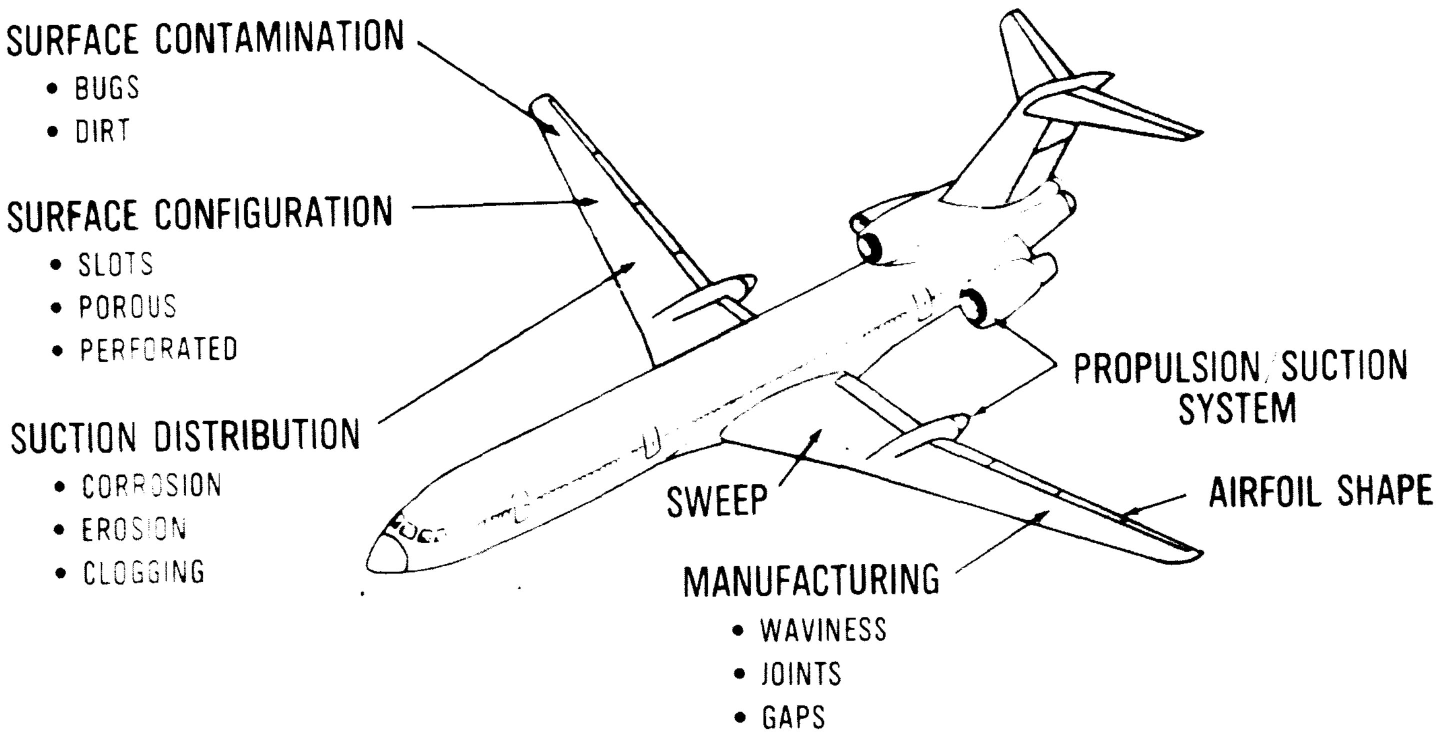
--the costs and magnitude of the technical efforts necessary to proceed with the development of large primary structures were underestimated and

--the potentially hazardous effects of graphite composites on the environment needed further research.

The project was reduced in scope due to the aforementioned reasons, and, thus, the cost estimate was reduced to $110 million. NASA estimates that the proposed new effort will cost about $119 million in addition to the $110 million ongoing program, and it is possible that a follow-on program of $79 million will also be needed. Thus, the total estimate ranges from $229 million to $308 million. The revised estimate had not been officially approved by NASA or OMB at the time of our review.

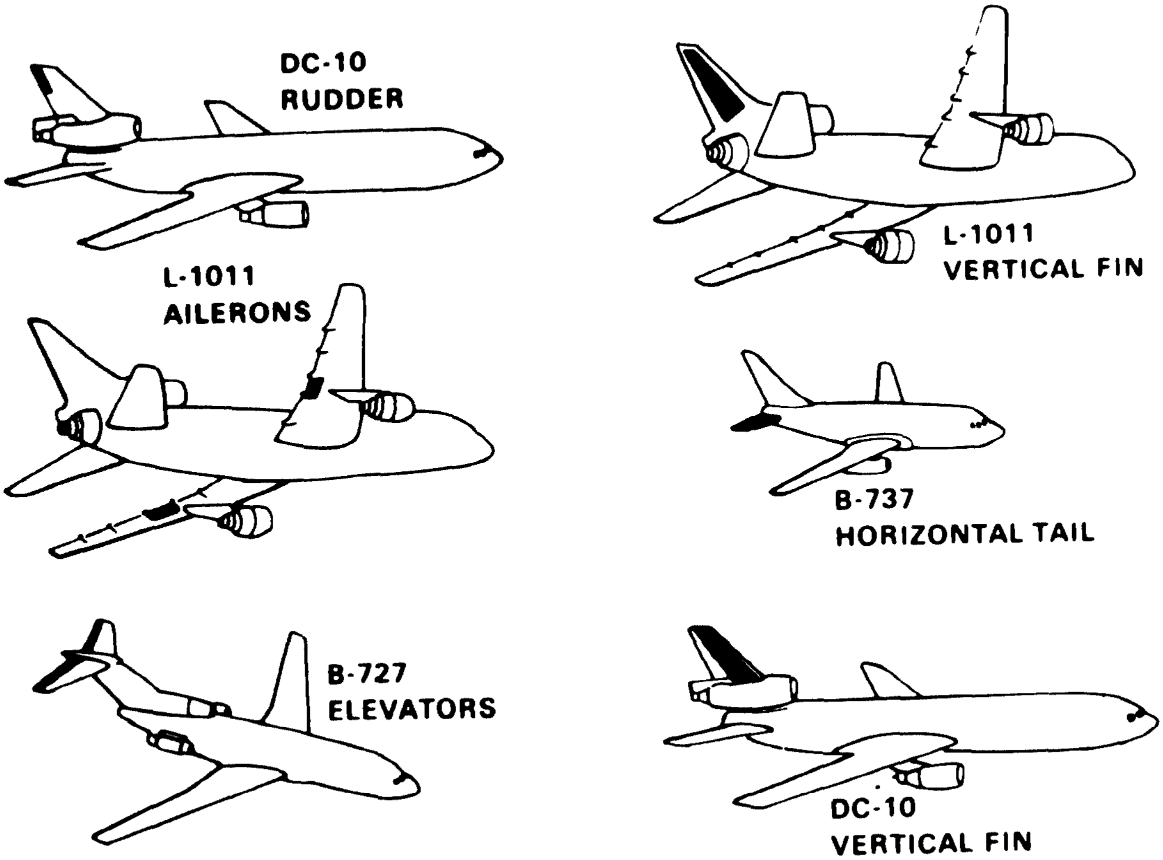
For details on the CPAS project, see page 54.

LAMINAR FLOW CONTROL



Source NASA

COMPOSITE PRIMARY AIRCRAFT STRUCTURES



Source NASA

Conclusions

The status of ACEE was determined by evaluating the reported progress made on the individual projects in relation to the objectives established in the task force report. With the exception of the ECI project, all the ACEE projects have identified technologies with the potential to meet the performance goals for reduced fuel consumption. It is unlikely, however, that all the technologies being developed will meet the technology readiness target dates. 1/

Another complicating factor is that there is no assurance that the Administration and the Congress will provide the increased funds necessary to develop the technology on three high risk ACEE projects. These three projects--ATP, LFC, CPAS--are big payoff projects and, therefore, are crucial to the ultimate goal of improving aircraft fuel efficiency. The cumulative effect of missed technology readiness dates, assumptions, and funding uncertainties makes it difficult to predict whether ACEE will meet its projected fuel savings. The application of this technology in any new aircraft is governed by factors such as market demand, Government regulations, financial condition of the aviation industry, foreign competition, and the length of time needed to incorporate the technology.

OPPORTUNITY FOR IMPROVING COORDINATION

Congressional committees have expressed concern about coordination between NASA and DOD on similar research programs. The ACEE program provided us an opportunity to determine how well NASA and DOD coordinate research activities. Accordingly, we looked at the coordination procedures pertaining to the composite materials and propulsion aspects of ACEE, which represented the areas most likely experiencing similar efforts. NASA and DOD have established coordination procedures to prevent duplication and improve the use of available resources in their composite materials and propulsion programs. Because of these coordination activities and the differences in aircraft operational requirements, the composite materials and propulsion aspects of ACEE were not unnecessarily duplicating DOD efforts.

1/In our draft report, we proposed that, in future efforts to accelerate new technology, NASA inform the Congress of the implications of any slippages in these dates. We reconsidered this proposal based on NASA's and OMB's comments and believe it is not necessary. (See apps. III and V.)

The primary focal point for coordinating composite technology development at the working level has been the DOD/NASA composites interdependency program. Participants said that the program has been beneficial in avoiding duplication and hope the program can continue. Although the program has been functioning since 1976, it does not have a formal interagency agreement and a charter outlining specific duties nor have the accomplishments of its annual meetings been promptly recorded. One way to formalize this program could be to include it under the Aeronautics and Astronautics Coordinating Board. The Board is the principal formal coordination group between NASA and DOD. It provides broad policy guidance and is supported by panels such as the Aeronautics Panel. The panels are authorized to establish subpanels to accomplish functions of the panels.

Conclusion and Recommendation

The DOD/NASA composites interdependency program should be formalized to ensure future benefits and to retain continuity. One suggested way is to incorporate this program under the Aeronautics Panel of the Aeronautics and Astronautics Coordinating Board.

We recommend that the NASA Administrator and the Secretary of Defense formalize the organization and responsibilities of the two agencies in the composites interdependency program.

Agency Comments and our Evaluation

DOD chose not to provide us with written comments on our draft report. The DOD cochairman of the Aeronautics Panel of the Aeronautics and Astronautics Coordinating Board, however, agreed with our recommendation, saying such action would help to ensure the programs' benefits and retain continuity. He told us action would soon be taken to implement our recommendation. NASA did not include in its comments on the draft report any reference to formalizing the DOD/NASA composites interdependency program. OMB suggested a clarification of this recommendation, which has been done.

CHAPTER 3

PROJECT STATUS REPORTS TO THE CONGRESS SHOULD BE EXPANDED TO AERONAUTICAL PROJECTS

NASA's present method of informing the Congress about multimillion dollar aeronautical projects lacks conciseness and consistency. A standard format similar to the project status report (PSR), currently used for reporting on space projects, would provide conciseness and consistency and improve congressional visibility of those aeronautical projects which span many years and involve hundreds of millions of dollars. The current budget justifications and hearing materials requesting ACEE funds are quite voluminous and only generally explain potentially significant changes. In our opinion, NASA should include ACEE and similar aeronautical efforts in a standard reporting system.

NASA prepares semiannual PSRs on selected space projects because of a request from the chairman, Subcommittee on Department of Housing and Urban Development-Independent Agencies, Senate Committee on Appropriations. They are patterned after DOD's Selected Acquisition Reports and contain sections on (1) the project's mission, contractors, and NASA's project management components, (2) summary highlights, (3) mission and technical characteristics, (4) scheduled milestones, (5) program acquisition costs, (6) support costs, and (7) other organization involvement. PSRs show original and current estimated costs, schedule changes, and reasons for any variance experienced.

NASA's policy is to prepare PSRs only when requested by congressional sources. NASA believes these reports are an unnecessary burden because they are special and not considered part of the NASA information system.

Aeronautical R&D budget presentations through fiscal year 1980 categorized all requirements into research and technology base, system studies, systems technology programs, and experimental programs. (See p. 31.) Under the experimental programs, only the EEE and CPAS projects were identified. This was the only visible reference to ACEE in the funding section of the budget presentations. The narrative sections discuss the other four projects, but funding requirements are not identified.

The fiscal year 1981 budget was restructured into research and technology base and systems technology programs.

This change eliminated the identification of the funding levels for the EEE and CPAS projects.

NASA provided additional details on ACEE during testimony before the congressional authorization and appropriation subcommittees. This testimony generally concentrated on technical progress, particularly during the annual program review held before the budget cycle. Cost data was generally provided in answer to questions, but this data was not related to the original estimates in the task force report. Changing technology readiness dates were not always clearly identified. Further, even though the ACEE program has experienced changes, NASA testified during the 1980 authorization hearings that "In the overall ACEE program plan, which we have been following successfully for three years, FY 1980 is the year of peak activity." Since the only overall documented program plan is the task force report, it is difficult to relate this statement to the status of ACEE as described in chapter 2. A standard reporting format would help describe program changes and allow an easy tracking of such changes.

Also, personnel costs related to ACEE receive no visibility. Without such data, the congressional committees are not being fully informed of the cost to achieve technology readiness for programs like ACEE. Personnel costs applicable to the ACEE program totaled $25 million at the time of our review. Such costs could double before ACEE is completed.

Traditionally, NASA excludes personnel costs from project estimates and reports it provides the Congress, as it believes such costs are relatively fixed, not sensitive to changes in project activity, and reported properly in the authorization and appropriation structure.

