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Report to the Congress; by Elmer B. Staats, Comptroller General.

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Congressional Relevance: House Committee on Armed Services; Senate Committee on Armed Services; Congress.

The multinational F-16 single-engine fighter aircraft has been approved for full production; the first-production F-16 is scheduled for delivery in August 1978. The United States and four European countries (Belgium, the Netherlands, Denmark, and Norway) plan to purchase 998 F-16s, and a letter of offer and acceptance has been signed for sale of 160 F-16s to Iran.
Findings/Conclusions: The significant advantages that this aircraft holds for NATO standardization and future cooperative ventures may far outweigh any risk caused by the accelerated pace of the program. However, a number of uncertainties about the F-16 remain: critical development and operational flight testing remains, issues of the F-16's ability to survive and remain invulnerable in battle remain unresolved, the F-100 engine problems are serious because it has only one engine, and the rate of loss due to engine malfunction is currently estimated to be three times higher than called for by Air Force specifications. The basic delivery schedule requirements have caused some degree of concurrency between full-scale development, production, and deployments, and this has created an element of risk for the production program that could complicate correction of subsystem design problems.
Recommendations: The Secretary of Defense should: require the Secretary of the Air Force to review the F-16 program schedule and identify management decision points and key indicators of program progress; require a complete program review before making any commitments for F-16 purchases beyond the present commitment to buy 650 aircraft; revise Selected Acquisition Report instructions to provide not only the reporting of the Office of the Secretary's approved program cost estimate, but also the services' best program cost estimate; and require that any request for congressional approval of future F-16 foreign military sales use the F-16 master plan guidelines as specific criteria for assessing the sales effect on the U.S. Air Force program. (RRS)

BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

Status Of The Air Force's F-16 Aircraft Program

The Department of Defense approved full production for the F-16 on October 13, 1977. Although sufficient testing was accomplished for the program to enter full production, a number of uncertainties are associated with the program.

The uncertainties include F-100 engine problems, an ambitious deployment schedule and support requirements generated by this deployment, subsystem design problems, support of European manufacturers and survivability/vulnerability issues.

GAO recommends that the Secretary of Defense require a complete program review before making any commitments for USAF F-16 purchases beyond the first 650 aircraft. This review should include an updated military need assessment and comparison of F-16 performance under realistic operational conditions.

UNITED STATES GENERAL ACCOUNTING OFFICE

PSAD-78-36

APRIL 24, 1978

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

B-163058

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

This report presents our views on the major issues of the F-16 Aircraft Weapon System. A draft of this report was reviewed by agency officials associated with the program and their comments are incorporated as appropriate.

For the past several years we have annually reported to the Congress on the status of selected major weapons systems. This report is one of a series of reports that we are furnishing this year to the Congress for its use in reviewing fiscal year 1979 requests for funds.

We made our review pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

We are sending copies of this report to the Acting Director, Office of Management and Budget, and the Secretary of Defense.

Elmer B. Staats
Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

STATUS OF THE AIR FORCE'S F-16 AIRCRAFT PROGRAM

DIGEST

The multinational F-16 single-engine fighter aircraft program is completing full-scale development, has been approved for production, and first delivery is scheduled for August 1978.

The United States, Belgium, the Netherlands, Denmark, and Norway plan to purchase 998 F-16s; 650 for the United States and 348 for the European countries. Ultimately, the U.S. Air Force plans to buy 1,388 F-16s. A letter of offer and acceptance has been signed for sale of 160 F-16s to Iran. Sales to other countries are expected.

Development of the aircraft has been the sole responsibility of the United States. On October 13, 1977, the Deputy Secretary of Defense decided that the F-16 was sufficiently advanced so that it could go into full production even though a large amount of development and operational testing and evaluation remained. He stated that, on the whole, the program was ready to enter full production. GAO's review did not disclose any reasons for questioning that decision.

The rapid progression of the F-16 program from development into production due in part, in GAO's opinion, to international political and economic factors, has created an element of risk. However, the significant advantages that this program holds for NATO standardization and future cooperative ventures may far outweigh any risk caused by the accelerated pace of the program. Current problems can be expected to impact on program cost and schedule. Although the F-16 program is experiencing problems, they do not seem to be any more severe than those previously experienced in other major systems. And, experience with other systems shows that these problems are resolved over time. The most critical concerns at this time include performance of the F-100 engine and the deployment and support schedule.

Tear Sheet. Upon removal, the report cover date should be noted hereon.

UNCERTAINTIES IN F-16 PROGRAM

In reviewing the F-16 program, GAO identified a number of uncertainties. The following are the most important, but there are others. (See pp. 14 to 17.)

--Critical development and operational flight testing remains. (See pp. 17 and 18.)

--Issues of the F-16's ability to survive and remain invulnerable in battle remain unresolved. Proposals to incorportate modifications to increase the F-16's survivability remain undecided. (See p. 19.)

--The F-100 engine problems on the F-16 are serious because it has only one engine (compared to two for the F-15). (See pp. 8 to 12.)

--The rate of loss for the F-16 due to engine malfunction is currently estimated by the Air Force to be three times higher than that called for by Air Force specifications. (See pp. 12 and 13.)

GAO's report shows the following important problems.

Air Force officials stated that funding limitations may prevent the F-100 engine from reaching its full potential on schedule.

Competing contractors developed prototypes of the F-16 to demonstrate the feasibility of a low-cost, highly maneuverable fighter for the air superiority mission, but there was no Air Force requirement to incorporate survivability and vulnerability protection into its design.

The F-16 system program office concluded that if improvement in present F-16 survivability is desired, two modifications would be effective in relation to the cost.

Neither modification can be incorporated into the first and second block of aircraft. Incorporation in subsequent production blocks and retrofit of the first two aircraft blocks will depend on further test results. If approved, these modifications will increase F-16 program costs.

THE ELEMENT OF RISK

GAO's review also showed that concurrent production of the F-16 while development and testing are in progress has created an element of risk which in part has been accepted due to the political and economic environment of the program. Design problems have caused schedule slips in important subsystems which could affect the capabilities of early-production. Furthermore, an ambitious and concurrent deployment schedule will create support problems throughout the program.

In other words, the basic F-16 program schedule established by the Air Force and European delivery requirements has caused some degree of concurrency between full-scale development, production, and deployments, and this has created an element of risk for the production program. This could also complicate correction of subsystem design problems.

Because of production lead time and early F-16 delivery requirements, a large number of production components were scheduled for manufacture during the full-scale development program. This situation was compounded by the need to provide production components to European manufacturers to support their schedule requirements.

Problems encountered during development testing will have to be corrected on the production aircraft. This may require engineering and design changes and new manufacturing procedures on the production line. It also requires that completed components be changed to meet the new design.

Three important F-16 subsystems--radar, stores management, and avionics--have experienced development design problems that already have caused schedule slips. These have not yet completed first testing, and correction of test problems will have an increasing effect on production schedules.

To meet the delivery schedules established in planning documents, the F-16 production program has a rapid buildup at its start. F-16 deployment will require seven bases to be opened in six countries in 18 months. The following data shows the number of production aircraft, and the number of different base locations during early F-16 deployment.

Calendar year	Production aircraft (cumulative)	Number of bases (cumulative)
1979	90	3
1980	312	8
1981	642	14
1982	1,087	22
1983	1,560	29

No modern fighter program faces the potential early support problems posed by the F-16 deployment schedule. (See pp. 25 to 27.)

Cost estimates presented at the Defense Systems Acquisition Review Council IIIB were not approved by the Office of the Secretary of Defense until the budget review cycle was completed in December 1977. Although these costs are subject to change, they represented the Air Force's best estimate at that time and should have been highlighted in the September Selected Acquisition Report as an Air Force estimate not yet approved. Otherwise, the Congress is not notified of potential program cost growth in a timely manner.

DESIGN TO COST

Design to cost is a management concept; it means that a cost goal is established to control program costs by tradeoffs between performance.

Design-to-cost estimates should be based on the same assumptions and ground rules as the design-to-cost goal. The current design-to-cost estimate should not be used to measure progress in achieving the established goal because it uses different assumptions. (See pp. 30 and 31.)

