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RELEASED

Review Of The Military Qualification Test On The F-15 Engine B-168664

Department of the Air Force

**BY THE COMPTROLLER GENERAL
OF THE UNITED STATES**

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JAN. 3, 1974



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

B-168664 :

CTR The Honorable Les Aspin
House of Representatives

Dear Mr. Aspin:

In accordance with your requests of May 17 and 22, 1973, we have reviewed the events surrounding the April 1973 military qualification test (MQT) for the F-15 engine. The detailed answers to your questions are included in appendix I and are summarized below.

Since January 1973, four attempts have been made to pass the 150-hour MQT.

- The first began January 1973 but was suspended on February 26, 1973, after a turbine blade broke and caused substantial damage to the engine. (See p. 10.)
- The second began April 1, 1973, under reduced operating requirements because stiffened stator blades were being developed and were not yet proven. This test was successfully completed on April 17, 1973. (See p. 11.)
- 1-30* --The third began July 31, 1973, with an engine using stiffened stator blades. On August 21, 1973, the test engine was destroyed after completing about 132 hours of the test. Air Force officials attributed this failure to overheating in the turbine section. (See p. 16.)
- The fourth began September 13, 1973, and was completed October 12, 1973. (See p. 16.)

In February 1973 the engine failed the first official MQT because of a problem in the engine's turbine section. On March 14, 1973, while the first MQT was suspended, another

engine was being tested under high-pressure conditions at another facility. During this test an explosion and engine fire occurred. As a result of these failures, an engineering team recommended that the System Program Office's (SPO's) Engine Qualification Test Review Board relax those test conditions suspected to have caused the problems until improved components could be installed in test engines.

Air Force regulations permit the System Program Director, who is the SPO official responsible for the overall management of the project, to make modifications within the approved program thresholds set forth in development concept papers (DCPs). SPO officials stated that modification of the F-15 engine MQT requirements was within the approved program.

The Air Force modified the speed and altitude conditions of the second test conducted in April because a problem with the fan stator assembly, identified in March 1973, could have destroyed the engine. The primary advantage of conducting the modified test was to assess the basic durability of the engine to give the Air Force a basis to maintain production engine delivery schedules for the first wing of aircraft. A substantial change in the engine delivery schedule could have meant renegotiating the airframe contract which, according to SPO officials, would have substantially increased the program cost. The Air Force, however, did not determine what the increase would have been on the basis that it would not have been possible to do so due to the complex relationships D. 183 between the McDonnell Aircraft Company (MCAIR) and its various subcontractors. The only way to determine the cost would have been through renegotiating a new contract with MCAIR. Under the terms of the contract with MCAIR, it would not have been possible, without a significant waiver or deviation, to accept airframes without engines, since the contract was structured to provide for the delivery of a fully integrated F-15 weapon system.

When the F-15 System Program Director authorized the contractor to perform the modified MQT, he had initially planned to accept the results of that test, with the exception of a test on the fan stator assembly, as fulfilling the contract requirement. Although the modified test was

sucessfully completed, the Air Force directed that the contractor be required to perform another full MQT on the entire engine to meet the original test requirement before the Air Force exercised the production option. On April 25, 1973, the Deputy Secretary of Defense approved a funding allotment for MCAIR and Pratt & Whitney Aircraft Division, United Aircraft Corporation. The funds were to permit both contractors to continue their production for the first wing of aircraft through September 1973 or until a 150-hour engine MQT was successfully completed, whichever occurred first.

As part of the negotiations after the April test, Pratt & Whitney received a \$3 million increase in the ceiling price of lot II engines for the first wing of aircraft and an increase for the engine component improvement program (CIP) from \$56.1 million for 10 months to \$106 million for 12 months, after completing the full MQT. SPO officials stated that the \$3 million increase in the ceiling was the result of the Air Force's intent to maintain the original engine delivery schedule. C.1687

SPO officials, in commenting on this report, said the \$49.9 million increase for CIP was to compensate for the Navy's share of CIP which, we were told, was withdrawn from the program when the Navy decided not to go into production on the F-401 engine. However, our review of the contract showed that the \$56.1 million was a combined amount for both the F-100 and F-401 engines and included both Air Force and Navy participation in CIP. We believe that the \$49.9 million increase was for continuing development in those areas where problems had been encountered during development and specifically during MQT.