In our opinion, NASA should prepare PSRs for aeronautical programs like ACEE and these PSRs should include personnel costs related to the projects.

CONCLUSION

Through the existing budget and hearing records, NASA has attempted to inform congressional committees of the status of ACEE. Such presentations are voluminous and only generally explain potentially significant changes. Using a standard format for reporting on the status of a multimillion dollar, long term program would provide the Congress with meaningful, consistent, and concise information which would improve committee preparation for annual hearings. Such reports would provide necessary information to track changes in the cost, schedule, and performance requirements originally presented to the Congress.

AGENCY COMMENTS AND OUR EVALUATION

NASA and OMB questioned the value of providing semiannual status reports for technology development programs. NASA stated that limiting this type of reporting to hardware development project activities appears more appropriate.

We believe a standard reporting format similar to PSRs are as appropriate for ACEE-type technology development programs as they are for hardware development projects. The ACEE program and each of the six projects have goals and milestones and involve expending hundreds of millions of dollars over an extended period of time. Using a standard format similar to the PSR system for programs like ACEE would be of value because the Congress would be provided with consistent and concise information regarding the program's status.

RECOMMENDATION

We recommend that the Administrator of NASA prepare semiannual PSRs for ACEE and similar large future aeronautical programs which show original and current estimated costs, schedule, technical characteristics, and reasons for any variances experienced.

CHAPTER 4

NASA'S ROLE IN

AERONAUTICS NEEDS DEFINITION

NASA's role in aeronautics has centered around basic research and technology work which provides the foundation for future advances in aeronautics and gives rise to focused accelerated development programs such as ACEE. NASA has been encouraged to increase emphasis on these focused efforts that have nearer term payoff, while also being encouraged to increase long term basic research work. Without a significant increase in resources, NASA cannot satisfy both of these demands. There is a need for the development of policy guidance and direction to maintain a balanced aeronautical research and technology program that will be responsive to national needs.

NASA'S ROLE IN AERONAUTICS

Since the early 1900s, NASA and its predecessor, the National Advisory Committee for Aeronautics, have been the focal point for advancing aeronautics in the United States. NASA's basic research and technology work provides the technical foundation from which focused efforts such as ACEE arise. According to NASA, since this basic work is the underpinning of all future aeronautical advances, it is the most important element of the aeronautics program. While NASA and DOD share the responsibility for conducting basic aeronautical research and technology, DOD's efforts are focused on weapons-oriented combat aircraft. This means that both DOD and industry depend more on NASA for basic, long term aeronautical research and technology. To meet these increasing demands, experts from industry, DOD, universities, and NASA have stated that NASA needs to increase its basic aeronautical research and technology efforts.

Experts encourage NASA to do more basic, long term work

Experts from industry, DOD, and universities have encouraged NASA to do more basic, long term work, whose results would have much broader application than what nearer term projects provide. NASA has recognized that more basic work could be done. Several studies of the issue have been made. Two of these studies, conducted in-house by NASA personnel, concluded that NASA should increase its far term, basic research and technology efforts. A third study, conducted by the Aeronautics and Space Engineering Board of the National Research Council, reported that in several instances the manpower and dollar resources devoted to NASA's basic research and technology should be increased. The study also recommended that NASA's current research and technology base effort should concentrate more on fundamentals and should be less hardware oriented.

DOD has testified before the Congress that although they support the ACEE program, it has made NASA's aeronautics program biased towards fuel efficiency. At the same time, DOD identified some basic aerodynamics and helicopter work which needed to be done by NASA. The basic work conducted by NASA and DOD was seen as increasingly valuable since industry has been forced to concentrate on short term efforts. DOD stated that emphasizing the near term work at the expense of the longer term, more basic work tends to "mortgage our future for the present."

When the ACEE program was being advocated, NASA and industry cited it as an appropriate effort for the Government to undertake. Reasons for this included the burden on industry caused by increased foreign competition which is heavily subsidized and the high risk and costs associated with advanced aeronautical technology. In two ACEE projects NASA is funding product improvement which in the past has been funded by industry. Also, NASA is developing the technology which will enable industry to initiate the development of advanced aircraft engines, a burden traditionally borne by DOD.

NASA's advisory committees have stated numerous times that NASA should strengthen its fundamental aeronautics work. The committees have also strongly recommended that NASA devote more resources to basic research and technology since it is this work which underlies any advances in aeronautics. NASA has recognized the need to increase basic research and technology activities, but has met with limited success in obtaining the additional resources partly because it is harder to justify resources for longer term, fundamental efforts than for highly visible efforts that can show near term results.

In October 1979 NASA proposed to the House Science and Technology Committee several large programs to follow ACEE. Although NASA did identify several focused efforts similar to ACEE, it also cited opportunities to initiate new thrusts in fundamental technology areas in propulsion, aviation safety, avionics, and human factors.

RECENT ATTEMPTS TO PROVIDE POLICY GUIDANCE

Aeronautics experts have recognized the difficulty NASA has in allocating its aeronautics program resources among near term and far term needs, given budget limitations. Although much of the difficulty is attributed to insufficient resources, experts have cited a lack of policy guidance to bridge the gap between the goals set forth in the National Aeronautics and Space Act of 1958 and NASA's program objectives as contributing to the confusion over NASA's role in aeronautics. According to testimony before the House Science and Technology Subcommittee on Transportation, Aviation, and Weather, the Aeronautics and Space Engineering Board was concerned about this issue and believed that a statement from the Administration was needed, in view of limitations on the available budget and the serious need for resources in so many areas, which would either confirm or redefine NASA's role and goals in aeronautics. Some attempts have been made along the lines of clarifying the Government's role in research and technology, but they have had limited success.

In 1978 the President's Office of Science and Technology Policy, with NASA's assistance, began work on establishing a policy in aeronautics. However, the effort has been given a low priority and, at the time of our review, was being forestalled due to higher priority tasks.

In January 1979 Senate Bill S. 212 was introduced to establish a national space and aeronautics policy; however, it had not been enacted as of May 1980. The aeronautics portion of the bill dealt mainly with what program areas should be covered in aeronautics.

Also in 1979 the President set forth Federal policy in science and technology in a message to the Congress. This message stated that the Federal Government undertakes R&D where there is a national need to accelerate the rate of development of new technologies in the private sector, but that industry should finance activities having near term, commercial payoff. The policy also stated that the Government should do more basic research, an area in which it has a dominant role. Although this policy statement brings us closer to clearly defining NASA's role in aeronautics, it never refers to aeronautics, only to R&D in general.

CONCLUSIONS, AGENCY COMMENTS, OUR EVALUATIONS, AND RECOMMENDATION

We recognize the need for NASA to place increased emphasis on more near term efforts due to declines in military applications, the burden on U.S. industry from increased foreign competition, and the need to address urgent national needs such as fuel conservation. We also recognize the need for NASA to reemphasize basic research and technology since it is this work which will foster future advances in aeronautics. Although increasing NASA's resources has often been cited as a solution to the problem of meeting far term and near term needs, we believe that the first step must be the formulation of a policy which clearly defines NASA's role in aeronautics. NASA then should be in a better position to make the most effective use of its resources and better able to allocate any additional resources between far term and near term activities.

We requested written comments from the Director of the Office of Science and Technology Policy and NASA regarding the need for a policy clearly defining NASA's role in aeronautics. The Office of Science and Technology Policy did not respond, and NASA comments made no reference to the need for a policy. However, NASA did maintain that ACEE has near and far term benefits and that long term work is not sacrificed for near term oriented work. OMB generally agreed with our recommendation. (See apps. III and V.)

We believe there is a need for clear policy in this area and recommend that the Director of the Office of Science and Technology Policy and the NASA Administrator renew their efforts and propose an aeronautics policy statement to the President and the Congress. In developing such a statement, other Government agencies such as DOD and the Federal Aviation Administration should participate in its development. The statement should:

--Reaffirm NASA's role in aeronautics, recognizing the increased demands on NASA to do more far term and near term work and assuring that near term work will not be emphasized at the expense of the far term work.

--Bridge the gap between the goals set forth in the National Aeronautics and Space Act of 1958 and the objectives of NASA's aeronautics program.

--Define how far NASA should go in making technology available for industry (for example, drawing the distinction between NASA's role and industry's role specifically addressing such questions as, should NASA fund product improvement and how far should NASA go in the development of new aircraft and new engines.)

NASA'S AERONAUTICS RESEARCH

AND TECHNOLOGY PROGRAM FUNDING

Over recent years, NASA's aeronautics program has grown, but it is still a small part of NASA's R&D budget. For example, the total R&D budget request for fiscal year 1981 was about $4.6 billion and the aeronautics program was about $0.3 billion. A breakout of the aeronautical R&D budget for 1976-81 shows the most recent trends.

Aeronautical R&D Budget
Fiscal Years 1976-81

	Actual					Estimated	
	1976	TQ (note a)	1977	1978	1979	1980	1981 (note b)
	(millions)						
Budget element:							
Research and technology base	$ 85.4	$21.4	$ 90.7	$ 97.8	$109.7	$119.0	$131.1
System studies	3.1	.7	3.0	3.0	3.0	3.2	-
Systems technology programs	43.2	12.3	60.8	75.8	84.7	112.6	159.2
Experimental programs	43.7	9.4	35.6	51.4	66.7	73.5	-
Total	$175.4	$43.8	$190.1	$228.0	$264.1	$308.3	$290.3

a/Transition quarter.

b/Budget structure changed for fiscal year 1981 and reduced to two elements by combining system studies, systems technology programs, and experimental programs.

These amounts do not include support of NASA's aeronautics program from the research and program management (salaries, maintenance, supplies, and so forth) and construction of facilities appropriations. For example, the fiscal year 1981 budget estimates for these appropriations were $207.7 million and $45.3 million, respectively.

A description of the former budget elements is as follows:

--Research and technology base--maintaining a foundation of aeronautical expertise through fundamental research and technology.

--System studies--studying the requirements and impacts of advanced aeronautical systems for planning future efforts.

--Systems technology programs--providing technology demonstration and proof of concept for systems which have matured under basic research and technology.

--Experimental programs--verifying the most promising concepts through testing on large-scale hardware such as an experimental engine or an experimental testbed aircraft.

In addition to the above breakdown of NASA's aeronautics budget, the charts on page 32 show a breakdown of the budget into aeronautical applications and fundamental research and technology. The transport aircraft and advanced propulsion applications include ACEE.

The following chart shows ACEE funding and its relationship to the aeronautics program.

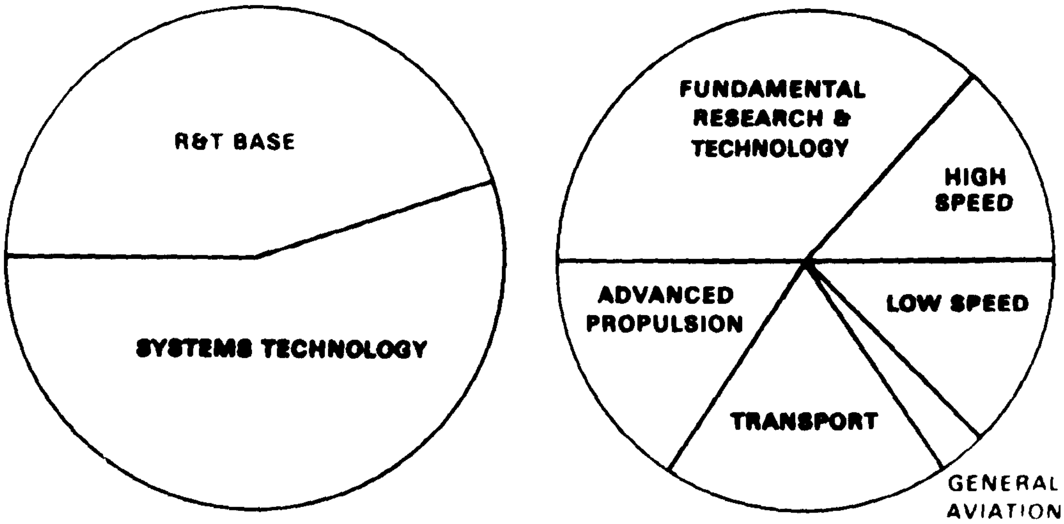
ACEE Funds
Fiscal Years 1976-81

	Actual					Estimated	
	1976	TQ (note a)	1977	1978	1979	1980	1981
	(millions R&D)						
ACEE	$9.5	$4.8	$39.7	$70.2	$97.4	$116.1	$85.0
Percent of aeronautics program	5	11	21	31	37	38	29

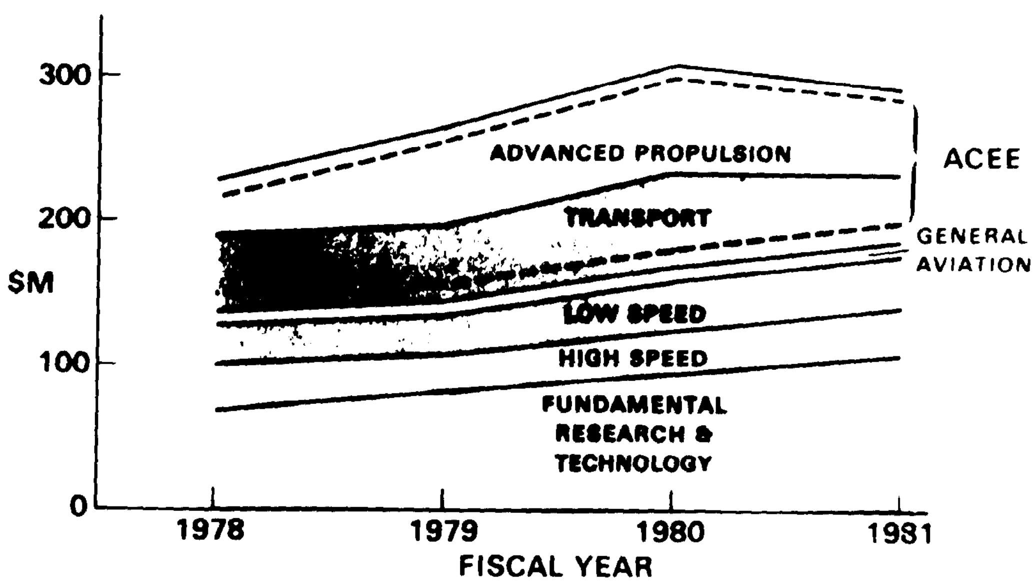
a/Transition quarter.