RECOMMENDATIONS

GAO recommends that the Secretary of Defense:

--Require the Secretary of the Air Force to review the F-16 program schedule and identify management decision points and key indicators of program progress. This should be done to establish firm management goals and realistic measures of program progress.

--Require a complete program review before making any commitments for USAF F-16 purchases beyond the present commitment to buy 650 aircraft. This review should include an updated threat assessment and a comparison of F-16 performance under realistic operational conditions to the updated threat. In addition, the program assessment should include an evaluation of the supportability and the producibility of the F-16 aircraft consistent with the F-16 Memorandum of Understanding and F-16 Foreign Military Sales Master Plan(s).

- --Revise Selected Acquisition Report instructions to provide not only the reporting of the Office of the Secretary of Defense approved program cost estimate, but also the services' best program cost estimate.

- --Require that any request for congressional approval of future F-16 foreign military sales use the F-16 Master Plan guidelines as specific criteria for assessing the sales effect on the U.S. Air Force program.

A draft of this report was reviewed by Agency officials and their comments have been incorporated as appropriate. Defense officials feel that major accomplishments have been demonstrated and actions undertaken to guarantee a relatively low-cost, multimission, high performance aircraft.

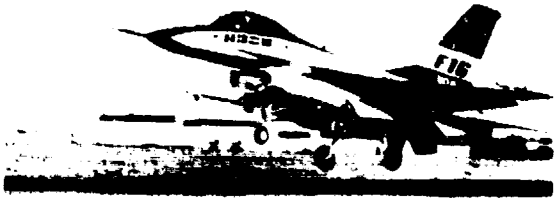
Contents

ABBREVIATIONS

ACEVAL	air combat evaluation
AFTEC	Air Force Test and Evaluation Center
AIMVAL	air intercept missile evaluation
AIS	Avionics Intermediate Shop
AME	alternate mission equipment
ASD	Aeronautical Systems Division
CIP	Component Improvement Program
DCP	Decision Coordinating Paper
DDR&E	Director, Defense Research and Engineering
DOD	Department of Defense
DSARC	Defense Systems Acquisition Review Council
DTC	design-to-cost
DTR&E	design test research and engineering
EEC	engine electronic control
EMC	electronic magnetic compatibility
EPG	European Participating Governments
FMS	foreign military sales
GAO	General Accounting Office
IOC	initial operational capability
IOT&E	initial operational test and evaluation
JTF	Joint Test Force
LWF	lightweight fighter

MOU	Memorandum of Understanding
NATO	North Atlantic Treaty Organization
NTE	not to exceed
OSD	Office of the Secretary of Defense
ROC	required operational capability
SAR	Selected Acquisition Report
SPO	System Program Office
TAC	Tactical Air Command
USAF	United States Air Force

F-16 No. 1



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F-16 No. 3

F-16 No. 4

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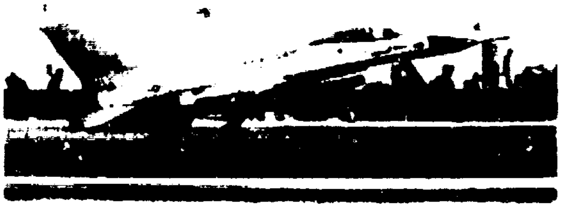

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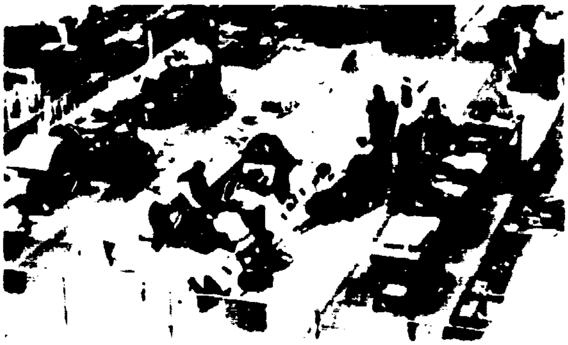

STATUS OF THE EIGHT FULL-SCALE DEVELOPMENT AIRCRAFT (FIVE FLYING, THREE NEARING COMPLETION) (Courtesy General Dynamics Corp.)

CHAPTER 1

INTRODUCTION

The F-16 program is completing full-scale development and has been approved for full production; the first-production F-16 is scheduled for delivery in August 1978. Under a multinational commitment the United States and four European countries--Belgium, the Netherlands, Denmark, and Norway--plan to purchase 998 F-16s; 650 for the United States and 348 for the European countries. Ultimately, the U.S. Air Force (USAF) plans to buy 1,388 F-16s. A letter of offer and acceptance has been signed for sale of 160 F-16s to Iran.

In conjunction with the purchase, production and assembly contracts equal to 10 percent of the procurement value of the first 650 U.S. F-16 aircraft, 40 percent of the procurement value of the 348 European aircraft, and 15 percent of the procurement value of third-country sales will be offered for placement with industries in the participating European countries.

BACKGROUND

The F-16 program is a follow-on to the lightweight fighter (LWF) prototype program which was initiated to investigate the feasibility and operational utility of a highly maneuverable, lower-cost fighter.

LWF was approved for prototyping in January 1972. The contractors, General Dynamics Corporation and the Northrop Corporation, each built and flew two prototypes.

During late 1974, the Air Force evaluated the LWF prototypes and solicited full-scale development proposals from the contractors for the Air Combat Fighter. In January 1975 the Air Force selected a derivative of the General Dynamics prototype to be the Air Combat Fighter, called the F-16. On January 13, 1975, the Air Force awarded a F-16 full-scale development contract to General Dynamics.

In June 1975, the four European Governments entered into a detailed memorandum of understanding and preliminary contracts with the U.S. Government, specifying the planned coproduction and the five-nation procurement of the F-16. These arrangements were finalized in letters of offer and acceptance signed in May 1977.

PROGRAM MANAGEMENT

Department of Defense (DOD) regulations provide that the system Program Director will have primary responsibility for the acquisition of major weapons systems. On the F-16 program, however, much of the policymaking power and program management authority is diffused through a group of organizations outside the System Program Office (SPO). This action is required by the F-16's unique multinational requirements, program budget constraints, and the joint F100 engine procurement requirements of the F-15 and the F-16.

Multinational Fighter Program Steering Committee

The Multinational Fighter Program Steering Committee was created by the Memorandum of Understanding establishing the F-16 multinational program. The Steering Committee represents the multinational partnership in the F-16 program, and is comprised of one principal member from each participating nation. Subcommittees have been set up to monitor specific areas and resolve disputes through recommendations to the Steering Committee. The Memorandum of Understanding specifies that the Steering Committee will be responsible for broad policy matters, advice, and counsel to the SPO Director. The emphasis on partnership and the program's political implications have resulted in the Steering Committee making program policy--particularly in areas such as coproduction manufacturing, cost sharing of configuration changes and contractual services, and currency management. The effect of the Steering Committee's decisions in these areas restricts the Program Director's management perogatives.

Because the committee and its subcommittees are deliberative bodies that meet infrequently, issue resolution is often a time-consuming process. This can create additional management problems because the SPO is forced to work around problems until a solution is reached.

Configuration Steering Group

The F-16 was conceived, designed, and authorized as a low-cost aircraft. USAF is committed to make every effort to keep aircraft costs within the amended design-to-cost objective of $4.555 million per aircraft. The Configuration Steering Group is a high level body which was established by the Chief of Staff following the signing of the F-16 contract to review and control the production configuration of the aircraft and related equipment to obtain the best balance of operational performance and total program cost. They were directed to hold the development, production, and inventory support costs of the aircraft to a minimum consistent with required operational performance capabilities. The Configuration Steering Group Chairman, who is also the USAF Deputy Chief of Staff for Research and Development, said that the Configuration Steering Group's current objective is to restrict aircraft configuration changes in order to maintain the program budget while providing the most operationally effective aircraft.

Although the Configuration Steering Group management of configuration changes removes a burden from the F-16 Program Office, it also limits the Program Director's decisions and control. Under existing conditions the Program Director can not add operational improvement to the aircraft without the approval of the Configuration Steering Group.