A full MQT started on July 31, 1973, on an engine with a modified fan stator assembly. On August 21 a major failure occurred while the engine was being tested at those speeds and altitude points which had been relaxed during the modified test. SPO officials stated that the failure was caused by certain components overheating in the turbine section of the engine. To prevent the problem from occurring in the next test, cooling air was redirected to those components. Testing started again on September 13 and was completed

October 12, 1973. The engine was also tested under the original requirements. The altitude portion, however, was conducted before, rather than after, the sea-level portion. In addition, certain altitude cycles were rearranged to preclude problems related to the test facility. SPO officials said the changes did not conflict with the original test requirements and that the various congressional committees had been informed of the changes made.

5 / 6 When it became apparent that the test could not be completed by September 30, the Deputy Secretary of Defense granted the Air Force an extension and additional funding of \$19 million to MCAIR and \$10 million to Pratt & Whitney through October 1973. SPO officials stated that this decision was based on the results of several Defense System Acquisition Review Council (DSARC) reviews. Of the \$19 million granted to MCAIR, \$11 million was to sustain 1973 efforts; \$8 million was to sustain 1974 efforts and was not connected with the delay.

Since the Air Force did not determine the cost impact of delaying airframe deliveries, it is difficult to assess the relative degrees of risk between the options that were available. The Air Force chose to maintain the original airframe and engine schedules by authorizing partial funding of production efforts through October 1973. These actions, as SPO indicated, resulted in the same risk as exercising the full engine and airframe production options since the termination liability under partial or full commitment is the same. The Air Force's decision to run a modified test and continue production efforts apparently will cost the Government an estimated \$500,000 to \$1 million to rerun the test. Other costs to the Government are the (1) \$3 million increase in the ceiling price for lot II engines which resulted from the delay in completing MQT and from the Air Force's desire to maintain the original engine production delivery schedule, (2) \$49.9 million increase for CIP, to continue development in the areas in which problems had been encountered during development, and (3) increase in additional costs incurred after the first MQT in January 1973, which is believed to have been associated, in part, with the attempts of Pratt & Whitney to pass MQT. These latter costs amounted to approximately

\$53.7 million between February 28 and August 31, 1973, for both F-100 and F-401 development effort.

In our opinion, the Air Force's decision to delay exercising the engine production option until a successful MQT was completed and the decision of the Deputy Secretary of Defense to provide partial funding to permit both Pratt & Whitney and MCAIR to continue production efforts for a limited period were acceptable management decisions in view of the other alternatives available under the terms of the engine contract. The other alternatives would have been to (1) terminate the engine contract or (2) exercise the production option on the basis of a modified MQT. The first alternative did not appear to be either reasonable or practical in view of the stated need for the F-15 weapon system. The second alternative was not desirable because of prior commitments the Air Force made to congressional committees concerning MQT and the need to determine whether there were continuing problems with the engine. Because of its decision, the Air Force was able to continue the program at the original engine delivery schedule with a limited commitment to major future engine and airframe production.

The problems encountered in qualifying the engine for the F-15 are neither unique nor entirely unexpected. During recent years a number of new high-performance engines have been developed for both commercial and military aircrafts. With every attempt to develop engines with greater thrust-to-weight ratios, there have been problems associated with materials and performance. As a rule, these problems have been solved over a period of time through CIPs.

On the basis of the results of DSARC's review of the F-15 engine test program status and a technical examination of the test program performance and its results by the staff of the Office of the Director of Defense Research and Engineering, the Deputy Secretary of Defense, on October 17, 1973, authorized full funding of both the F-15 engine and airframe programs. The engine contractor was also allowed to begin CIP.

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Because the engine development program is critical to the success of the overall F-15 program, we intend to continue surveillance of this program.

We have discussed this report with Air Force Headquarters and F-15 SPO officials and have considered their comments in preparing it.

We do not plan to distribute this report further unless you agree or publicly announce its contents.

Sincerely yours,

A handwritten signature in cursive script that reads "James B. Stacks". The signature is written in dark ink and is positioned below the typed name.

Comptroller General
of the United States

DETAILED RESULTS OF THE
REVIEW OF THE F-15 ENGINE
MILITARY QUALIFICATION TEST
THE ENGINE PROGRAM AND CONTRACT PROVISIONS

The Air Force and the Navy jointly funded the engine development project to develop common-core engines for the Air Force F-15 aircraft (F-100 engine) and the Navy F-14B aircraft (F-401 engine). Although the engine contract provides for developing both Air Force and Navy engines, we restricted our review to the Air Force portion. (See app. II.)

The overall F-15 procurement program, including the engine program, is oriented to achieving demonstration milestones; certain milestones, such as MQT, relate directly to major decisions to authorize production of engines and airframes. A schedule showing program contract milestones is included as appendix III.