AERONAUTICS R&T -- FY 1981

TOTAL R&D $290.3M



AERONAUTICS R&T



Source NASA (R&T Research and Technology)

DETAILS ON ACEE PROGRAM

ECI

The ECI project objectives were

--to achieve a 5-percent reduction in fuel consumption on current turbofan commercial transports and

--to identify sources of performance degradation on current high-bypass turbofan engines.

The objectives were to be met by improving the performance of selected engine components and thereby reducing fuel consumption and by diagnostic testing of inservice engines. The improved components were expected to be incorporated into new production of current engines after 1980, and information on the causes of engine performance degradation would be used to aid in the design of future engines.

Performance

The component improvement portion of ECI is producing less than a 5-percent reduction in fuel consumption on current engine models. However, the two major engine manufacturers are offering a 6-percent reduction in fuel consumption on future engine models, a portion of which is attributable to ECI technology. The engine diagnostics segment has identified causes for engine degradation, and certain actions to overcome such deterioration have been recommended.

Component improvement

Several improved components have been completed and are being incorporated into production for current engine models. However, the goal of a 5-percent reduction in fuel consumption will not be met because the predicted fuel savings for components selected for improvement would not average 5 percent on each engine. NASA agrees this portion of the ECI project will not meet the fuel saving goal of 5 percent on current engine models, but it believes the ECI project is contributing significantly to the next new models of turbofan engines which are reported to be 6 percent more fuel efficient than current engines. Engine manufacturers also stated that the ECI project accelerated their own fuel efficiency efforts.

Based on feasibility analyses performed by General Electric and Pratt & Whitney Aircraft, NASA selected 17 components for fuel efficiency improvements. The schedule on page 38 shows the original predicted fuel reduction savings for these components when applied to specific engines would range from 2.1 to 4.6 percent for a total of about 6.8 billion gallons of fuel through the year 2005. We estimated that a 5-percent reduction in fuel consumption for each engine would yield about 11 billion gallons over the same time frame.

The ECI project manager stated that NASA was unable to select enough component improvements to reach an average fuel savings of 5 percent on each engine because some promising component improvements had too much development risk and questionable retrofit potential. He also cited time and money constraints as limiting factors.

As of July 31, 1979, work on five components had been completed--three by General Electric and two by Pratt & Whitney Aircraft. (See sch. on p. 38.) The completed components have been offered to the airlines in the production of current engine models, and one of the Pratt & Whitney Aircraft components and all three General Electric components have been accepted and introduced into production on current engines.

Data available at the time of our review indicated that research and technology efforts are generally meeting the potential fuel reduction savings originally estimated for each engine component. As shown in the schedule on page 38, fuel savings potential has increased on some components and decreased on others. Since development of advanced technology contains a certain degree of risk, it is not unusual for final results to vary from initial predictions. If the revised estimates are borne out through completion, it appears that the potential fuel savings for the specific engines will range from 1.8 to 4.6 percent. Also, as noted in the schedule, Pratt & Whitney Aircraft has indicated that two components may not enter production. If this holds true, the potential fuel savings for the affected engine models may be less. Most of this reduction would be due to the 3.8 aspect ratio fan not entering production. However, it is NASA's position that most of this effort provided added technology for an advanced fan to be used on another proposed engine.

The ECI project manager stated that this portion of ECI will not reduce fuel consumption by 5 percent on each engine, but he believes the agency should be given credit for stimulating fuel savings competition between engine manufacturers. He believes that reduced fuel consumption will result since both domestic manufacturers plan to produce engines in 1982 that will be 6 percent more fuel efficient than current engines. Both manufacturers have stated that some of the 6-percent improvement can be attributed to the ECI project. The General Electric Company estimated that about 4 percent of this improvement could be traced to technology developed in the NASA project. Pratt & Whitney Aircraft did not estimate the impact of the ECI project on their 1982 engine. Both manufacturers stated that as a result of the ECI project, component improvement designed to achieve greater fuel efficiency was accelerated during a period when energy related problems were not given a high priority.

Engine diagnostics

Through the collection and analysis of engine performance deterioration data, the engine manufacturers have isolated areas of an engine where deterioration is occurring and some of the reasons or probable causes for it, such as engine usage, improper maintenance procedures, environmental conditions, and so forth. With this data, the engine manufacturers developed revised maintenance procedures which, if followed, could result in a 1-percent fuel savings for high-bypass turbofan engines. However, the decision on actual use of the revised procedures will be made by the airlines based on the results of cost-benefit analyses.

Several airlines were not optimistic regarding the cost benefits of improved maintenance procedures developed under the ECI engine diagnostics work. Pan American and Eastern Airlines were awarded contracts by NASA to independently assess the performance improvement and engine diagnostics work of the two engine manufacturers. Pan American has found few recommendations as to what steps can be taken to reduce or slow down engine deterioration short of periodic and costly refurbishment of key modules. They reported that even this technique does not of itself improve performance retention, but merely reduces the interval between shop visits so that the average level of deterioration is reduced. According to Pan American, refurbishment is probably inevitable during the service life of an engine, but accomplishment at intervals less than 10,000 hours would be highly uneconomical. A Pan American report dated December 19, 1978, contained the following comment:

> "Program data so far indicates initially relatively large TSFC (thrust specific fuel consumption) losses occur on new engines followed by more gradual but nevertheless persistent deterioration as hours/cycles build on the engines. Furthermore, the data indicates that something less than half the overall deterioration is likely to be recovered (temporarily, at that) during shop visits. In other words, the engines reach deteriorated plateau which can only be maintained at considerable expense and which may not be cost effective."

Eastern Airlines reported that since performance improvement and engine diagnostics are running concurrently, there is little likelihood that this deterioration analysis will significantly impact the performance improvement concepts. For this reason, Eastern believes the engine diagnostics portion of the ECI project may result only in a few maintenance actions which may already be in practice at some airlines. According to Eastern, the engine diagnostics program does not go far enough. They say maintenance attacks engine deterioration by repairing deteriorated parts--it does not necessarily eliminate the cause for the part deteriorating. Eastern favors a program that can respond to the results of engine diagnostics by developing cost-effective fixes designed to eliminate or slow deterioration. In other words, the airline feels that identifying the cause of engine deterioration is a necessary first step, but modifying components to eliminate the deterioration should be the real objective.

In response to the Pan American and Eastern reports, NASA noted that the program was not structured to use information from the engine diagnostics work to design, test, and verify performance retention concepts which could be incorporated into current engines. Nevertheless, they said that in selecting the component improvements, performance retention was one of the considerations. Further, from the very beginning, the main thrust of the diagnostics program was to provide information which could be used to improve maintenance practices on current engines and aid in the design of future engines.

The ECI project manager believed that the 1 percent potential increases in fuel savings resulting from engine diagnostics should be added to the results being achieved under the component improvement portion of ECI. He based this statement on the premise that the goal of 5-percent reduction in fuel consumption relates to the project as a whole, not to just the component improvement segment. NASA officials also said that several airlines have changed maintenance procedures because of NASA's efforts. Further, NASA's reports on ECI include the 1 percent fuel savings in computing the fuel efficiency improvements on the individual engines. Because of this, NASA contends that the potential fuel savings for the specific engines range from 2.7 to 5.6 percent.

Technology readiness

With the exception of three components, NASA will meet the original technology readiness date of 1981. In a few instances, the expected technology readiness dates will be reached before 1981.

The technology readiness dates of the task force and those incorporated into the project plan for component improvements are not the same. The task force expected all component improvements to be completed by 1981, with some completed before that date. The project plan set a 1980-82 time frame for technology readiness. The project manager said the task force milestone date was too optimistic in view of the advanced technological efforts required to meet the improvement goal as well as the amount of funds provided. He said certain concepts had a steep learning curve and technology readiness could not be accomplished within the task force time frame.

Despite the difference in dates between the task force and the project plan, all but three components are scheduled to be completed prior to the task force technology readiness date. Currently, 5 components have been completed, 2 were terminated prior to completion, and 7 of the remaining 10 components are expected to be completed by the end of 1980. Of the three components to be completed after 1980, one is scheduled for completion in February 1981, one in September 1981, and the final one in May 1982.

The difference between the task force and project plan technology readiness dates may affect the estimated fuel savings potential of ECI. We were, however, unable to measure this effect because several components were completed before 1980 and because of uncertainties in projected engine sales.

R&D costs

At the time of our review, NASA estimated the project cost to be $39.5 million as compared to the original estimated cost of $40 million. Because development of some improved components has been terminated, NASA has obligated but unspent funds of about $3 million. NASA plans to use these funds for additional engine diagnostics work to further identify and understand causes of engine performance deterioration.

The ultimate cost to the Government for the ECI project will be much less than the estimated $39.5 million, as the component improvement contracts contain cost recovery clauses. Generally, the clauses stipulate that the contractors will repay NASA's costs on the component improvments as new components are sold. Based on its work to date, General Electric indicates that almost all of the $12.6 million in component improvement funds provided by NASA will be returned to the Government. Cost recovery estimates were not available from the other contractor at the time of our review.

Fuel Savings Estimates for Specific Current Engine Models

Improvements	Estimated percent SFC reduction at cruise (note a)		Original estimated gallons saved	Completed July 1979	Engine applications				
					General Electric		Pratt & Whitney		
	Original	July 1979			CF6-6	CF6-50	JT8D	JT9D-7	JT9D-70/59
			(000,000 omitted)						
General Electric:									
New fan	1.7	1.8	1,056	yes	x	x	-	-	-
New front mount	0.3	0.1	211	yes	x	x	-	-	-
High pressure turbine aerodynamics	1.3	1.3	296	no	x	-	-	-	-
High pressure turbine roundness	0.4	0.4	398	no	-	x	-	-	-
High pressure turbine active clearance control	0.6	0.6	242	no	x	-	-	-	-
Low pressure turbine active clearance control	0.3	0.3	92	no	-	x	-	-	-
Short core nozzle	1.0	0.9	457	yes	-	x	-	-	-
Total			2,752						
Pratt & Whitney:									
Trenched high pressure compressor	0.9	0.9	273	no	-	-	x	-	-
High pressure turbine outer air seal	0.5	0.6	90	b/yes	-	-	x	-	-
High pressure turbine root discharge blade	0.9	0.9	259	no	-	-	x	-	-
3.8 aspect ratio fan	1.3	1.3	720	b/work stopped	-	-	-	x	-
Trenched high pressure compressor	0.3	-	493	terminated	-	-	-	x	x
High pressure turbine active clearance control	0.9	0.7	468	yes	-	-	-	-	x
High pressure turbine thermal barrier coating	0.2	0.2	259	no	-	-	-	x	x
High pressure turbine ceramic outer air seal	0.3	0.3	516	no	-	-	-	x	x
Total			3,078						
Douglas Aircraft:									
DC-9 nacelle drag reduction	0.5	0.5	85	no	-	-	x	-	-
DC-10 reduced engine bleed	0.7	0.8	859	no	x	x	-	-	x
Total			944						
Total			6,774						
SFC percent reduction - original estimate					4.6	4.4	2.8	2.1	2.4
SFC percent reduction - current estimate					4.6	4.3	2.9	1.8	2.0

a/Specific fuel consumption (SFC).

b/Manufacturer indicates component may not enter production on current engine models.

APPENDIX II

EEE

The overall objectives of the EEE project were to develop, evaluate, and demonstrate by 1983 the technology base for an advanced turbofan engine which would achieve

--a 10- to 15-percent reduction in specific fuel consumption,

--a 5-percent reduction in aircraft direct operating cost, and

--a 50-percent reduction in engine deterioration.

Further, the 1981 emission standards and the latest Federal Aviation Administration's noise requirements were to be met.

In essence, the objectives and goals were intended to be met by increasing the bypass ratio, increasing the overall engine pressure ratio and operating temperatures, improving component efficiencies, and reducing engine weight. Turbofan engines using this technology were expected to be ready for use in the early 1990s.

Performance

At the time of our review, projections indicated that the technology being developed under the EEE project would be sufficient to demonstrate the feasibility of producing an advanced turbofan engine capable of achieving the goals. However, this project has 4 years to go, and the many advanced components being developed must be integrated and tested as a system. Until successful integration and testing occurs, the degree of success in meeting the goals will be unknown.