Engine management

The F100 engine program has been managed by a directorate within the F-15 Program Office known as the Joint Engine Project Office. Although responsible for engine procurement for both programs, the actual management and procurement actions were performed by F-15 Program Office personnel. Only a small contingent of F-16 personnel was directly involved in engine management. In October 1977, F100 engine management was transferred to the Propulsion Systems Program Office, which eventually will manage engine procurement for all USAF systems.

The Pratt & Whitney F100 engine is used in both the single-engine F-16 and the two-engine F-15 fighters. Safety and reliability requirements are more stringent for a single-engine aircraft. Although both aircraft use the same engine, F-16 engine requirements therefore are not identical to F-15 requirements.

Defense Security Assistance Agency

The Defense Security Assistance Agency is DOD's focal point for foreign military sales (FMS). It is responsible for administering all DOD security assistance programs within guidelines established by the Assistant Secretary of Defense for International Security Affairs. Agency responsibilities include negotiating sales agreements, maintaining liaison with industry, and management of credit financing for FMS.

System Program Office

Within the environment created by the above groups, the SPO, located at Wright-Patterson Air Force Base, Ohio, has management responsibility for the F-16 program. Personnel from each European participating government (EPG) are assigned to the SPO and participate in F-16 program management. To provide management functions in Europe, a joint USAF/European F-16 Program Office has been established in Brussels, Belgium.

In addition to the normal functions involved in managing a major weapons acquisition, the F-16 Program Office is responsible for the success of the multinational program commitments. Multinational objectives such as offset commitments, EPG not-to-exceed (NTE) price, and standardization must be balanced against basic USAF objectives. Tracking these objectives, monitoring the complex coproduction program, and managing the highly compacted development schedule for a new weapons system poses an unprecedented challenge for the F-16 Program Office.

SYSTEM DESCRIPTION

The F-16 is a single-engine, highly maneuverable fighter aircraft that will be used by USAF tactical air forces and four North Atlantic Treaty Organization (NATO) countries. It is a multimission aircraft with air-to-air and air-to-surface missions.

The Air Force plans to have single- and two-seat models of F-16 aircraft. Both models will be capable of performing all F-16 missions. The Air Force plans to use the two-seat aircraft primarily for training. Currently, about 85 percent of USAF F-16s will be single-seat models.

The F-16 avionics will include a pulse-doppler radar that will have an air-to-air and air-to-surface capability. The F-16 radar is being developed by Westinghouse Corporation.

RELATIONSHIP TO OTHER SYSTEMS

According to the program Decision Coordinating Paper (DCP), the F-16 will complement the F-15 in the air superiority mission role. It will also supplement the air-to-surface capabilities of the F-4, F-111, and A-10 as required. As the Air Force acquires the F-16 aircraft, it will form operational units and will transfer some F-4s to the Air Force Reserve.

The F-16 will be used by the purchasing European Governments to replace their current F-104 and other fighter aircraft.

Air-to-air mission armament

The F-16 air-to-air armament consists of the 20mm, M61A1 cannon and up to six AIM-9J/L Sidewinder missiles. The Sidewinder is a short-range infrared guided missile. In anticipation of the development of a new, more effective radar missile, the Air Force has directed the F-16 contractor to provide the space, weight, power, and cooling provisions necessary for such incorporation.

Air-to-surface mission armament

The F-16 air-to-surface armament includes the Maverick missile, a close air support antiarmor weapon. It will also carry a variety of guided and unguided bombs and will be certified to carry nuclear weapons. Currently, the Air Force considers the F-16 mission to be 50-percent air-to-air and 50-percent air-to-surface.

SCOPE

Our review was made at Headquarters, USAF, Washington, D.C.; Headquarters, Tactical Air Command, Langley Air Force Base, Virginia; F-16 Air Force Flight Test Center, Edwards Air Force Base, California; and the F-16 SPO and the Joint Engine Project Office at Wright-Patterson Air Force Base, Ohio. We also obtained information from the F-16 prime contractors--General Dynamics, Forth Worth, Texas; and the Pratt & Whitney Aircraft group of United Technologies Corporation, West Palm Beach, Florida.

CHAPTER 2

TESTING AND PERFORMANCE

On October 13, 1977, the Deputy Secretary of Defense approved F-16 full production. It was recognized that the Air Force has a large amount of development and operational test and evaluation to be accomplished, but that on the whole the program was ready to enter full production. The following discussions address test background, Defense Systems Acquisition Review Council IIIB (DSARC IIIB) test requirements, engine and aircraft testing results, survivability/vulnerability and the potential implications of recent tests on the F-16.

TEST BACKGROUND

The F-16 full-scale development test program was constructed to prove that the advanced technology features of the prototype F-16 can be incorporated into the F-16 at low risk, and that the F-16 weapons system can meet its performance goals and minimize acquisition and life cycle costs while successfully accomplishing its operational role.

The full-scale development test program is an integrated effort including contractor and Air Force development, test, and evaluation (DT&E) and initial operational test and evaluation (IOT&E).

DT&E flight tests are conducted by a Joint Test Force that includes representatives from General Dynamics and various Air Force organizations. The Joint Test Force Director is responsible to the Air Force Flight Test Center Commander for providing operational control of the Joint Test Force and to the F-16 SPO for implementing direction.

The Air Force Test and Evaluation Center (AFTEC), an independent test organization, manages F-16 operational test and evaluation that consists of the IOT&E phase before the DSARC IIIB decision and a subsequent follow-on test and evaluation phase. AFTEC operational test and evaluation team members also participate in the F-16 Joint Test Force.

DSARC IIIB TEST ASSESSMENT

To reduce risks to a point where a realistic production decision could be made, DSARC II established test milestones that had to be accomplished before the DSARC IIIB decision. During the full-scale development test program the Air Force made minor revisions to the lightning, component damage tolerance, and IOT&E test milestones. In making these revisions some of these tests were scheduled to be established after DSARC IIIB.

In the DSARC IIIB technical assessment the SPO concluded that using preliminary flight test data, the current configuration of the F-16 and a future F-16, with a possible 552 pound weight growth will meet or exceed all the performance thresholds cited in the July 1977 F-16 DCP.

In AFTEC's IOT&E assessment and the SPO's overall test assessment, both organizations recognized that problems were experienced during the test program and corrective action was being proposed and taken. After a review of the problems and corrections, both organizations concluded that F-16 testing was sufficient to justify full production approval at DSARC IIIB.

F-16 PERFORMANCE CONCERNS

At DSARC IIIB the Air Force was particularly concerned about F100 engine problems and various problems experienced during F-16 full-scale development. Since the F100 engine powers both the F-16 and the F-15, the F-15 engine problems have the potential of occurring on the F-16. While the engine problems experienced on the F-15 are serious, the same problems could be significantly more serious on the F-16 since it has only one engine compared with two on the F-15. Although the F100 engine in the F-16 has not experienced as many problems as it has in the F-15, F-16s have only about 1,500 flight hours of F100 use. Further, the F-16/F100 usage was experienced in a full-scale test environment, which does not equate to the F-15/F100 operational environment. Until more experience is obtained in engine use in an F-16 operational environment, the Air Force cannot be assured that engine problems experienced in the F-15 will not be experienced in the F-16. Because of the situation there are changes being made to the F100 engine which will be used in the F-16.

Concurrent F-16 development and production magnifies the importance of these problems since any change in the development design after production starts will cause a corresponding change in the production article. Consequently, there is risk in starting production before design is complete. F100 engine and F-16 full-scale development problems are discussed below.

Engine problems

The F-16 is powered by a single Pratt & Whitney F100 turbofan engine. The F100 engine, which was originally developed for and is now operational in the F-15, was determined to be fully qualified in October 1973. As of September 8, 1977, the engine had accumulated more than 200,000 operating hours and 100,000 flight hours, as shown below.

F100 Engine Operating and Flight Hours as of September 8, 1977

Program	Total operating hours	Flight hours
F-15	172,852	100,168
F-16	3,021	1,489
Development and component improvement program	38,776	-
Total	214,649	101,657

F100 engine experience shows the following engine deficiencies are causing operational effectiveness, safety, and maintenance problems:

--Turbine blade failures and noncontainment of turbine blades in engine.

--Engine stalls.

--Engine stagnations.

--Main fuel pump malfunctions.

--Ground starting problems.

--Augmentor malfunctions and durability problems.