The NASA project plan implementing the task force report provided for two phases: (1) engine definition studies with limited technology work and (2) component development and integration. The engine definition studies were successfully completed under parallel contracts awarded to General Electric and Pratt & Whitney Aircraft. The contractors, through investigation of prior and ongoing NASA projects and other projects and through limited technology efforts, each prepared a preliminary design of a specific engine configuration which they considered most likely to achieve the EEE project goals. There are differences in the engine designs, reflecting the approach and thinking of the individual company on the types and levels of technology involved.

At the time of our review, the EEE project was into the component development and integration phase, which is being accomplished primarily under parallel contracts with General Electric and Pratt & Whitney Aircraft. The primary objectives of this phase are to (1) develop the advanced component technologies and designs needed to achieve higher thermodynamic and propulsion efficiencies, (2) integrate the high-spool components and evaluate their combined performance in core-engine tests, (3) integrate the low-spool components with the high-spool components and evaluate their system performance in a simulated engine test, and (4) design a future flight propulsion system that might use these components and, based on this design, predict the potential fuel conservation benefits.

The parallel contracts emphasize advancement of the component and systems technology to levels required for possible future development of more energy efficient engines. Engine system analysis, design, and integration are continuing to provide refinement to engine design and performance estimates. To the extent necessary, technology studies (analysis, design, and small-scale concept testing) are being performed. Advanced engine components are being designed and developed with performance to be verified in full-scale component testing. In addition, NASA may conduct supporting research and technology in areas that appear critical to the success of the EEE project.

Project primary goals and predicted performance of the engine designs follow. While the projections are aggregate figures for the two engines, they appear reasonable in relation to the individual engine projections.

Project goal	Predicted performance (related to current turbofan engines)
10-15% fuel savings	14.5% reduction in specific fuel consumption 16-20% reduction in fuel burned
At least 5% reduced direct operating cost	7-11% reduction
At least 50% reduced performance deterioration	50% reduction

In addition, projections indicate that the General Electric engine design will meet or exceed the project environmental goals and that the Pratt & Whitney Aircraft preliminary engine design will meet or exceed all but one of the environmental goals. This design is just short of meeting the nitric oxide emission requirement. NASA was optimistic and Pratt & Whitney was highly confident that this goal will be met.

Demonstrating the technology necessary to achieve the project goals will be accomplished at the end of the core/low-spool evaluation, which is 4 years in the future. Consequently, the degree of success for this project will remain unknown until then. In the meantime, NASA and the contractors will continue to make refinements to the engine design and evaluate the impact of such changes on performance estimates. Both contractors and NASA have a high degree of confidence that the project will meet all goals.

Technology readiness

While the technology readiness date is still firm for 1983, it is becoming extremely tight. A few major problems have surfaced, which have delayed the core-engine integration and testing. When considering the amount of effort remaining and the complexities inherent in this project, there is a possibility that the planned 1983 technology readiness date will be delayed. Fortunately, however, any delay up to 1 to 2 years should not affect the potential fuel savings. In fact, if the engine manufacturers use the advanced components for derivatives of current engines rather than just for developing a new engine, the fuel savings could be much greater than anticipated.

Although all major components for both contractors have been defined, thus meeting the 1979 target for completing detailed definition of advanced component configurations, some problems have occurred in development of the components to meet detailed design and testing target dates, resulting in the core-engine tests being delayed. At the time of our review, the problems encountered had not required a change in the core/low-spool testing targets dates. Both contractors were experiencing delays in hardware deliveries from vendors due to the booming sales of commercial aircraft engines. General Electric is more affected because it is more dependent on outside vendors. Also, the long delivery schedules have caused several changes in General Electric's testing schedule. However, these changes have not affected the 1983 technology readiness date because General Electric had planned to complete its work 9 months earlier than envisioned by the task force report and thus has some leeway in its schedule.

While Pratt & Whitney Aircraft is experiencing some hardware fabrication delays, the indicated slippage of

4 months in core-engine tests is mainly due to high-pressure compressor redesign problems. In January 1979 all detailed design effort on the compressor was deferred for 3 months while the contractor determined why the basic compressor design was not achieving its efficiency goal. The compressor was subsequently redesigned, which indicated a 9-month slippage on this major component at the time of our review.

While the problems encountered to date have caused no changes in the technology readiness date and none are currently planned, this date for both contractors is becoming tight. The project manager agreed that additional problems are likely to occur due to the technical complexities and magnitude of the EEE project. As a result, we believe there is a reasonably high probability that the 1983 technology readiness date will slip. Stretching out the technology readiness date into 1984 and even 1985 probably would not adversely affect the potential fuel savings since production of a new energy efficient engine based on EEE technology could still occur in the 1990s as envisioned by the 1975 task force.

The fuel savings from the EEE efforts may be greater than anticipated. According to contractor officials at both General Electric and Pratt & Whitney Aircraft, some of the advanced components developed under this project will probably be incorporated into derivatives of current engines several years before a new energy efficient engine appears on the market. NASA officials stated that their discussions with corporate officials verify this probability. Further, they stated that the probability of this occurring was one of the reasons NASA's project plan provided for more intensive development and design of components than intended by the 1975 task force as discussed more fully under the cost segment of this project.

R&D costs

As of July 1979, NASA estimated that the cost to the Government for the EEE project through completion would total about $200 million as compared to the task force's estimate of $175 million--an increase of $25 million. The increased cost estimate is primarily attributed to NASA's changing its approach for achieving technology readiness from the time of the 1975 task force report until the approval of the detailed project plan in June 1977.

The task force report estimated that new funding authority of $175 million would be needed over 7 years to achieve the objectives of the EEE project, whereas the project plan estimated the cost to be $198.5 million--a difference of $23.5 million. The increase was attributed to changing the approach to achieve the desired technology. Under the task force plan, two contractors were to be used through component development and detailed engine designs and one contractor was to build and test an experimental engine. The project plan provided for using two contractors throughout the project, increasing emphasis on component development, and replacing the experimental engine with core-engine and core/ low-spool testing of the components as a system. A NASA official stated that the advantages of the approach contained in the project plan over that envisioned by the task force were obtaining more technology at a lower risk and retaining the competitive position of both engine companies in the world market.

The project cost estimate as of July 1979 was $199.7 million, or $1.2 million greater than the project plan. According to NASA, this difference is attributed to the actual rate of inflation being higher than originally estimated.

ATP

The ATP project was intended to demonstrate by 1985 the technology required to develop an advanced turboprop engine system that, when installed in commercial airliners cruising at Mach 0.8 (540 mi./hr.) and altitudes above 30,000 feet, will offer

--a 15- to 20-percent savings in fuel usage compared to a turbofan engine employing the same levels of core-engine technology and

--low levels of cabin noise and vibration.

These objectives were to be achieved by designing and developing propellers capable of at least 80-percent efficiency at cruise conditions with reduced propeller source noise and by developing fuselage wall noise attenuation concepts to reduce noise transmission to cabin interiors. This technology was intended to be applied to new transport aircraft designs which could be ready for service in 1988 and beyond.

Performance

It is too early to say whether or not NASA will successfully demonstrate the technology necessary for a turboprop propulsion system to achieve the project objectives.

This project was planned to be accomplished in four phases and with the following tasks:

I. Perform systems studies to determine the potential of turboprop airplanes; identify desirable designs and assess technology deficiencies; advance the understanding of aerodynamics and relative to high-speed, highly loaded propellers, nacelles, and airframe interactions; conduct wind tunnel tests on integrated propeller/airframe combinations.

II. Advance the technology of structures materials and the dynamics of blades for use on these propellers, develop components to be applied in an experimental turboprop based on an existing or modified core engine, and define the configuration of an experimental engine.

III. Integrate engine components and engine core and perform engine ground tests emphasizing propeller thrust, efficiency, noise, dynamics, and vibration.

IV. Assess existing airplanes compatible with the ground-tested propulsion systems and suitable for a flight demonstration, analyze the structural modifications required for the selected demonstration airplane, modify the airplane, install engines, and perform flight tests.

At the time of our review, ATP was in the first phase. NASA has demonstrated a propeller efficiency rate of nearly 80 percent on a small scale (2 ft. in diameter) propeller. The first phase involves analyzing and testing the interaction between the propeller slipstream and airframe; developing propeller noise prediction programs; evaluating preliminary designs for advanced large-scale propellers; and evaluating the interactions of the propellers, nacelle, and wing.

According to the task force report, the subsequent phases would require 7 years to complete. The first phase is scheduled for completion in fiscal year 1980.

Technology readiness

ATP is 3 years behind schedule because NASA initially delayed the planned starting time; and, after it was underway, OMB did not approve the start of the second phase. The slippage in the technology readiness milestone will delay the potential fuel savings anticipated from this project.

Although the task force envisioned the ATP project starting in fiscal year 1976, it did not start until fiscal year 1978--2 years behind schedule. This delay was the result of NASA's wanting to demonstrate the feasibility of the proposed concept before requesting ATP funding. In the period from 1976 to 1978, NASA conducted basic research and technology efforts to design, build, and test several small-scale propellers. After achieving a 77-percent efficiency level with one of the turboprops, NASA believed it had adequately demonstrated the feasibility of the proposed concept and requested and received ATP funding for fiscal year 1978.

Subsequently, OMB refused to fund the second phase for fiscal year 1980 because it was not approving any new starts. The refusal to fund the second phase for fiscal year 1980 will delay ATP by 1 year since the task force plan called for a 1-year overlap of phases I and II.

In total, ATP is about 3 years behind schedule. The project manager stated that these delays have pushed the technology readiness date from 1985 to the 1987-88 time frame. The task force assumed that the turboprop engine would be on some newly designed medium-range commercial aircraft in 1988 and would be placed on additional new aircraft in 1995. In view of the revised 1987-88 technology readiness date, there is little likelihood that a turboprop engine could be inservice by 1988 on a newly designed aircraft.

The possible use of turboprop engines on 1995 commercial aircraft is still uncertain, but it has gained support since the 1975 task force report. First of all, turboprop development is not far enough along for airlines and aircraft manufacturers to make meaningful predictions about when the turboprop engine might be used on an aircraft. Before such a prediction can be made, NASA will need to demonstrate the reliability of the engine and an acceptable level of performance. Secondly, aircraft manufacturers stated that they will need to design and develop a new aircraft to accommodate a turboprop engine, which could take 5 to 7 years. They also stated that integrating a turboprop propulsion system on the wing of an existing aircraft may not be economically feasible.

In this regard, NASA officials said there is no technical basis for believing that a turboprop system could not be installed on the wing of almost any existing aircraft. Further, they noted that one aircraft manufacturer is investigating the integration of a turboprop system on the wing of an existing aircraft.

In further support of the turboprop, NASA project officials believe that current and future fuel prices tend to favor the future use of turboprop aircraft. Several airlines have indicated support for continuing development of the turboprop propulsion system because of its fuel savings potential and reduced noise levels, a growing environmental concern. Aircraft manufacturers also support the system because of its potential application to military and cargo aircraft as well as its fuel savings capability on commercial aircraft.

NASA project officials agreed that the 3-year delay will probably result in not achieving all of the fuel savings originally intended through 2005. However, they contend that the fuel savings potential of at least 15 percent over a turbofan engine is so significant that continuing the ATP project is worthwhile.

R&D costs

At the time of our review, NASA had not completed a detailed project plan setting forth the strategies to demonstrate the turboprop technology and the cost to implement the strategies.

The 1975 task force report estimated that NASA would require $125 million for the ATP project. Of this amount, $75 million was to be used for developing the engine and propellers and for performing engine ground tests emphasizing propeller thrusts, efficiency, noise, dynamics, and vibration. The remaining $50 million provided for selecting a demonstration aircraft, modifying the airplane to alleviate cabin noise and vibration, installing the engines, and performing flight tests.

At the completion of our review, NASA was preparing a detailed project plan for this project, implementing the overall task force plan. The project plan will include project objectives, technical plan, management approval, procurement strategy, project schedules, resources plan, management review, and so forth.

Although a project plan has not been prepared, project officials at Lewis Research Center believe that the task force's entire $125 million estimate will be required. The project manager stated that the project will include flight testing because such tests will be necessary to gain airline and aircraft manufacturer acceptance of the turboprop.

EET

The purpose of the EET project was to demonstrate evolutionary advances in aerodynamics by 1983 which would enable future aircraft to be 10 to 20 percent more fuel efficient than current aircraft. Basically this goal was to be achieved through the development of advanced wings (supercritical, high aspect ratio), improved integration between engines and airframes, and active (automatic) flight controls. Newly designed aircraft incorporating most of these advances were expected to be ready for use by 1988.

Performance

The EET project has identified and verified advancements in supercritical aerodynamics and active controls which, when incorporated in an aircraft, could achieve the original fuel savings goal of 10 to 20 percent. Unlike the other ACEE projects, the EET concepts are not being developed in parallel by the aircraft manufacturers. NASA maintains that such parallel development in EET is not necessary because the technology is relatively easy to transfer. However, since only one of the three major aircraft manufacturers is working on the high aspect ratio, supercritical wing, which accounts for most of the EET fuel savings estimate, we are uncertain whether the other two manufacturers will be in as good a position to maximize the benefits of supercritical aerodynamics.

The EET project was originally to be accomplished in three phases: (1) identifying aerodynamic concepts with fuel savings potential, (2) selecting and further developing and testing the more promising concepts, and (3) flight testing the selected concepts of high risk, such as the supercritical wing. Since the original plan, phases II and III have been combined. In doing this, NASA added work in integrated active controls, DC-10 wing load alleviation, and flight demonstration of an L-1011 with extensive active controls.