These are serious problems for the twin-engine F-15; but they can be even more serious for the F-16 because it is a single-engine aircraft. Historically, twin-engine aircraft have maintained a major engine-related safety advantage over single-engine aircraft due to the redundance offered by the second engine.

Under the F100 Component Improvement Program (CIP), funds are being provided to Pratt & Whitney to correct the engine problems. However, we were advised that funding limitations may preclude the F100 engine from reaching its full potential.

The following is a more detailed discussion of the engine deficiencies and corrective actions.

Turbine blade separations and noncontainment of separated blades in engine

The F100 engine is designed to contain broken compressor and turbine blades in the engine. Through April 15, 1977, there have been 14 second-stage turbine blade separations in operational and test flight engines, of which 4 have actually gone through the engine containment structure. Separation of a turbine blade requires engine shutdown. Although this alone may cause an F-16 loss, failure to contain a turbine blade increases this possibility because the fuel tank is located above the engine.

The contractor has determined that high vibration stresses, fuel nozzle contamination, and electronic engine control (EEC) malfunctions have caused the blade separations and has initiated corrective action.

Investigations of the noncontained turbine blades have shown that three of the four incidents resulted from an engine overtemperature/overspeed condition because the EEC malfunctioned. In the other incident the engine containment case was found to be below the design specifications. Thirteen other production cases from the same production lot were found not strong enough for containment and were removed from operational engines.

Changes to the engine to increase containment capability have been identified. As yet, no final decision has been made on either option. In the interim, F-16 full-scale development aircraft have belly bands installed on all engines.

Engine stalls

An engine stall is a momentary pause in engine operation that may or may not be self-correcting. A stall which is not self-correcting is called a stagnation, which is discussed in the next section. When a stall occurs, the pilot's attention is diverted to check engine gauges and, if necessary, take corrective action by moving the throttle. The Tactical Air Command (TAC) considers stalls a serious problem, particularly in combat when loss of power can given an enemy aircraft a distinct advantage.

Air Force officials stated that engine stalls are inherent in all jet engines, but their frequency can be reduced. The stall rate of the F100 engine in TAC operations had dropped from 9 per 1,000 engine flying hours in early 1976 to 4.1 per 1,000 engine flying hours at the end of 1977 due to improvements in the current engine configuration.

A device capable of reducing the engine stall rate is being developed. The device, known as the light off detector, automatically reduces the potential of an augmentor-induced stall when engine conditions are conducive to cause one. Yet, after the light off detector is actuated and eliminates the stall, the pilot must move the throttle to intermediate power before returning to augmentation. TAC believes this may be an undesirable recovery system because in both the F-16 and F-15 the delay in reaching the desired thrust caused by recycling the throttle--not to mention the distraction--could adversely affect the outcome of an aerial combat encounter.

The Air Force is continuing efforts to reduce the engine stall rate and plans to take the pilot out of the corrective actions to the extent practical.

Engine stagnations

Engine stagnation is a condition which to date can only be corrected by shutting down the engine and restarting it. The August 1976 Follow-on Operational Test and Evaluation Final Report on the F-15 disclosed that simulated air combat engagements were lost while pilots were checking gages and performing engine shutdowns and restarts after stagnations. TAC has advised that the performance and safety effects of a stagnation on the F-16 is of upmost concern to them.

Stagnation, which may occur anywhere in a flight envelope but most frequently at high altitude and low speed, is caused primarily by augmentor blow-out and automatic reignition.

When a stagnation occurs and the engine is shut down, an F-16 pilot must be able to effect an aerial restart if he is to avoid an emergency landing or ejection. This is critical in all F-16 missions, the stagnation rate for the current engine configuration in TAC operations is 2.3 per 1,000 engine flight hours. While Air Force officials said it will be extremely difficult to make an engine that will never stagnate they are confident that the rate of stagnations can be significantly reduced.

To reduce the number of stagnations, various corrective actions to the EEC, unified fuel control, fuel nozzle, and other engine components have been and are being tested. Results of testing to date indicate a potential stagnation rate reduction to 1.3 per 1,000 engine flight hours. With additional corrective actions to be tested, the Air Force hopes to reduce stagnations to .5 per 1,000 engine flight hours in 1979.

Main fuel pump malfunctions

The main fuel pump has a current CIP goal of 750 to 1,000 operating hours, and, at engine maturity, a specification requirement of 4,000 hours. From December 1976 through 1977 there have been 40 main fuel pump malfunctions resulting in 26 F-15 single-engine landings. The exact cause of the reduced pump reliability is cavitation at low flow and subsequent metal errosion. The immediate corrective action was to revert to a previous production configuration which will reduce the maximum operating hours of the pump to between 400 and 500 hours. All F-15 and F-16 aircraft are flying with this particular pump.

Because of concern over single-engine aircraft safety, plans are underway to develop an alternate dual-element main fuel pump which features inherent pumping redundance. The estimated incorporation date is February 1980. This means that 127 F-16s (81 for the U.S. Air Force and 46 for the Europeans) will not have the dual-element main fuel pump until that date.

Ground starting problems

Some F100 engines do not start on the first attempt to start a cold engine. Subsequent attempts tend to be more successful as the engine warms up. Until corrected, this could be a serious problem in the event of war.

As of August 31, 1977, 31 of over 700 delivered engines have exhibited this problem, of which 14 would not start until their compressor seals were refurbished. Corrective actions taken to date have been procedural. Air Force officials advised that these are near-term solutions and investigation is still underway to develop a permanent solution.

Augmentor malfunctions and durability problems

The August 1976 Follow-on Operational Test and Evaluation Final Report on the F-15 aircraft reported that several engine malfunctions greatly degraded F-15 effectiveness during air combat. Specifically, the augmentor did not always ignite or had late ignitions and blowouts, which decreased performance. Further, the late ignitions created a 100- to 200-foot torch behind the aircraft, which marked its position.

The currently configured lot IV engine improved augmentor ignition and reduced blowouts. Yet through July 1977 38 percent of these engines have experienced inconsistent augmentor operation during F-15 acceptance tests. This has been reduced to 5.5 percent from August 1 through November 17, 1977.

Through July 1977 the F100 engine experienced 223 F-15 stagnations, of which 76 percent occurred while the augmentor was in use. Because of the augmentor problems and related engine stagnations, a fix has been incorporated that automatically changes the maximum amount of augmentation available while flying in a portion of the flight envelope. Currently, the F-16 pilot is restricted in using the augmentor. The air Force is hopeful that these restrictions will be lifted as the problems are corrected. (See p. 13.)

In addition to these performance problems, the augmentor/nozzle module has experienced thermal and fatigue durability problems that have contributed to increased operational maintenance requirements. Improved components have been demonstrated, but many efforts in this area have been deferred until higher priority problems have been resolved.

Effect of engine problems

In early 1977 the Air Force requested that Pratt & Whitney prepare a report on projected F-16 losses based on actual engine experience in the twin-engine F-15. Pratt & Whitney projected 16 losses per 100,000 flying hours in their first report and 15.6 losses per 100,000 flying hours in their second report (dated July 19, 1977).

In making these projections, it was assumed that if a problem which would result in a F-16 loss was identified and corrective action implemented, all later incidents would not occur. For example, of the 26 F-15 single-engine landings caused by main fuel pump malfunctions, two occurred before corrective action was implemented in the fleet. It was assumed the F-16 fleet would be grounded after the first two losses until a fix was incorporated.

Since this estimate, several additional estimates have been made to include consideration of corrective actions already implemented or that are to be implemented. As a result of F100 engine experience on the F-15 aircraft several modifications have been made to the engine. These changes have been considered by the USAF in estimating a projected 9.7 loss rate per 100,000 flight hours for the F-16. After additional corrective actions the Air Force is predicting a further decrease in the engine loss rate. The Air Force Inspection and Safety Center projects an engine-caused loss rate of 3.5 to 5.5 losses per 100,000 engine flight hours, and the F-16 Systems Program Office projects a rate of 2.9 losses per 100,000 engine flight hours. A third assessment is based on actual F100 engine experience accumulated in the F-15 aircraft, which assumes that once an engine problem is identified and corrective action is implemented, all later projected incidents will be discounted by the estimated effectiveness of the corrective action. This assessment includes 113,000 hours of flight experience through September 1977, and results in a projection of 4.3 hazardous failures per 100,000 engine flight hours when the F-16 is introduced in the inventory.

The F-16 specification goal for F-16 loss due to engine malfunction is 1 per 100,000 flight hours after the aircraft has accumulated 200,000 flight hours. As discussed above, the most optimistic estimated loss rate is about three times higher than the specification goal. Although the F-16 projected loss rate due to engine malfunctions is high compared to the specification goal, they are in line with actual loss rates experienced by other single-engine aircraft.

In addition to the projected loss rates, the F-16 is currently restricted in using its augmentor in a portion of its flight envelope. These restrictions were established to assure low risk to the F-16 flight test program in light of the engine's stagnation problem. F-16 production aircraft are not planned to have augmentor restrictions. Current restrictions will be lifted when successful stagnation fixes are incorporated and when the envelope is cleared by flight experience.

Effect of CIP funding limitations

Air Force officials advised that funding limitations, together with the money needed to resolve the problems described above, may preclude the F100 engine from reaching its full potential on schedule.

SPO officials advised that the single-engine safety items needed to decrease the estimated loss rate are fully funded. However, component reliability, durability improvements, and depot repair tasks are either only partially funded or deferred for later years.

Air Force officials said that the funding limitations have come at a time when the complexity of the problems described above requires considerable time and money to resolve. These limitations necessitated extensive deletions in proposed tasks. Specifically, 35 of 144 tasks, 725 engineering test hours, and durability and depot repair efforts were deleted from CIP work for fiscal year 1978.

Deficiencies experienced during F-16 full-scale development

During full-scale development testing the F-16 aircraft experienced deficiencies in crew station qualification, structural integrity, radar operation, flight stability, jet fuel starter reliability, and environmental control system effectiveness.

Crew station qualification

To date the crew station has experienced problems with the canopy birdstrike and canopy/aircrew ejection tests. At 350 nautical miles per hour, the F-16 canopy is required to deflect a 4-pound bird. The full-scale development F-16 is designed with a coated 1/2-inch polycarbonate canopy; this canopy failed during birdstrike tests. After considering various alternatives, the SPO determined that a 3/4 inch polycarbonate canopy with a modified coating will satisfy the birdstrike requirement.

Currently, AFTEC is concerned about the susceptibility of the proposed canopy coating to wind and rain erosion. SPO officials stated that extensive laboratory tests on the proposed coating indicated that a substantial improvement in durability had been created in comparison to earlier coatings. Based on these tests the F-16 SPO estimates a canopy life of 2 to 5 years, which is consistent with other fighter aircraft.

Early crew station ejection tests for the F-16B two-seat aircraft failed since the aft seat and the test dummy collided with the canopy. The contractor corrected the problem by increasing the time between canopy jettison and seat ejection. Accordingly, the pilot escape tests have been completed for the full-scale development ejection system. Tests of the new, heavier canopy are not scheduled until the first quarter of 1978.

Structural integrity

Cracks developed in several bulkheads during durability testing. General Dynamics has made the necessary redesigns to correct the problems. Because of program concurrency, the contractor had begun manufacturing the bulkheads for the first 36 production aircraft before testing disclosed the structural problem. General Dynamics strengthened these bulkheads by adding metal plates. Starting with aircraft number 37, the contractor will install thicker, redesigned bulkheads.

Radar operation

The F-16 radar is a multimode, pulse-doppler radar developed by Westinghouse Electric Corporation that provides both air-to-air and air-to-surface modes of operation. In the air-to-air mode, the radar has a look-up and look-down capability. In the air-to-surface mode, the radar provides air-to-ground ranging, ground mapping, ground map doppler beam sharpening, beacon map mode, and sea clutter modes.

During June and July 1977, operation of the radar in aircraft A-3 disclosed an excessive number of false targets, reduced detection range, and unacceptable doppler beam sharpening. On July 30, 1977, aircraft A-3 was sent to Westinghouse Electric (Baltimore, Maryland) for system improvements.

Since the return of aircraft A-3 to Edwards Air Force Base, the radar has experienced problems with air-to-ground ranging and improper antenna scanning during air combat maneuvering. Although beam sharpening was improved, it still does not operate optimally. Ground mapping and sea modes tested by USAF and Westinghouse showed problems. Although some radar problems were still being experienced, the Air Force considered the F-16 radar to have adequately demonstrated the radar milestone.

Flight stability

High-angle-of-attack testing as of November 29, 1977, indicated that maximum command aircraft rolls in excess of 180 degrees above the 22 degrees angle-of-attack could result in unstable flight control conditions whereby the aircraft starts to rotate in pitch of its own accord. When the angle of attack exceeds 29 degrees the yaw rate limiter in the flight control system automatically changes the control surfaces to prevent a spin.

Since November 29, 1977, high-angle-of-attack flight tests of the F-16 have been conducted with modified flight control computer hardware. Testing has demonstrated that the F-16 pilot can perform unrestricted roll maneuvers up to the required maximum of 25.2-degree angle of attack. Air Force officials state that although the modification caused a minimal reduction in roll performance, the F-16 is still superior to most current aircraft.

Jet fuel starter reliability

The jet fuel starter is a gas turbine that is primarily used to ground start the F100 engine. The power required to crank the jet fuel starter is derived from two hydraulic accumulators, which are adequate for two start attempts under normal conditions and one start under cold conditions (less than 38 degrees fahrenheit).

Only 77 percent of all initial ground starts with the jet fuel starter have been successful. In 10 percent of the starts more than two attempts were required to achieve an engine start. In these instances, the accumulators must be recharged by the ground crew. According to Air Force officials, the unsuccessful starts are due to random component failures; the contractor has initiated corrective action. Inconsistent ground starts with the jet fuel starter could have a detrimental effect on performance when the aircraft is required to be airborne in a short time.

Environmental control system effectiveness

The environmental control system takes bleed air from the engine compressor, conditions the air, and distributes it for cabin and equipment conditioning.

Early in the full-scale development program the Air Force recognized that the F-16A and F-16B heat exchangers had low performance (although adequate for the full-scale development program). Consequently, the Air Force decided that an improved heat exchanger and a revised ram air circuit would be incorporated into production aircraft.

To correct these problems General Dynamics has revised the air distribution in the full-scale development F-16B environmental control systems to simulate the production configuration. Additional air distribution changes have been made to improve defogging capability and to provide the required air to the avionics. These distribution changes will also be incorporated in F-16B production aircraft.

POST-DSARC TESTS

Although the Air Force had about 42 months of YF-16 and F-16 testing experience before the full-production decision (i.e., the DSARC IIIB), only about 10 months of testing was accomplished on full-scale development aircraft. The pre-DSARC IIIB testing does not constitute complete testing of the F-16 aircraft, much more testing is planned and full-scale development testing will not be completed until early 1979. DT&E assessments scheduled to be accomplished after DSARC include the following:

--Air-to-air and air-to-ground gunnery accuracy, missile compatibility, and bombing accuracy.

--Engine air starts using the jet fuel starter.

--Qualification of peculiar F-16 engine modifications (i.e., the backup fuel control and the dual-element main fuel pump).

--Complete qualification testing of F-16 radar, including the built in test, electronic counter-countermeasures, and sea modes of operation.

--Total fire control system accuracy.

--Complete electromagnetic compatibility demonstration, including the penetration aids.

--Completion of various ground tests--lightning, canopy/aircrew qualifications, component damage tolerance tests on the vertical tail, and durability tests of the patched and redesigned bulkheads.

- --High-angle-of-attack demonstrations for post-stall and different external store configurations.

- --F-16B performance and flying qualities tests.

- --Air-to-air tracking.

- --Operational testing on wet runways.

AFTEC's pre-DSARC IIIB tests and evaluations were structured to assess the sufficiency of initial operational testing to support a full-production decision. The extent that AFTEC can conduct operational testing is limited by the overall progress of the DT&E effort--which includes the development of aircraft systems, the installation of the systems in aircraft, and the availability of the aircraft for operational testing. While AFTEC accomplished nearly all planned IOT&E tests, many tests could not be scheduled until after DSARC IIIB. AFTEC's F-16 follow-on test and evaluation (i.e., the post-DSARC IIIB effort) is structured to address specific objectives, including the following:

- --Evaluate the F-16 military utility and operational effectiveness during routine, air-to-air, air-to-surface, interdiction, and close air support operations.