The revised project plan called for technology development by the three major aircraft manufacturers--Boeing, McDonnell-Douglas, and Lockheed--as well as a substantial in-house effort by NASA. Key technologies identified in the task force and project plans for achieving the fuel savings goal were (1) the supercritical wing, a longer, thicker wing which increases lift and reduces the amount of fuel necessary to cruise and (2) active controls which automatically compensate for sudden changes in flight conditions, allowing the use of high aspect ratio, supercritical wings and smaller, lighter aircraft structures. Studies have shown that the major share of the fuel savings is due to the supercritical wing.

Although EET was to be accomplished by contracts with McDonnell-Douglas, Boeing, and Lockheed, each contractor was free to choose which concepts to work on during the project. During phase I, McDonnell-Douglas evaluated the supercritical wing, winglets (vertical wingtip extensions), active controls, and propulsion-airframe integration. Boeing evaluated wing-tip extensions (horizontal), winglets, smooth wing surfaces, active controls, and high lift devices. Lockheed looked at wingtip extensions and active controls.

At the time of our review, phase II of the project had begun. Based largely on the EET work completed under phase I, Lockheed has incorporated wingtip extensions with limited active controls on new production L-1011s, which are estimated to be 3 percent more fuel efficient. Based on phase I results, the following work is planned for phase II:

--McDonnell-Douglas: design, fabricate, and test an active control system; winglet development for DC-10 derivatives; high lift development for supercritical wing; and propulsion-airframe integration development.

--Boeing: develop and evaluate active controls and aerodynamics technology; the aerodynamics applies to derivative B-747 applications and further investigations of natural laminar flow (smooth wing surfaces).

--Lockheed: design and analyze active control system and conduct flight tests and ground tests of prototype structures on an L-1011 incorporating active controls.

In addition to the contracted effort, the NASA in-house effort will continue evaluating optimum supercritical wing designs and reliable, maintainable, and cost-effective active control systems.

As can be seen by phases I and II activities, only McDonnell-Douglas has worked and will continue to work on the supercritical wing in addition to active controls. Boeing and Lockheed, on the other hand, are concentrating mainly on derivative aircraft and active controls. Thus, when the EET project terminates at the end of phase II, it appears that McDonnell-Douglas may be in a better position than Boeing and Lockheed to integrate the advances in supercritical wings and active controls necessary for designing new aircraft with fuel savings of 10 to 20 percent. NASA officials stated that both Boeing and Lockheed are working on their own advanced wings outside of EET. Also, they maintain that design coordinates for the high aspect ratio, supercritical wing can be easily transferred to other aircraft manufacturers.

Technology readiness

The EET project is scheduled to be completed by 1983, which is the same time frame envisioned in the 1975 task force report.

R&D costs

The cost estimate as of July 1979 was $85.7 million compared to original projections of $50 million, an increase of $35.7 million. According to NASA, $8 million of the increase represents ongoing aerodynamics and active controls work which was incorporated into EET, and $27 million of the increase represents additional active controls work added when phases II and III were combined.

LFC

The objective of the LFC project was to develop and demonstrate by 1985 a practical, reliable, and maintainable suction system for reducing surface-airstream friction, thereby increasing fuel efficiency by 20 to 40 percent. In meeting this objective, NASA is working on a system which removes the layer of air that rubs against the outer surfaces of an airplane while in flight. Removing this surface layer of air keeps the airflow over the aircraft from becoming rough, thereby allowing the airplane to pass through the air with less effort. The envisioned system will remove this surface air by drawing it through slots or holes in the wings and other surfaces, maintaining smoother, laminar airflow over the airplane. Although this system has already been proven successful in actual flight, no one has been able to make it reliable and economically maintainable. It is these areas on which the LFC project is focused. The Task Force envisioned that the LFC technology developed could be available for use on aircraft introduced in 1990.

It should be noted that the 20- to 40-percent fuel savings possible through LFC will only be available to long-range aircraft. According to NASA officials, significant benefits can be obtained only from aircraft with ranges greater than 2,000 miles, and maximum fuel savings will occur on flights of over 5,000 miles. Thus, the benefits of LFC will accrue only on long flights, which limits the application of this technology to aircraft flying these distances.

Performance

With most of the project still ahead of NASA, the prospects for developing a practical LFC system yielding 20- to 40-percent fuel savings are still uncertain. Although several advances have been made, NASA has realized that the work necessary to achieve the project objectives entails more than originally anticipated and has made changes in the project to accommodate the additional work. Thus, it is difficult to determine how much closer NASA is to developing a reliable and maintainable LFC system.

The original LFC plan called for three phases: (1) exploratory research in aircraft concepts, aerodynamics, and materials, (2) fabrication methods; reliability and maintenance concepts; and component design, fabrication, and testing, and (3) flight test of an LFC system on either a research or transport aircraft. The major tests to be conducted in the LFC project were later identified as follows:

--Advanced LFC airfoil wind tunnel test (phase I).

--Advanced LFC wing section flight test (phase II).

--Wing box structure ground test (phase II).

--LFC system flight test (phase III).

NASA has completed the first phase of the project and was in phase II at the time of our review. As a result of phase I, NASA has defined the characteristics of an advanced LFC wing, developed computer codes to predict suction requirements and surface airflow, developed noise prediction methods for an LFC system, and identified a potential way of keeping the front part of the wing clean.

After starting the LFC project, NASA found that the work necessary to carry out the planned tasks was more complex than orginally anticipated. The increased complexity of the LFC work is perhaps best illustrated by the advanced LFC airfoil wind tunnel test, originally planned for completion in phase I.

During phase I, NASA researchers designed an airfoil for the wind tunnel test model with an advanced shape that required more time to be incorporated into the airfoil model than originally estimated. This was worsened by the fact that NASA had difficulty in getting the needed people on time; so the work was already going slower than planned. Also, there was confusion among the researchers as to what the objectives of the wind tunnel test were. At this point, Langley Research Center officials appointed an assessment committee made up of NASA personnel to review the proposed wind tunnel test and to clarify its objectives. Although the committee endorsed the test, given the difficulties it presented, it surfaced serious problems in the LFC project, including:

--The LFC project was compressed to the extent that the first and perhaps most important phase, in which the basic design data and understanding of the physical problems are addressed, was given inadequate time.

--The current cost and time estimates for the LFC project were overly optimistic.

In order to correct these problems, the committee recommended that the overall LFC project should be restructured to provide adequate time for the wind tunnel test and the supporting research that was needed. The committee also made recommendations as to how the management of the project and test could be improved.

In addition to the problems encountered with the advanced airfoil model and the wind tunnel test itself, NASA discovered that the wind tunnel at the Ames Research Center chosen for the test needed modifications in order to meet the required airflow characteristics, which were not envisioned in the original project estimates. Based on this new information, NASA decided to move the airfoil model test to a wind tunnel at the Langley Research Center, which, although it also needed modifications, was more convenient because most of the LFC work was being done by this Center. In order to correct the problems relating to the advanced LFC airfoil wind tunnel test, more time and effort was required than originally planned so that the LFC project could proceed.

In addition to the problems in the airfoil wind tunnel test, NASA has also had to expand the LFC concept evaluation studies in phase I and the wing box development and testing planned for phase II because in both cases NASA discovered that more work was necessary than originally envisioned.

The LFC project was restructured in 1978 to allow for the additional time and effort required to conduct the advanced LFC airfoil wind tunnel test. The restructuring was necessary because the airfoil model test is crucial to the other major LFC tests (wing box ground test, wing section flight test, and LFC system flight test), and these cannot be conducted until the data from the airfoil wind tunnel test is available. Under the restructured plan, phase I was reduced in scope in that the airfoil wind tunnel tests were moved back into phase II, and the concept evaluation studies were extended into phase II. The advanced LFC wing section flight test has been divided into two efforts, a test of a leading edge wing section in phase II and a test of the full wing section (referred to as the chord) in phase IIA, a new phase. The wing box effort has been similarly divided with the wing box design now planned for phase II, and the wing box fabrication and testing planned for phase IIA. The wing section flight tests and wing box ground test were stretched out so that they could utilize the data from the airfoil wind tunnel test. Also, an advanced research and technology effort was added to phases II and IIA. Phase III has not changed in content although it has been delayed as the earlier phases have been stretched out. It appears that this restructuring confirmed the concern expressed by the assessment committee that the original LFC project was too compressed to allow enough time for the work in phase I.

At the time of our review, NASA was considering a proposal to restructure the LFC project again in order to generate more data for initiating phase III earlier than currently planned. In contrast, after this proposal was made, NASA informed us that the Aeronautics and Space Engineering Board reviewed the LFC project and recommended that the project proceed at a more modest pace until breakthroughs in technology occur that would make the concept more practical and warrant an overall system demonstration. In view of these current planning considerations, it appears that the future direction of the LFC project is still open to changes.

Thus, as the LFC project progressed, it became apparent that the work necessary to achieve the project objectives was more complex than originally anticipated; and the project was restructured to allow more time for this work to be conducted. With the completion of the LFC project still 10 years away and the future structure of the project still open to change, it is difficult to determine how much closer NASA is to developing a reliable, economically maintainable LFC system which will enable fuel savings of 20 to 40 percent to be achieved.

Technology readiness

At the time of our review, the LFC project was projected to be approximately 4 years behind the original schedule because the project was stretched out to allow more time and effort to be spent on the advanced airfoil wind tunnel test as well as other tests later in the project. Since the technology readiness date will slip, the application of LFC technology and its resultant fuel savings will most likely be delayed.

As previously mentioned, the advanced LFC airfoil wind tunnel test is crucial to the major tests to be conducted in the latter phases of the LFC project (wing section flight test, wing box ground test, and LFC system flight test). NASA has had to allow more time to prepare for and conduct this test because several problems have been encountered. As a result, NASA plans to complete the airfoil wind tunnel test in 1981, 3 years later than originally estimated.

Since it was necessary to allow the additional 3 years needed to conduct the advanced airfoil wind tunnel test, NASA had to restructure the LFC project so that the other tests could be stretched out to incorporate the results of the airfoil wind tunnel test. As a result of this restructuring, the advanced LFC wing section flight test has been delayed 4 years and the wing box structure ground test has been delayed 3 years. The LFC system flight test, which comprises phase III of the project, has consequently been delayed 4 years, from the original planned completion of 1985 to the current plan of 1989. Since technology readiness was to be achieved at the end of phase III, it has also been moved back until 1989.

As a result of the LFC technology readiness' slipping to 1989, the LFC technology will most likely not be available for application on a 1990 aircraft as envisioned by the task force, given the 5- to 7-year delay between technology readiness and application. Rather, it appears that an LFC system will not be available until the mid- to late 1990s, thus delaying the amount of fuel savings originally envisioned from the technology.

R&D costs

The R&D cost estimate as of July 1979 for the LFC project was $227 million, compared to the task force estimate of $100 million. The breakdown of these costs estimates is as follows:

	Original program (note a)	Current program
	(millions)	
Phase I	$ 7	$ 7
Phase II	33	b/ 29
Phase IIA	-	b/ 60
Phase III	60	b/131
Total R&D	100	227
Construction of facilities	-	2
Total	$100	$229

a/These figures have been adjusted for inflation.

b/These figures are in 1980 dollars and do not include inflation for the years beyond 1980. Also, phases IIA and III had not been approved by OMB or the Congress at the completion of our review.

The combined increased costs in the revised phases II and IIA ($29 million and $60 million, respectively) over the original phase II ($33 million) are due to stretching out various tests and including additional work, as explained in previous sections. The growth in the phase III costs ($131 million current vs. $60 million original) is due mainly to the fact that, after NASA got into the LFC project, it realized that phase III costs were underestimated. In addition to the growth in R&D costs, $2 million is needed for unanticipated wind tunnel modifications to conduct the advanced airfoil wind tunnel test.

CPAS

The CPAS project was designed to demonstrate by 1983 the technology for achieving a

--10- to 15-percent reduction in fuel usage relative to current aircraft and

--25-percent reduction in weight compared to current aircraft.

In order to achieve these objectives, NASA was to design, build, fly, and gather manufacturing experience on the primary structures of an aircraft, namely the wing, fuselage, and tail. It was envisioned that a new aircraft with extensive use of composites could be ready for introduction in 1990.

Performance

Although the use of composite materials offers potential fuel savings of 10 to 15 percent, the ACEE composites project as planned at the time of our review will save at best 1-1/2 percent. This small savings is due to the fact that during the first 2 years of the project NASA deferred the composite wing and fuselage portions for various reasons. These two structures constitute the major share of the potential weight and fuel savings. At the completion of our review, NASA was planning a major program addition to restore work on the wing and provide industry with the option to work on the fuselage.

The task force report presented five major tasks to be accomplished under CPAS. These tasks were: (1) complete an ongoing program to design, fabricate, ground test, and conduct inservice flight evaluation of a composite vertical tail, (2) complete a previously planned effort to design, fabricate, ground test, and conduct inservice flight evaluation of a composite wing, (3) expand the ongoing composite vertical tail program to include the other two major airframe manufacturers, (4) make additional vertical tails to provide the three major airframe manufacturers with production experience, and (5) design, fabricate, ground test, and conduct inservice flight evaluation of a composite fuselage. The first four tasks were judged to be the highest priorities and were thus designated as the baseline program. The fuselage was judged to be the lowest priority and was referred to as level II. The funding estimate in the task force report included all five tasks; and, had the funding been approved, all the tasks would have begun by fiscal year 1977.