- --Evaluate Air Force maintenance training for the F-16 weapon system.

- --Evaluate the mission completion success probability of the F-16 weapon system for specified missions.

- --Provide preliminary information of F-16 tactics.

- --Identify operational deficiencies.

- --Recommend or evaluate desirable production configuration changes, tradeoffs, improvements, or modifications that would enhance F-16 mission accomplishment.

AFTEC will not test or evaluate F-16 vulnerability during follow-on testing. Pilot reports and data on F-16 performance or characteristics that may affect survivability/vulnerability assessments will be provided to appropriate agencies for their consideration and use.

SURVIVABILITY/VULNERABILITY

During the lightweight fighter program, the competing contractors developed prototypes to demonstrate the feasibility of a low-cost, highly maneuverable fighter for the air superiority mission. During this program there was no USAF requirement to incorporate survivability/vulnerability technology into the design.

In the transition phase from prototype to full-scale development, each contractor conducted survivability/vulnerability studies and prepared a survivability program for an aircraft that would have an air superiority mission with a secondary air-to-surface capability. According to SPO officials, the Air Force evaluated the survivability features of both prototypes during source selection assessment, and incorporated a survivability/vulnerability program in the F-16 contract.

Later, at the direction of Headquarters Air Force Systems Command, an Air Force Independent Survivability Review Team evaluated F-16 characteristics.

As a result of the concerns expressed by the review team, the Air Force directed the contractor to accelerate its planned reassessment of F-16 survivability and vulnerability. In a June 1976 report, the contractor discussed the effect that four vulnerability reduction modifications would have on the F-16.

The F-16 SPO has subsequently made another analysis of F-16 survivability and vulnerability. Unlike the other F-16 survivability and vulnerability analysis, the SPO analysis did not contain a recommendation, but a conclusion that placed the initiative for any followup action on the Configuration Steering Group. The SPO analysis concluded that, if improvement in the present F-16 survivability is desired, two modifications would be cost/mission effective.

Neither modification can be incorporated in the first and second block of production aircraft. Incorporation in subsequent production blocks and retrofit of the first two blocks will depend on the results of further testing. If approved, these modifications will increase F-16 program costs.

POTENTIAL IMPLICATIONS OF RECENT AIMVAL/ACEVAL TEST ON THE F-16

cently, the Air Intercept Missile Evaluation/Air Combat Evaluation (AIMVAL/ACEVAL) was completed at Nellis Air Force Base. This joint test program was created with Air Force and Navy participation, to develop performance characteristics for a common Air Force/Navy short-range missile and to provide quantitative data on multiple aircraft engagements in the close-in visual arena. While the F-16 was not directly involved in this test program (Blue forces flew F-14 and F-15 aircraft and Red forces flew the F-5E), overall conclusions and observations will affect the F-16 program because of similarities in equipment and because the F-16 was designed for combat by vision.

Under the conditions tested, important operational limitations were disclosed for armament that the F-16 and other fighter aircraft will or possibly could carry. One recommendation of the Joint Test Force (JTF) conducting the program is that new short-range missile seeker technologies be investigated and that a new medium-range, active radar missile be developed. Without such improvements in air-to-air armament, the JTF believes that U.S. fighter capabilities could be severely limited. Also, JTF noted that the single most important factor in the outcome of a close-in visual air engagement is numerical superiority. While advanced avionics technology can aid engagement options and responses, a numerically superior enemy with the capabilities postulated for the mid-1980s can produce high, and conceivably unacceptable, loss ratios.

CHAPTER 3

PROGRAM SCHEDULE

On October 13, 1977, the F-16 was approved for full production as a result of the DSARC IIIB program review. Although the F-16 program accomplished the final decision milestone in the Defense acquisition process, program problem areas remain to be resolved.

Concurrent production while development and testing are in progress has created an element of risk in the F-16 program. Design problems have caused schedule slips in important subsystems which could affect the capabilities of early-production aircraft. Furthermore, an ambitious and concurrent deployment schedule will create support problems throughout the program.

PROGRAM MILESTONES

The F-16 DSARC IIIB briefing was held on October 11, 1977. On October 13, 1977, the Deputy Secretary of Defense, while recognizing program accomplishments and concerns, approved F-16 full production.

The September 30, 1977, Selected Acquisition Report shows the following F-16 program milestones remaining:

Event	Date scheduled
First flight-production aircraft	Aug. 1978
First aircraft to TAC	Sept. 1978
Delivery of 100th production aircraft to USAF	May 1980

Although the first production F-16 will not be delivered until August 1978, DSARC IIIB represents the final DSARC review for the entire program. Currently, fundamental program issues remain undefined, and there are no firm milestones established for resolving them.

The principal undefined program issues are:

--Initial operational capability (IOC)--F-16 program schedules indicate that the first F-16 unit will achieve IOC in mid-1980. This is not an approved date for IOC, and is not a program milestone. Although 186 F-16s will have been delivered to USAF by the end of 1980, Defense has not established a firm IOC date for the F-16 program, and has not defined the requirements for F-16 operational capability for initial F-16 units.

--F-16 mission effectiveness--Although USAF intends to use the F-16 equally in both the air-to-air and air-to-surface roles, these plans are based on performance characteristics, analysis, and limited operational testing. TAC cannot assess its mission effectiveness until January 1979 when it accepts delivery of the first production aircraft. Integration testing with other aircraft will not begin until January 1980.

--Follow-on purchase--Under the Memorandum of Understanding, USAF is committed to buy 650 F-16s and plans to buy 738 additional aircraft. The DSARC IIIB decision approved an Air Force F-16 program of 1,388 aircraft with deliveries extending into 1987. Aircraft introduced into the inventory at this time will face a different environment and threats than the F-16 was designed to meet. Considering the length of the program, the testing yet to be accomplished and the changing operational environment a formal review is desirable.

PROGRAM CONCURRENCY

The basic F-16 program schedule established by USAF and European delivery requirements has caused some degree of concurrency between full-scale development, production, and deployment. This has created an element of risk for the F-16 production program, and could complicate the correction of subsystem design problems. These areas are discussed below.

Concurrency implications on production

Because of production lead time and early F-16 delivery requirements, a large number of production components were scheduled for manufacture during the full-scale development program. This situation was compounded by the need to provide production components to European manufacturers to support their schedule requirements. Problems encountered during development testing will have to be corrected on the production aircraft. This may require engineering and design changes and new manufacturing procedures on the production line. It also requires that completed components be changed to meet the new design.

An example of this situation occurred during structural tests when a number of cracks developed in four center fuselage bulkheads. Although the problem was identified and corrected early in the development test program (July through August 1977), the redesigned bulkheads are not incorporated until the 37th production aircraft.

Incorporation of changes to correct problems disclosed in tests will probably continue throughout the test program. Problems encountered later in the test program will require a greater amount of retrofit effort and have a much greater effect on program cost and schedule. For example, by the completion of most development testing in December 1978, forward fuselage assembly will be completed for 56 production aircraft, and 40 more will be in progress.

The schedule and cost risks inherent to the F-16 production program were the principal concern of the Program Office at the DSARC IIIB briefing. The effects of concurrency between the test program and production are likely to continue throughout the early years of F-16 production, and will require extensive management attention.

Subsystem design problems

Three important F-16 subsystems--the radar, the stores management system, and the avionics intermediate shop--have experienced development design problems that have already caused schedule slips. These systems have not yet completed initial testing, and correction of test problems will have an increasing effect on production schedules. Further schedule problems may affect the performance or supportability of early-production aircraft. DSARC concern with these areas resulted in the Deputy Secretary of Defense directing the Air Force to conduct followup assessments of these systems in the memorandum documenting the F-16 full-production decision.

Radar

Correcting performance problems has resulted in numerous design changes in F-16 radar, and has caused a delay in delivery of early-production units. Radar qualification testing will not be complete until February 1978. At that time

21 radar units will be in production and will be affected by any additional design changes. If additional qualification or flight test problems arise, further radar delivery schedule slips are likely.

Stores management system

The F-16 stores management system coordinates weapon delivery and inventory with other aircraft systems (such as radar and optical displays). The stores system completed a major redesign in the fall of 1976, and new capabilities were added during the development program. As a result, the system design is still not finalized, and the stores management manufacturing effort is 3 months behind schedule. Although production components are being delivered, flight testing the stores system has just begun its initial phase and will not be complete until December 1978.

Although SPO officials feel that the stores management system will be ready for the first-production F-16, they are concerned about the overall production effort and consider the delivery schedule to be a critical concern.

Avionics intermediate shop

The F-16 avionics intermediate shop (AIS) consists of four separate units of computer-controlled electronic test equipment to be used for aircraft maintenance at F-16 bases. AIS development problems on other weapons systems led to the F-16 program contracting with the manufacturer for support of early operational aircraft, and a phased development of organic support capability.

Because the AIS test capability must be tailored to the unit tested, development changes in F-16 electronic components require subsequent changes to AIS. The basic design will not be finalized until after the first production aircraft is delivered in August 1978. At that time 14 sets will be in production.

The AIS design problems resulted in schedule slips throughout the development program. Although the current schedule calls for delivery of the first production unit as originally planned, SPO considers this schedule to be optimistic and anticipates late delivery of some early-production equipment.

SUPPORT CONCERNS

To meet the delivery schedules established in USAF planning documents, the F-16 Memorandum of Understanding, and the foreign military sales agreement with Iran, the F-16 production program has a rapid initial buildup. F-16 deployment will require that seven bases be opened in six countries in 18 months. The diverse locations of these bases will compound the Program Office's efforts to assure adequate support for the aircraft. The following chart shows the number of production aircraft, and the number of different base locations during the early F-16 deployment.

Calendar year	Cumulative number of production aircraft	Cumulative number of aircraft bases
1979	90	3
1980	312	8
1981	642	14
1982	1,087	22
1983	1,560	29

An Air Force official conceded that no modern fighter program faces the potential early support problems posed by the F-16 deployment schedule.

At the DSARC IIIB briefing, F-16 support/deployment was the only major program element that SPO did not consider satisfactory. While stating that the F-16 was ready for production, it was pointed out that the support and deployment areas contained inherent risks. This briefing and other F-16 assessments identified areas of concern in the F-16 support and deployment areas. These concerns are discussed below.

--Program concurrency--Schedule concurrency between development, production, and deployment increases the risk of placing a new system in the field. It takes time to establish the reliability and maintainability of any new system, and to adjust the maintenance effort to the problems. The heavy deployment schedule means that hundreds of aircraft will be affected by routine initial problems. This will create a heavy demand for specific spare parts, will increase maintenance manhours, and will reduce flight hours.

--Avionics intermediate shop--AIS is designed to support aircraft maintenance at F-16 bases. Presently the AIS development and production schedules are success oriented, with no slack to compensate for future problems. Late AIS delivery may not limit the supportability of early aircraft because of provisions for contractor support. Extended development problems could affect the test capability at early bases and delay USAF development of the maintenance capability.

--Alternate mission equipment--Current planned procurements of alternate mission equipment (i.e., equipment that interfaces the airframe and weapons, electronic countermeasure pods, and fuel tanks) are less than TAC requirements. TAC officials believe if the current planned procurements of alternate mission equipments are not increased it will restrict the air-to-surface mission loadings of F-16 aircraft and will limit their operational capability.

--Maintenance training equipment--The F-16 will use a Mobile Training Set to provide maintenance training for F-16 support personnel. Under the General Dynamics contract the system will have to be designed and built in 12 months. According to Air Force officials the contract provides sufficient production time to meet delivery schedules, but it is not designed with any schedule slack to accommodate design and production problems. Any unanticipated problems could cause late delivery of the trainer. This would force maintenance crew training to begin without the necessary equipment and would degrade the quality of training available.

--Pilot training--TAC will begin to receive F-16 training aircraft in January 1979. The first operational squadron was originally due to reach operational capability in mid-1980. Because of requirements to train European and test pilots, and a low projected use rate for early aircraft, TAC has determined it could not train all the early required pilots on available F-16 training aircraft. To correct this projected pilot shortage, TAC will use the first operational squadron for early pilot training. This will delay IOC by approximately 6 months. Although TAC officials believe this action will be sufficient to meet their minimum requirements for pilot training, they emphasized that these plans depend on aircraft deliveries, support and maintenance schedules, and the number of training flights that can be flown on each aircraft during the first year of the training program. Any delays in support equipment or problems with logistics arrangement could further delay the USAF operational capability.

--<u>Impact of Foreign Military Sales</u>--The F-16 FMS master plan defines USAF's ability to deliver a supportable weapons system for third country sales and establishes ground rules to be met by future sales. The memorandums documenting the DSARC IIIA and DSARC IIIB decisions both stress the importance of following these ground rules. The current sale to Iran was approved despite USAF's opinion that the early deliveries to Iran would create a very high risk for the entire F-16 program. At present, however, additional F-16 sales are being contemplated that violate master plan guidelines. Both the Program Office and TAC have expressed concern over the effect of F-16 FMS, particularly if they occur outside the FMS master plan guidelines. SPO is concerned with the effect of such sales on F-16 deployment, support, and multinational program commitments. TAC has expressed concern that the F-16 FMS program is not being centrally focused or managed. TAC feels that successful deployment of USAF and EPG F-16s requires strict adherence to the FMS master plan, and that any future deviations would create severe testing, training, support, and schedule problems.

This view was endorsed by the Office of the Secretary of Defense in the F-16 DCP signed on November 29, 1977, which states that it is imperative that the master plan be followed when accepting additional F-16 third country sales.

CHAPTER 4

COST STATUS

Our review of the cost of the F-16 program has shown that the September 30, 1977, SAR understates estimated program costs by about $1.31 billion. We found that the F-15 budget does not have complete estimates for alternate mission equipment, PAVE PENNY capability, and we believe, the F-16 engineering change order allowance is too low to fund probable production line changes. We also found that TAC and the F-16 SPO have identified additional requirements which, if approved, will further increase costs. Finally, the design-to-cost estimate presented at DSARC IIIB is $206,000 greater than its goal. This, however, is not a valid measure of cost control because the estimate's overhead cost is based on more aircraft than the goal and does not include nonrecurring costs as originally intended. A more detailed discussion of these findings follow.

BEST ESTIMATE NOT REFLECTED IN SARs

The cost estimates presented at DSARC IIIB were not approved by OSD until the budget review cycle was completed in December 1977. Although DSARC IIIB costs are subject to change, they represented the Air Force's best estimate at that time and, we believe, should have been presented in the September SAR as an Air Force estimate not yet approved by OSD. Otherwise, the Congress is not notified of potential program cost growth in a timely manner.

The F-16 program cost estimate prepared in September 1977 and briefed to DSARC IIIB in October 1977 and the September 1977 SAR are shown below.

Total Program Cost

(in millions of then-year dollars)

Program	SAR September 30, 1977	DSARC IIIB briefing	Increase
Development	$ 891.1	$ 1,004.9	$ 113.8
Procurement	12,942.2	14,142.3	1,200.1
Total program	$13,833.3	$15,147.2	$1,313.9

Of the $1.31 billion dollar increase, about $1.28 billion represents escalation. The remaining increase represents program changes, changes in estimating methodology, and reprograming of interim contractor support.

POTENTIAL COST GROWTH AREAS

The F-16 budget does not have complete estimates for alternate mission equipment (AME) and a PAVE PENNY (laser target identification system) capability. An additional $164.7 million will be needed for these items. We believe this situation will cause the F-16 program cost to increase further.

Incomplete estimates for AME and interface

AME includes such items as fuel tanks, pylons, missile launchers and adaptors, bomb racks, electronic countermeasure adaptors, and various interface units. The type and quantity of AME an aircraft uses depends on the aircraft's mission.

When the F-16 airframe contract was negotiated, the Air Force and General Dynamics viewed the F-16 as having primarily an air-to-air mission. Accordingly, General Dynamics proposed quantities of AME consistent with the F-16 perceived role. The Air Force subsequently changed the F-16 mission to a swing fighter with a 50-percent air-to-air and a 50-percent air-to-surface capability.