The budget presented in January 1976 reflected a change in project priorities. This submission moved the fuselage effort to the high-priority baseline program, while the tasks to expand the vertical tail program and to make additional vertical tails were moved to level II and excluded from the funding request. Apparently these changes were made to reflect a more aggressive program.

Following the budget submission, NASA restructured the CPAS project in February 1976. The fuselage effort was moved back into level II, and its funding was redirected to the restructured CPAS efforts. This restructuring, in effect, deferred the startup of the fuselage effort beyond the time frame envisioned in the task force report. The tasks to expand the vertical tail program and to make additional vertical tails were reinstated in the baseline program. Also, the startup of the wing development effort planned for fiscal year 1976 was delayed until fiscal year 1978, being preceded by multiple wing conceptual design studies. Finally, a task was added to the project, which was not part of the task force plan, to design, fabricate, flight test, and gather manufacturing experience on secondary structures (such as rudders, elevators, and ailerons). This restructured project was less aggressive than the one previously proposed. NASA restructured the project to reflect concerns of the major airframe manufacturers that additional experience with secondary structures was needed to assure the early introduction of composites into the production of future aircraft.

Even after the project was restructured in February 1976, problems were encountered which led to other changes. In July 1976 NASA added an effort to provide more data for predicting the durability of composites. In December 1976 the increased estimated costs of the secondary structures and tails began to jeopardize the wing development program. This concern was further borne out in March 1977 when NASA conducted a program review with industry. At this meeting industry officials reiterated the need to gain more experience with secondary structures and recommended that the wing development program be down scoped and further delayed. NASA officials at this meeting agreed with the industry position and presented revised cost estimates that were running 26 percent higher than anticipated. Shortly thereafter, potential hazards in the release of carbon graphite fibers, a basic component of the ACEE composite material, became a matter of concern. The potential hazards were health impacts and accidental interference with electrical equipment.

These problems were reflected in the restructuring of the CPAS project for fiscal year 1979. The wing development effort and the additional production of vertical tails effort were deleted because of the projected cost increases and the uncertainties of the potential hazards from the release of carbon graphite fibers. The flight service portions of the secondary structures were also deleted because of the carbon graphite fiber problem. Added to the project was a study on the carbon graphite fiber release problem.

Based on our discussions with NASA officials and aircraft manufacturers, part of the reason that the original costs were underestimated was because more basic data in composites was needed than originally anticipated to develop large structures and because the original project was too aggressive in this aspect. Also, in 1978 an aeronautical expert testified before the former House Subcommittee on Transportation, Aviation and Weather of the Committee on Science and Technology that, in its haste to have composites applied to commercial aircraft structures, NASA had not allowed enough resources for the basic research needed in the composites area. This concern over an adequate data base in composites was further supported by the results of the conceptual wing studies, which cited a need for expanding the data base before application to primary structures.

Because of the problems encountered and NASA's resultant deferral of the composite fuselage and wing, the current CPAS project consists only of tail sections and a secondary structures effort which was added after the project started. The current structures can at best achieve a weight savings of 3 percent, which equates to a fuel savings of 1-1/2 percent. This is considerably less than the original projections of 10- to 15-percent fuel savings.

Despite the problems encountered, successes have occurred in the composites area. Each of the three major airframe manufacturers is applying composites to its aircraft structures. The Boeing Aircraft Company, for example, will use 1,500 pounds of the ACEE composite material on its proposed 767 for a weight savings of 450 pounds.

Technology readiness

Because NASA has deferred most of the originally planned development of the composite primary structures, the technology readiness date of 1983 is not attainable. At the completion of our review, NASA was considering an expansion involving the composite wing and possibly the fuselage. Preliminary estimates showed that if NASA obtains additional funds to increase the scope of effort to address the previously mentioned problems, technology readiness may be possible in the 1987-89 time frame. However, the expanded scope had not been referred to OMB or to the Congress for its consideration at the completion of our review. Consequently, we are unable to venture an opinion as to when, if ever, technology readiness will be achieved for the composite wing and fuselage.

R&D costs

The CPAS project costs as of July 1979 were estimated at $110 million, as compared to the original planned costs of $217 million (task force estimate of $180 million plus $37 million ongoing). The cost reductions are due to the down-scoping of the project, which basically resulted in the deferral of the composite wing and fuselage and additional production of tails while smaller efforts in secondary structures, durability, and fiber release studies were added. The following table shows the breakout of both the original costs and current costs, identifying what changes have occurred in the CPAS project since its beginning.

NASA is planning a follow-on large primary structures technology development program, which will restore work on the composite wing and will provide industry with the option to work on a composite fuselage. This follow-on program, estimated to cost $119 million, would run from fiscal year 1981 to 1986. However, OMB declined to approve the startup in fiscal year 1981. The program includes designing, fabricating, and ground testing a composite wing box structure although it does not include a complete wing. It is NASA's position, that at the completion of this program, industry will have enough confidence to incorporate composite wings in the design of new aircraft.

According to NASA, an augmentation program may possibly be needed at the completion of the proposed wing box program. Such an augmentation program would go beyond the wing box effort in that it would include the fabrication and ground testing of a complete composite wing. NASA estimates the cost of this effort to be $79 million. NASA believes that this program will be necessary if

--the design of new aircraft is delayed beyond the expected date of 1986, in which case it is envisioned that, since the application of the composite wing on the new aircraft would necessarily be delayed until the decision is made to proceed with the new aircraft, industry's efforts on the composite wing will slow down in response to the delayed application date (NASA feels that the augmentation program will compensate for this slowdown and will keep the technology going at a good pace until it can be applied on new aircraft) or

--aircraft manufacturers do not have enough confidence at the completion of the wing box effort to incorporate composite wings in new aircraft designs, in which case the augmentation program will provide the manufacturers with the additional confidence necessary to design new aircraft with composite wings.

A difference in opinion exists over whether the manufacturers will be in a position to commit themselves to produce aircraft with composite wings at the completion

Original task force estimate	Original estimated cost	Current budgeted effort	Estimated cost July 1979
	(millions)		(millions)
Inservice experience of:			
Vertical tail	$10	Tail development in progress	$21
Wing	70	Deleted after wing design studies	1
Expansion of vertical tail program to include three major airframe manufacturers	20	In progress	31
Extension of vertical tail program to support the early production phase	47	Deleted	-
Construction and in-service experience of a composite fuselage	70	Deleted	-
Not part of original plan	-	Design and develop- of small components by three major airframe manufacturers	16
Not part of original plan	-	Fiber release studies added	34
Not part of original plan	-	Composites durability effort added	2
Total	a/$217	Total	b/104
		Reserve funds	6
		Total	$110

a/To make this comparison, we added the ongoing estimate, to the ACEE estimate, or $37 million + $180 million.

b/Due to rounding of figures, column totals $105 million.

of NASA's $119 million follow-on program. Although NASA believes that industry will have enough confidence at the end of the program, other people in the Government and industry feel that the $79 million augmentation program will be needed. The augmentation program extends into fiscal year 1988.

At the time of our review, two of the three aircraft manufacturers stated that flight testing would be necessary before they would commit to the production of aircraft with composite wings. Such flight testing is not envisioned at this time in either the $119 million follow-on program or in the $79 million augmentation program.

Thus, if the proposed follow-on program for the composite wing box is approved and if it becomes necessary to augment the program with the complete composite wing, the total cost of the composites project could run to $308 million as shown in the following chart.

	R&D costs (millions)
Current project	$110
Proposed follow-on	a/119
Augmentation (optional)	a/ 79
Total	$308

a/In 1981 dollars.

Further, if flight testing becomes necessary, additional resources may be required.

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

JAN 2 4 1980

Mr. J. H. Stolarow
Director
Procurement and Systems
Acquisition Division
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Stolarow:

Thank you for the opportunity to review GAO's draft report entitled, "NASA's Aeronautics Program--A Look At The Aircraft Energy Efficiency Program, Code 952211, which was forwarded with your letter, dated December 10, 1979.

Cognizant NASA officials at Langley Research Center, Lewis Research Center and at Headquarters have reviewed the draft. We are very concerned about the negative tone of the report and its implications regarding the value of the NASA Aircraft Energy Efficiency (ACEE) Program and similar programs. We consider the discussion in the Digest as being presented without consideration of the constraints and guidelines under which the ACEE program was developed and conducted. This tends to offer a misleading and distorted view of the program. [GAO note: See p. iv.]

In addition, the GAO examiners' use of the schedules and milestones in the 1975 Task Force Report as a basis for evaluating success of the ACEE program suggests there may be a lack of understanding by the examiners of the implementation and conduct of technology development programs. It is clear that the examiners did not understand that the phasing of the elements of the ACEE program were defined and established specifically to provide for program alterations or terminations, based upon technical progress or problems encountered. Additionally, the examiners did not understand that the primary purpose of the ACEE program was to accelerate

[GAO note: Page references in this appendix have been changed to correspond to page numbers in the final report. The report has been modified to recognize these comments. Where appropriate, additional GAO comments have been added in app. IV.]

R&T in certain areas to enable achievement of an ambitious energy efficiency goal. To successfully meet all milestones within costs for such a program would have indicated a failure to set sufficiently ambitious goals with which to force real advances in technology. In retrospect, we may have been too conservative. [GAO note: See p. 4.]

Finally, the major advances made possible by the program are treated so lightly in the Digest section as to appear trivial. [GAO note: See p. i.]

Contrary to the overall draft report implications, we believe that the ACEE Program has been a significant contributor to the U.S. aviation research and technology effort. It has provided for a focusing of national technological capability in the critical area of aircraft energy efficiency. It has brought together in a team effort, the government, industry, and universities to address this common problem area and has provided results which will have a major influence on transport aircraft of the future. Clearly, the Congress considers the ACEE Program to be beneficial and successful. In the FY 1980 NASA Authorization Hearings before the House Subcommittee on Transportation, Aviation and Communications, the Subcommittee specifically requested that NASA identify other program options "along the lines of the highly successful Aircraft Energy Efficiency Program" which could result in transport aircraft with increased productivity, and which would favorably impact the balance of trade. These programs should take advantage of the funding wedge available as the ACEE Program funding requirements decrease. The industry community is also highly supportive of ACEE. The program has provided for focused efforts on their part to address specific requirements. The OMB supports the ACEE program as evidenced by their approval for funding requests.

I will now specifically address the report recommendations in the order presented on page vii.

1. The NASA programs are, by nature, programs which address high risk technology activities. If the activities were low risk, then NASA would deem that it is industry's responsibility and NASA-type technology would not be required. In the ACEE Program, the phasing of the program elements and the decision points identified were addressing the risk elements of the program. In fact, the decision points were specifically identified and placed in the various program elements to insure that progress had taken place and that new knowledge was available in order to proceed with the program. NASA will continue to identify technology uncertainties and will ensure that the relationship of proposed projects to ongoing basic work is clearly understood. [GAO note: See p. 20.]

2. We question the value of providing semi-annual status reports for technology development programs. Limiting this type of reporting to hardware development project activities appears more appropriate. [GAO note: See p. 24.]

3. In cases where it is determined that some form of direct financial participation by the contractor is appropriate, both cost sharing and recoupment should be considered as options. It cannot be safely assumed that research and development "will provide commercial payoff." The precise form of financial participation should be established after review of all pertinent factors, rather than to assume that one form or the other is preferable in all cases. [GAO note: See p. 7.]

Regarding the GAO recommendation concerning a joint DOD/NASA program in composites, we do not believe that this would be useful or appropriate. The DOD needs are in the area of tactical aircraft, whereas the NASA program addresses civil transports. The requirements for these two types of aircraft are significantly different. Civil transports require durability and long-term reliability, and these factors are not of major concern for tactical aircraft. For these reasons, it is believed that the requirements of the DOD and NASA would not be satisfied by a joint program. [GAO note 1: See p. 77.]

This concludes my overview comments. I have enclosed additional comments which address the NASA concerns in more depth as well as comments on specific information presented in the draft report.

If we can be of further assistance, please let me know.

Very truly yours,

A. M. Lovelace
for
Robert A. Frosch
Administrator

Enclosures

1. General Comments
2. Specific Comments

cc: GAO/Mr. Robert Coufal

General Comments on GAO Draft Report

"NASA's Aeronautics Program - A Look at the Aircraft Energy Efficiency Program"

The draft report presents a distorted view of the NASA planning and implementation activities concerning the Aircraft Energy Efficiency Program. The lack of recognition by the GAO that the ACEE program was implemented to provide technology for potential development by industry rather than hardware end products which could immediately be applied by industry creates the false impression that the program has been less than successful. Also, the GAO does not recognize that funding constraints were imposed on NASA by the Administration which prevented NASA achievement of schedules as outlined in the Task Force Report. [GAO note 2: See p. 77.]
Specifically, the ACEE program, initiated in 1976 and estimated to cost $670M, is a collection of six distinct elements. However, these program elements are not all projects, only three have project characteristics--the Energy Efficient Engine (E^3), the Composite Primary Aircraft Structures (CPAS) and Engine Component Improvement (ECI) programs. The other elements are designed to provide a technology foundation which in itself would not necessarily result in specific hardware carried to the point where the transition to industrial application would be possible immediately. All elements of the ACEE program as proposed in 1976, were phased to attempt to insure that the proper data bases existed before commitments of large levels of resources were made to full-scale demonstration hardware or flight testing; nowhere in the GAO report is there an apparent recognition of this. Nowhere in the report is there a recognition that the pace of the various program elements was impacted by funding constraints imposed outside of NASA rather than within. Nowhere in the report is there a recognition that the Task Force Report was not a program plan but was instead an outline of activities which would be modified and adjusted as various areas of technology were developed. [GAO note 3: See p. 77.]