As a result of the changed mission, the quantity of AME supplied under the F-16 contract does not satisfy TAC requirements. If the Air Force buys the additional equipment TAC wants, the estimated cost of AME equipment will increase $128.3 million (then-year dollars).

As with AME, the F-16 budget includes only part of the total funds needed for a PAVE PENNY capability. PAVE PENNY is a laser target identification system. Although the actual PAVE PENNY pods are being funded by the PAVE PENNY SPO, the F-16 internal capability to accept PAVE PENNY is funded by the F-16 SPO. While the September 30, 1977, F-16 SAR includes an estimate of $4.2 million for PAVE PENNY interface cost, SPO officials concede that an additional $36.4 million will be needed.

They explained that PAVE PENNY is one of several laser target identification systems that could be used on the F-16; PAVE PENNY being the least expensive of the available options.

The F-16 DCP required that the F-16 have the necessary space, weight, power, and cooling provisions for PAVE PENNY. The interface cost was funded to avoid a much more expensive retrofit cost should OSD require that the F-16 have a laser target identification system.

POTENTIAL NEW REQUIREMENTS

TAC and the F-16 SPO have identified additional requirements they would like to incorporate in the F-16 aircraft. Presently, there is uncertainty about the benefits and penalties associated with each.

When the F-16 program began full-scale development in January 1975, TAC had not prepared a Required Operational Capability (ROC) for a lightweight fighter. More than a year later TAC issued a ROC for the F-16 aircraft, identifying requirements for an internal (rather than podded) electronic countermeasures set, a new beyond-visual-range missile, and an engine diagnostic system. The ROC also requires that consideration be given to a NAVSTAR/Global Positioning System receiver and contain space provisions for a digital data link system so that it can be interfaced with the Joint Tactical Information Distribution System. Furthermore, the F-16 SPO is strongly advocating development of a digital electronic engine control as a replacement for the present engine control. They believe the digital electronic engine control has potential for major life cycle cost savings.

Configuration Steering Group officials stated that the final decision to incorporate new requirements will be predicated on cost-effective considerations. This, in turn, will be constrained by budget limitations and the Congress willingness to approve the additional funding.

DESIGN TO COST

Design to cost is a management concept wherein a cost goal is established to control program costs by tradeoffs between performance, cost, and schedule. Cost, as a key design parameter, is supposed to be reviewed on a continuing basis as an inherent part of the acquisition process.

The design-to-cost goal must be expressed in constant dollars, be based upon a specific production quantity and rate, and establish firm ground rules on cost elements included in the goal. Accordingly, design-to-cost estimates should be based on the same assumptions and ground rules as the design-to-cost goal.

The F-16 design-to-cost estimate presented at DSARC IIIB was $4.761 million per aircraft (fiscal year 1975 dollars), $206,000 greater than the $4.555 million goal. This estimate includes an allocation of overhead to the 160 Iranian F-16s and to some long lead-time items for the planned follow-on USAF buy in addition to the 650 USAF aircraft on which the original goal was established. As a result the current estimate should not be used to measure progress in achieving the established goal.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Our review disclosed that the remaining program milestones are not adequate measures of program progress--despite identified program risks, engine performance problems, and threat uncertainties. Under current acquisition procedures DOD is not required to conduct a formal program review for the purchase of 738 additional USAF F-16s; program cost reports need improvement and additional foreign military sales may have an adverse effect on the USAF F-16 program.

INADEQUATE PROGRAM MILESTONES

The DSARC IIIB decision was the last management milestone currently established for the F-16 program. The three remaining SAR milestones represent primarily delivery schedule events rather than management decision points. Despite known engine problems, the importance of remaining flight testing, and identified production and support risks, no milestones have been established to measure progress in these areas.

IOC is an effective measure of program progress, particularly in areas of logistics and support. USAF has not established a firm date for the first tactical unit to achieve IOC, and it has not established criteria for determining F-16 IOC.

Although USAF intends to use the F-16 equally in both the air-to-air and air-to-surface role, this designation is based on basic performance characteristics and has not been validated through operational testing. TAC will not begin to assess mission effectiveness until January 1979, and will not begin to determine how the F-16 will integrate with other aircraft until January 1981. There is no firm date for establishing initial aircraft mission effectiveness and operational use, although over 325 aircraft will be delivered by the end of 1981.

We recommend that the Secretary of Defense require the Secretary of the Air Force to review the post-DSARC IIIB F-16 program schedule, to identify management decision points and key indicators of program progress, and establish them as program milestones in the DCP. This should be done to establish firm management goals and realistic measures of program progress for the 650-aircraft program.

ADDITIONAL F-16 PURCHASES

USAF currently plans to buy 738 F-16s in addition to the 650-aircraft commitment in the Memorandum of Understanding (MOU). This purchase would require F-16 production through 1987. Aircraft entering service at this time will encounter a different environment and different threats than the F-16 was designed to meet. Accordingly it may be necessary to revise the operational concepts of the F-16 to meet changing conditions.

The need for such a reassessment is strongly indicated by the recent results of the joint Navy and Air Force AIMVAL/ACEVAL test programs. The AIMVAL/ACEVAL JTF concluded that, in order to meet a postulated threat, U.S. aircraft will need new and/or improved armament and tactics. The results of those test programs (which involved substantial evaluation of many facets of air-to-air engagements, including tactics, armament and varying force sizes) will undoubtedly have some implications for the F-16.

F-16 production approval was given despite identified program risks and engine performance problems. Because the aircraft's mission effectiveness has not yet been established, it is too early to adequately assess its ability to combat the post-1987 threat environment.

We therefore recommend that the Secretary of Defense require a complete program review before making any commitments for USAF F-16 purchases beyond 650 aircraft. This review should include an updated threat assessment and a comparison of F-16 performance to the updated threat under realistic operational conditions. In addition, the program assessment should include an evaluation of the supportability and the producibility of the F-16 aircraft consistent with the F-16 MOU and F-16 FMS agreement(s).

PROGRAM COST REPORTS NEED IMPROVEMENT

Defense instructions and Air Force regulations preclude reporting accurate and timely cost information on SARs unless it is first approved by OSD. For the F-16 program, OSD cost approval has come when the budget review cycle is completed in December. Accordingly, the December SAR reflects the approved OSD cost position. This procedure has caused some F-16 SARs to be inaccurate and misrepresents the status of the F-16 program cost. For example, the costs in the September 30, 1977, SAR are understated because they do not include $1.31 billion for increased escalation and program changes experienced since December 1976.

The F-16 budget does not have complete estimates for alternate mission equipment and a PAVE PENNY capability.

We recommend that the Secretary of Defense revise SAR instructions to provide not only the reporting of the OSD-approved program cost estimate, but also the services' best program cost estimates. This would surface any major cost changes and promptly alert the Congress.

The F-16 design-to-cost (DTC) estimate presented at DSARC IIIB was $4.761 million per aircraft (fiscal year 1975 dollars)--$206,000 greater than the $4.555 million goal. This, however, is not a valid measure of cost control because the estimate is based on a larger number of aircraft than the goal and does not include nonrecurring costs as required. Accordingly, we recommend that the Secretary of Defense initiate actions to assure that the DTC estimate and goal are compared under consistent ground rules.

FOREIGN MILITARY SALES EFFECT ON USAF PROGRAM

If additional sales to third countries occur outside the current F-16 FMS master plan, the Program Office and TAC are concerned about the effect on USAF's ability to support its own aircraft. Because of F-16 coproduction commitments, such sales could also affect USAF F-16 production and cost.

The F-16 FMS master plan provides ground rules for future F-16 sales to third countries. These guidelines represent USAF's best judgment of the criteria to be applied to future F-16 FMS sales. The DCP, signed by the Deputy Secretary of Defense, states that it is imperative that the master plan be followed when accepting additional third-country customers. Nonetheless, political pressure for F-16 FMS could result in proposals for sales outside the master plan.

We therefore recommend that the Secretary of Defense require that any request for congressional approval of future F-16 FMS use the original F-16 master plan guidelines as specific criteria for assessing the sale's effect on the USAF program. This will assist the Congress in understanding the cost and readiness implications of proposed F-16 FMS.

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