No agency, neither NASA nor OMB, ever stated that the 1976 outline was an approved and fully funded program to be carried out meeting hard schedules. Thus, to conclude that the "program" will cost $300 million more than originally planned is erroneous. GAO comments that NASA's approach to explaining the "program" to the Congress was often inconsistent and possibly misleading is based on the lack of understanding by the study team that the program is not a hardware development program but instead, a technology development program with many elements focused on providing for an acceleration of technology development in critical areas. [GAO note 4: See p. 77.]

None of the three projects cited as high risk in the GAO report slipped "because NASA had not allowed enough time and money in the early part of the projects to gather data which was fundamental to their successful development." The Advanced Turboprop (APT) program slipped because requests for funding for the program were denied outside of NASA. Also, the intent of the early phases of the program was clearly to gather data fundamental to decisions on succeeding phases. There is no way to determine if the Laminar Flow Control (LFC) program has or has not slipped. This program element was established to gather fundamental data at a pace and scale which could not be funded out of the R&T Base program in order to provide an information base for decisions regarding whether or not to proceed to demonstrations of its practicality. The Composite Primary Aircraft Structures program, the major elements of which are now directed toward medium primary structures, is not proceeding according to the original estimates but instead was altered because the graphite fiber risk problem surfaced and NASA was directed to divert resources away from the original goals and to defer the implementation of plans for large structures. While the report is correct in stating that the application of results from these programs will have a delayed impact on application, the delays are consistent with the funding provided and have not impacted industry plans substantively. [GAO note 5: See p. 77.]

We do not agree with the statement on page iii that "Based on this experience with ACEE, NASA should allow more time in the early phases of future projects to accelerate technology development for obtaining more basic knowledge critical to their successful completion." The primary objective of the ACEE program, was to obtain the technology base necessary including gaps in basic knowledge. More time in the early phases surely would not accelerate technology. This vital point has been missed by the GAO examiners. [GAO note 5: See p. 77.]
While it is agreed that project milestones should not be set without considering technical uncertainties, it should be recognized that programs such as ACEE have goals-not hard milestones. Only in some specific elements such as E^3 or in some subparts of CPAS are milestones meaningful.

It may be possible to improve "future projects" by including an analysis of the sensitivity of completion dates and potential market applications to delays or changes. "Projects" or rather technology programs in Aeronautics can be planned with broad knowledge of when a technology should be ready for market applications but since NASA neither builds aircraft or engines nor makes the decision on technologies to be included and when, there never was and never will be (unless the government is building the aircraft) a predictable sensitivity to delays or changes in any technology plan. It is the nature of the aircraft business that technology may sit on the shelf for years before application. On the other hand, some technologies may be incorporated in aircraft designs even as the technology program is in progress. Such is the case for elements of the ECI program element.

We also disagree with the statement on page iv that, "in undertaking ACEE, NASA expanded its activities beyond its traditional role which has centered around basic research and technology." For many years, NASA has conducted both fundamental R&T in the R&T Base program and focused technology activities in the Systems Technology and Experimental programs. Thus, NASA's traditional role includes both basic and applied R&T. The ACEE program did expand one of its traditional roles, i.e., technology development and demonstration. [GAO note 6: See p. 77. Information on p. iv of draft deleted.]

On page iv, a concern is surfaced "that large focused projects may draw resources from NASA's more basic research and technology efforts and cause an imbalance." It should be recognized that program elements such as Advanced Turboprop, Laminar Flow Control, Composite Primary Aircraft Structures, and major parts of Energy Efficient Transport (EET) are expansions of the research and technology base and contribute to the development of fundamental knowledge and a technology base. The research being conducted in these areas is only possible because of the level of funding provided by the ACEE packaged research approach. Completely opposite conclusions can be drawn using the same data base that GAO did; these conclusions are that in the time frame of the ACEE program, the R&T Base funding increased, a significant fraction of ACEE funds for LFC, EET and CPAS were in direct support of research rather than for contracts with industry and that of the roughly 120 DMY now assigned to these programs, 100 DMY are in support of NASA R&T. These increases have occurred along with corresponding increases in NASA aeronautics manpower in the face of declining agency manpower ceilings. [GAO note 6: See p. 77. Information on p. iv of draft deleted.]

In describing potential means of providing resources for NASA aeronautics programs, the GAO team proposed an option that would require increasing cost sharing rates for contracted R&D. It is our opinion that this is a much less desirable approach than requiring reimbursement to the government for product improvements resulting from NASA sponsored activities. There are significant reimbursement activities under way in the ACEE program elements particularly with regard to the ECI project which will return most of the government's total investment. This in itself is proof of the efficacy of the ECI program element which has been criticized in the report for not meeting its "goals." [GAO note: See p. 7.]

APPENDIX III

Specific Comments on GAO Draft Report

"NASA's Aeronautics Program - A Look at the Aircraft Energy Efficiency Program"

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ii Paragraph 3

The reference to space project planning (i.e., "reports on original project goals, and updated cost, schedule and performance estimates") is appropriate for fixed end item pieces of hardware. The Aircraft Energy Efficiency (ACEE) Program is not in the same category since it deals with technology development. [GAO note: See p. 24.]

i Paragraph 4

The statement that Advanced Turboprop (ATP), Laminar Flow Control (LFC) and Composite Primary Aircraft Structures (CPAS) slipped several years because NASA had not allowed enough time and money in the early part of the projects to gather necessary data is incorrect. The CPAS program slipped because of the graphite fiber risk problem and the ATP project slipped because the program was not approved by OMB during the budget approval cycle. [GAO note 5: See p. 77.]

5 Paragraph 2

An ACEE program cost of $984 million is not a correct figure to use for comparison purposes. This figure is a compilation of data generated from internal NASA planning figures. It includes a $79 million optional composite structures augmentation and a $34 million fiber release-risk assessment activity not related to energy efficiency or the original task force goals. The "augmentation" is not part of the currently expected requirement, but was considered in internal NASA planning as a contingency against possible changes in industry fortunes in the 1986-89 time period. The fiber release studies were not a part of the required development effort to prepare the industry to apply composites, but were an emergency response to a potential environmental regard; they only shared with CPAS the same "unique project number" because they were supported with funds made available by deferral of the original wing development and component manufacturing efforts. [GAO note 7: See p. 78.]

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8 July 79 total estimates

The $308 million figure used for CPAS should be $195 million. The optional $79 million augmentation and the $34 million fiber release risk assessment should be footnoted (mentioned in the page 5 response). The $107 million and $107.7 million figures for CPAS should also reflect the fiber release risk assessment and should show $73 million and $73.7 million respectively. [GAO note 8: See p. 78.]
The July estimate for ECI should be $39.5 million instead of $38.9 million to use the correct FY-80 congressional budget number. [GAO note: Changes made.]

9 E^3 and ATP

The values under the "Fuel Savings" column are misleading. For E^3, the value for "current estimate" of 14.5% refers to a change in specific fuel consumption (SFC); for fuel savings (fuel burned) the value should be 13-22%. (See also page 10.) [GAO note 9: See p. 78.]

For Advanced Turboprop, the 15-20% refers to a turboprop compared to an equivalent technology turbofan engine. Thus, this value would be additive to the E^3 value if E^3 technology were used in the turboshaft engine of the advanced turboprop propulsion system. A footnote should explain this point. [GAO note: See explanation on p. 43.]

12 Third line

The report should specifically note that the change in approach was the plan as approved by Congress. The impetus for change resulted from a lack of program approval by OMB. [GAO note: Congressional actions are not an issue.]

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12 Paragraph 4

The application dates used here (1988, 1995) were <u>not</u> "planned" application dates, rather "possible" or "potential" application dates and page 100 of the Task Force Report includes a strong caveat as to the effect of market uncertainties on application. [GAO note: Report changed.]

20 Paragraph 1

The implication is that some of the technologies will <u>never</u> be applied to future aircraft; this is highly unlikely. Market conditions have a major and dominant influence on applications. [GAO note: See p. 20.]

Referenced section deleted.

As was mentioned earlier, data in the draft report itself shows no adverse effect on basic R&T. In fact, the data shows the opposite to be true. [GAO note: Report changed.]

Referenced section deleted.

As was mentioned previously, the ATP program was delayed because OMB did not approve the program as proposed. [GAO note 5: See p. 77.]

Referenced section deleted.

Again, OMB's delay in approving the proposed program instigated the changes. [GAO note 5: See p. 77.]

Referenced section deleted.

Only Laminar Flow can even be considered here. [GAO note: Report changed.]

12 Paragraph 4

There should be no judgement made about the 2 year slip in ATP since NASA did not "<u>plan</u>" an application for 1988. A "potential" application was assessed for an overall ACEE scenario to look at potential benefits. [GAO note: See p. 12.]

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Referenced section deleted.

The $25 million that is said to be "needed to continue developing the basic research knowledge" was an augmentation that was considered but was evaluated as unnecessary. "It", therefore, does not "confirm the concern that an expanded base of knowledge is necessary for successful application of composites"; rather, it validates the opposite. [GAO note: Report changed.]

Referenced section deleted.

The packaging of efforts into projects does not necessarily focus on only near term needs. The elements of ACEE provide for both far-term and near-term requirements. [GAO note: Point not at issue.]

Referenced sections deleted.

This planned acceleration did not assume "complete" success in all areas. The benefits of <u>all</u> six elements were not added to arrive at the 40 to 50 percent fuel savings potential. [GAO note: See p. 5.]

The three projects are not three years behind schedule. In CPAS, the secondary structure program had committment from Boeing for their 767 two years ahead of goal. [GAO note 5: See p. 77.]
The additional basic effort was only initiated in the Laminar Flow Program. [GAO note: Specific comment dropped from report.]

25 Paragraph 1

Again, the elements of ACEE cover both near term and far term needs. [GAO note: Point not at issue.]

26 Paragraph 3

The long term work is not sacrificed for near term oriented work. [GAO note: See ch. 4.]

Referenced section deleted.]

The EET program, in some cases, provides funds to support the verification of technology developed by NASA or resulting from NASA-sponsored work. This is not a departure from NASA's traditional work. [GAO note 6: See p. 77.]

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26 Paragraphs 1, 2, and 3

This whole dissertation, that NASA is focusing on near term oriented work that will impair its ability to do long term research, is totally inconsistent with the case presented on page 26 (paragraph 4) where NASA has cited opportunities and has proposed new programs oriented to long term fundamental R&T. [GAO note: See ch. 4]

22 Paragraph 4

The contention that "budget presentations identify only two of six projects of ACEE while the hearings records generally identify the other four ACEE projects only in response to committee questions" is in error and is disproved in transcript of the hearings before the Transportation, Aviation and Communication Subcommittee: Volume II, part I FY 1977, 78 and 79. [GAO note 10: See p. 78.]

Referenced section deleted.

The reference to "unapproved subsequent phases" was taken out of context as these out year phases were included in the task force plan. [GAO note: Deleted from report.]

Referenced section deleted.

There was no significant set back in composites as is referenced, and page 21 does not explain any set back. [GAO note: Deleted from report.]

Referenced section deleted.

The discussion of NASA/DOD cooperation on composites properly notes the impracticality of substantive joint efforts of the ACEE type because of differences in aircraft operational requirements and design criteria, but then suggests such joint action may be appropriate in future Large Composite Primary Structure efforts and chides NASA for not consumating an agreement (before the ACEE Composite Wing Development effort was deferred) to obtain composite wing flight service experience on an Air Force aircraft. GAO

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was shown that, in early planning of the previous wing effort, use of an Air Force vehicle was systematically evaluated and deemed a third priority alternative to the use of commerical passenger or cargo aircraft; deferral of the planned wing program occurred well before discussion with the Air Force would have been appropriate. [GAO note 1: See p. 77.]

The GAO report does not convey the scope of the ACEE efforts to keep DOD personnel aware of technology development in the CPAS program. Not only are written reports transmitted to Air Force, Army and Navy recipients (25 in all) and personnel of these organizations invited to CPAS Conferences, but all three agencies are invited to participate in NASA's detailed management reviews of design, manufacturing and test efforts on each of six CPAS contracts. Moreover, composite material properties data, generated by CPAS contractors, are required by NASA to be submitted to the Air Force for inclusion in their Advanced Composites Design Guide. [GAO note: See p. 20.]

31 The correct value for FY-77 is $39.7 million and $70.2 million for FY-78. [GAO note: Report changed.]

33 Paragraph 1

The five percent fuel consumption reduction goal for ECI was to be achieved through both component improvement and - where feasible - improvements coming about through better understanding of in service performance deterioration. [GAO note: This contention by NASA not supported by project documents.]

34 Third line

The value of 11 billion gallons is incorrect. There is no way that we can even estimate what the correct value would be for a 5 percent fuel savings since it would depend on the engine model for which a particular but undefined concept was applicable, on the market scenario for that engine model, on the retrofit potential, on the time of introduction, etc. [GAO note: This figure is a gross estimate by GAO to give some approximation of potential savings.]

34 Paragraph 1

The ECI managers comments were taken out of context and should explain that the component improvements had exten-

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sive development times, resulting in concept introduction after 1982 along with questionable retrofit in a few cases. [GAO note: See app. II, p. 34.]

37 Paragraph 4

$38.9 million should be changed to $39.5 million in both places as the FY-80 value presented to Congress is the best value to quote in the time frame of the GAO report. [GAO note: Report changed.]

41 Second line

NASA is not "highly confident", rather, "optimistic". P&WA is non-committal. [GAO note: NASA comment changed.]

42 Paragraph 1

The project manager did not state "there is a reasonably high probability that the 1983 technology readiness date will slip". This was a conclusion drawn by GAO which might or might not be correct if problems occur. [GAO note: Report modified.]

43 Paragraph 3

The Task Force Report (p. 46) cites the late 1980's not specifically 1988 for the introduction of new transport aircraft designs. [GAO note: Date referenced to p. 104 of task force report.]

49 Last paragraph.

The reference to the LFC program managers response when questioned about savings relating to altitude, speed, range, is incorrect. The response was that significant LFC benefits can be obtained only from aircraft ranges greater than 2000 miles - the greater the range, the greater the benefit. The magnitude of any economic advantage, however, will depend on fuel price. The estimated fuel savings were based on flying at Mach No. 0.8 at 35,000 to 40,000 feet altitude, and ranges of about 5,000 nautical miles. [GAO note: Report changed.]

51 Last paragraph

There is confusion here on what will be flight tested. The

APPENDIX III

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advanced LFC airfoil which will be in the wind tunnel test is not what will be flight tested in Phase II or IIA. The items to be flight tested were: 1) spanwise sections of the leading edge to front wing spar of a JETSTAR or DC-9 and 2) full chord laminarization of the inboard region of a validator aircraft wing (probably). This is not the Advanced LFC airfoil in the wind tunnel tests. [GAO note: Changes made.]

52 Line 15

"The airfoil flight tests" phrase is incorrect and should read "leading edge systems flight test. [GAO note: Changes made.]

53 Paragraph 3

Again, there are no plans to flight test the Advanced LFC airfoil in phase II or IIA. The reference may be to the leading edge system flight test. [GAO note: Agree.]

55 Paragraph 1

This section is incorrect. The early 80's were planned as the secondary structures goal and late 80's for the primary structures goal. There was some slippage from the original Task Force proposed schedule and as noted was perhaps due to unwarranted optimism about the air transport industry's readiness to move rapidily to large primary structure. The secondary structures and wing study efforts were introduced to bridge the industry confidence gap. The subsequent deferral of wing development efforts, because of the potential fiber release hazard, further postponed the possible "technology readiness" date for industry initial efforts to apply composites to wing structure; the earliest such date is now 1986, provided the current NASA-proposed Large Composite Primary Structures (LCPS) Program is initiated in FY 81. However, the growing air-transport-industry confidence in composites, derived in large measure from CPAS component programs, now suggests NASA-funded efforts toward fuselage applications may be confined to a few key technology issues within the context of the currently proposed LCPS effort. [GAO note 11: See p. 78.]

Page

57 Line 6

The statement that the wing studies cited a need for expanding the data base before application reflects an erroneous conclusion. The studies called for an expanding of the data base but to say that was to occur before application is not founded. The GAO auditors also cite comments from the NRC and on page 24 infer NASA concurrence from a proposed NASA composite materials research initiative which, for a while, was coupled with the proposed restoration of the LCPS program. Such a parallel material research effort is indeed supported by NASA Langley in order to provide "tougher" materials by 1986 that will admit reduced processing costs and higher design strains for greater weight savings. Such materials are emphatically not a necessary precursor to successful and beneficial application of composites to large primary structures. [GAO note: NASA comments conflict with source data cited on p. 57. Information on p. 24 of draft deleted.]

57 Paragraph 3

The time frame given technology readiness is not 1987-89 but 1986. [GAO note 11: See p. 78.]

The $110 million dollar figure should be $79 million (see page 5 comments). [GAO note 7 : See p. 78.]

58 and
59

The fiber release studies are not in the scope of the current project plan. The reference is made verbally on page 58 and numerically on page 59. [GAO note 7: See p. 78.]

60 Paragraph 1

The contention that "two of the three aircraft manufacturers stated that flight testing would be necessary before they would commit to the production of aircraft with composite wings" is absolutely unfounded and incorrect. [GAO note: The statements were made to GAO during plant visits.]

57 Numbers

The current project dollar figure should be $76 million and not $110 million (see page 8 comments). [GAO note 7: See p. 78.]

GAO NOTES ON NASA'S

JANUARY 24, 1980, LETTER

1. The suggestion in the draft report dealt with obtaining flight service experience for composite primary structures using a military transport, which was originally suggested by a U.S. Air Force Scientific Advisory Board Ad Hoc Committee. Since NASA no longer contemplates obtaining flight service experience of a composite wing, we dropped this point.

2. Page 6 of the report states that the ACEE program was implemented to provide technology for potential development by industry. Also, we stated several times in the report that the Administration imposed funding constraints on NASA.

3. NASA officials suggested that we use the term, project, when referring to the six components of the ACEE program. Further, the report describes the different phases of each project. (See app. II.) We also recognize in the report that the Administration imposed funding constraints on NASA. Chapter 2 and appendix II explain the revisions to the task force plan, which were made as the phases of each project progressed.

4. We did not say that the program was fully funded. We did state that the ACEE program, if carried out to reach the original goals, may cost $300 million more than originally estimated.

5. Comments in the report that NASA had not allowed enough time and money in the early part of the projects to gather data have been dropped. The report states that the ATP project was deferred because NASA judged that additional work was required on propeller aerodynamics and structures and on configuration studies before it would be prepared to focus this activity in a systems technology program. (See pp. 12 and 45 of report.)

   Appendix II also discusses the changes in the LFC project and identifies a new technology readiness date of 1989, which is 4 years later than originally estimated. (See p. 49.) Appendix II also discusses the changes to the composites project before the graphite fiber risk problem surfaced. (See p. 56.)

6. We agree that NASA's role includes both basic and applied research and technology and that ACEE expanded

6. one of its traditional roles. However, our principal concern is to maintain a balanced aeronautical program. (See ch. 4.)

7. Regarding the $79 million optional composite structures augmentation, we recognize in the report on page 58 the difference of opinion over the need for this additional effort. The $34 million fiber release risk assessment activity was part of NASA's cost estimates for CPAS.

8. The figures in the report status chart on page 8 were taken from the task force report and the individual project plans.

9. The original 10- to 15-percent estimate for EEE was in terms of specific fuel consumption and therefore, the current estimate was stated in terms of specific fuel consumption.

10. The 1977 transcripts deal with matters prior to ACEE approval. The 1978 and 1979 volumes contain information on technical progress on each ACEE project but do not show cost and schedule status as compared to original estimates. (See p. 23.)

11. The NASA comments, in our opinion, do not make the report presentation incorrect. One of the original goals was to demonstrate by 1983 the technology for applying composite materials to primary aircraft structures, namely the wing, fuselage, and tail. The secondary structures goal was added in the February 1976 restructuring. This restructuring also marked the deferral of the fuselage effort and called for the delay of the wing development effort. We disagree with citing the fiber release hazard as the sole reason for deferral of the wing development effort because the wing development effort was initially delayed in early 1976 and further down scoped in early 1977 to gain more experience with secondary structures and increasing cost estimates. Since these problems surfaced before the fiber release hazard, we believe the facts show that the fiber release hazard problem was only one of several reasons for deferring the wing development effort. We recognize the follow-on program mentioned in NASA's comments; and, if it is approved, the earliest technology readiness date would be 1986. However, we also recognize that there is a difference of opinion over whether the manufacturers will commit to producing composite wings at that time. If not, another effort would be necessary, which could extend into fiscal year 1988. Based on experience

APPENDIX IV

with composites in the ACEE program, we believe the prudent approach would be to assume that the augmentation effort might be necessary.

APPENDIX V

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

JAN 1980

Mr. Allan R. Voss
Director
General Government Division
United States General Accounting Office
Washington, D.C. 20548

Dear Mr. Voss:

Thank you for your letter of December 13, 1979, to Mr. McIntyre requesting our views on the draft GAO report on NASA's Aircraft Energy Efficiency (ACEE) program.

We have reviewed the draft report and believe that it contains some significant insights into the ACEE program. However, it appears to us that some of the conclusions presented in the report are unduly critical and do not fairly reflect the performance of NASA in conducting this program. We also believe that some of the basic analysis in this report needs to be strengthened to provide a more balanced evaluation of the program--reflecting its successes as well as its failures.

In the enclosed comments we have suggested ways to further strengthen this report without extensive rework. These comments have been discussed with Mr. Robert Coufal of your staff.

We understand that NASA also will provide you with its comments, particularly on the costs and milestones of the ACEE program.

Sincerely,

W. Bowman Cutter
Executive Associate Director
for Budget

Enclosure

Comments on GAO Draft Report
"NASA's Aeronautics Program - A Look at the
Aircraft Energy Efficiency Program"

1. Baseline for GAO Evaluation. The GAO report states that the original Task Force report on the ACEE program was chosen as the baseline for evaluation of NASA's performance because, "it provided a common starting point and the program received its congressional endorsement based on the plan set out in this report."

The Task Force recommendations do provide a convenient starting point, but it appears to us that they constitute an artificial baseline because:

- Task force plans in most research and technology-type programs are intended to provide a general framework, not a rigid prescription, for all future program activities. As certain phases of a program are completed, technical decisions need to be made on the magnitude and direction of subsequent work. This has occurred in the ACEE program.

- The Task Force report was not a commitment on the part of NASA or the Administration that the plan it contained would be followed exactly. This Administration, through its Zero Base Budgeting process, scrutinizes and prioritizes each program annually. Also, funding for some proposed initiatives within the ACEE program was not appropriated according to the schedules in the Task Force report.

It appears to us that the baseline against which the accomplishments of the ACEE program should be measured should consist of the ACEE-related proposals in the recent Budgets for which Congress has provided appropriations. However, we realize that at this stage of the GAO audit process, it may not be possible to perform extensive new analysis. Therefore, we recommend that some additional language be included in the report to emphasize that it is an assessment of accomplishments against a preliminary plan. Some language should also be included to reflect NASA's accomplishments, comparing them to the specific goals that were described in budget proposals approved by the Congress. Also, the successes of the program should be given appropriate emphasis. [GAO note: See p. iii.]

2. Aeronautics R&D Policy. The GAO report states that, "In undertaking ACEE, NASA has expanded its traditional role which has centered around basic research and technology," and that the Administration should study and clarify NASA's role in aeronautics, that is--whether NASA should emphasize near-term projects, far-term basic research and technology or both. We believe that the draft GAO report leaves one with the erroneous impression that NASA's aeronautics programs are being conducted in a policy vacuum. The current Administration's aeronautics R&D policy directions are determined by several factors:

APPENDIX V

- NASA's charter which requires it to improve the usefulness, performance, speed, safety and efficiency of aeronautical vehicles and to preserve U. S. leadership in aeronautical science, technology and applications. Both near-term and far-term projects are needed to implement this charter.

- The President's March 1979 message to Congress on science and technology that is applicable to all R&D in the Federal Government.

- Continuing assessment of NASA's future outlook in aeronautics through agency studies, five-year plans and advisory committee recommendations.

Moreover, through the budgetary decision-making process, the Administration examines each NASA proposal for aeronautics R&D in the light of this policy framework as well as other national needs (e.g., defense).

We suggest, therefore, that while recommending policy articulation, the GAO report should also recognize the existence of the present policy framework for aeronautics R&D in the Federal Government.

[GAO note: See ch. 4.]

3. Technical Uncertainties. The GAO report criticizes NASA for not adequately considering in advance the technical uncertainties that might prevent it from meeting its milestones. We believe that this is unduly harsh criticism because:

   - The ACEE program is for developing new technologies and for a program of this type, it is very difficult to determine at the outset what the specific technical uncertainties are.

   - The original Task Force report did contain statements such as, "Such success is dependent not only on the application of adequate resources, but also on a certain amount of good fortune" (p. 100) and "These factors are beyond the control of any one group and cannot be predicted with any certainty" (p. 107). The same views were expressed in the executive summary of the Task Force report.

   We believe that the recommendation on this, contained in the GAO report, would be very difficult to implement meaningfully, and recommend that it be deleted. [GAO note : See p. 20.]

4. Cost Sharing and Recoupment. The GAO recommendation that NASA seek higher cost sharing by contractors raises serious concerns:

   - Projects on which industry is willing to cost share substantially more may be such that it would conduct them even without NASA funding.

- The GAO report "Digest" also makes no reference to the cost recoupment feature in the ACEE program whereby successful application of developed technology may result in the Federal Government being paid back almost all its investments for certain projects.

We recommend that instead of recommending higher cost sharing, the GAO report should emphasize the cost recoupment feature and indicate that this feature be included in other similar programs. [GAO note: See p. 7.]

5. Formal NASA-DOD Agreement on the Composites Program. The GAO recommends that NASA and the Department of Defense enter into a formal agreement to further define relative agency roles on the composites program. We understand that NASA and DOD already have considerable interaction on the program, and question the need for a formal agreement. We understand that it is not the intention of GAO to recommend a formal Memorandum of Understanding between the agencies. This should be clarified in the report and suggestions for a suitable mechanism should be included. [GAO note: Report clarified.]
6. Semiannual Reports to Congress. Another GAO recommendation is that NASA should prepare semiannual reports to Congress for ACEE and similar programs. We believe that this would be an additional unnecessary burden on NASA and that it would not be feasible to submit reports with precise costs and schedules on the basic research and technology-type programs. We recommend strongly that this recommendation be reconsidered. [GAO note: See p. 24.]

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