The milestones included in the engine contract are inter-related with those included in the airframe contract and the successful completion of the milestones is the basis for program commitments. If the Air Force, as the procuror for both the engines and the airframe, is unable to deliver engines to MCAIR on schedule because a milestone cannot be completed, the contract provides that the Air Force determine the delay and make equitable adjustments as provided for in the changes clause of the contract.

The contractual arrangements with Pratt & Whitney make the successful MQT an important factor for completing the development portion of the contract and for authorizing the production of lot II engines for the first wing of aircraft. The contract required that MQT be completed in February 1973 so that the Air Force could approve the MQT report by May 1973. Air Force approval of the MQT report was a milestone established in the engine contract. The 3 months between completing the test and formal approval were for disassembling and inspecting the engine; analyzing test data; solving minor problems; and preparing, reviewing, and approving a report of the test results.

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The successful completion of the MQT endurance test in February was to result in the following chain of events.

- The production configuration for the engine was to be defined and the first of 59 production engines from lot I was to be accepted. Lot I production is for flight test engines and was authorized in March 1970.
- The production option for lot II engines to be installed in the first wing of F-15 aircraft was to be exercised upon acceptance of the first lot I engine.
- CIP was to be funded with a target price of \$18 million for March through August 1973 which was to begin when the production option was exercised.
- A formal MQT report was to be accepted by May 31, 1973.

If the contractor fails to meet a milestone, the engine contract provides that the Government

- terminate the contract in accordance with the termination clause,
- delay exercising the option to which the milestone relates until the milestone is satisfactorily accomplished, or
- exercise the option if the Government so requires.

Should exercising the option be delayed because the related milestone is not accomplished on time, the contractor may request an equal delay in the production engine delivery schedules but is precluded from obtaining an adjustment to previously negotiated prices for these engines.

The Air Force may direct the contractor to deliver engines with deficiencies before completing all required testing, provided that it is in the best interest of the Government. These engines are accepted with a deviation from contract requirements. Under the correction of deficiencies (COD) clause, the contractor must correct known deficiencies and any deficiencies

later revealed by testing or inspection at no increase in contract target or ceiling prices. The Air Force has currently accepted delivery of lot I engines with deviations; MQT has not been successfully completed. The contractor must retrofit these engines under the COD clause to make them the same as the production configuration at no change in target or ceiling prices. The lot I engines delivered to the Air Force through August 21, 1973, were accepted with an average of 22 deviations 1 of which was the fan stator assembly.

According to the Air Force, CIP is a continuous engineering program funded annually to improve reliability, maintainability, and producibility of the engine after MQT. Before MQT the engineering effort, to arrive at corrective actions for problems and deficiencies, is charged to item I of the contract.

Another important provision of the contract deals with the limitation of the Government's obligation. The limitation of Government obligation (LOGO) clause requires Pratt & Whitney to notify the Air Force, 17 months before each fiscal year allotment date, of the amount of additional funds required for performing the contract. Otherwise, the contractor must continue its effort even though funds will not be available until later years. The contractor will be reimbursed for allowable costs incurred in later years.

SPECIFIC AREAS OF INTEREST

Testing procedures on the F-15 engine with particular attention to the recent MQT completed this April

MQT, which is designed to demonstrate the suitability of the engine for production of lot II engines for the first wing of aircraft, includes inspections, component tests and demonstrations, and a 150-hour endurance test. The endurance test is crucial in qualifying an engine and is considered complete only when the test engine and components are operating satisfactorily at the end of the test.

The requirements and procedures for testing the F-15 engine are outlined in the engine specification and are more specifically set out in a test plan for the engine. The test plan requires the engine to operate for 150 hours--81.25 hours

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at sea-level and 68.75 hours under simulated altitude conditions. The test plan further provides the length of time the engine is to operate under each test condition.

Certain conditions in the test plan for the modified April test were changed from those in the original November 1972 test plan.

The requirement to run the engine at:

--40,000 feet for 38.25 hours at a speed of Mach 1.6 was changed to run for 38.50 hours.

--40,000 feet for 17.6 hours at a speed of Mach 2.3 was changed to 42,000 feet for 10 hours at a speed of Mach 2.2. This modification reduced the pressure at the fan inlet 22 percent at that test point.

--37,000 feet for 12.5 hours at a speed of Mach 2.3 was changed to 40,000 feet for 20 hours at a speed of Mach 2. This modification reduced the pressure 43 percent at that test point.

--46,000 feet for 0.40 hours at excursion to maximum velocity was changed to 51,000 feet for 0.25 hours.

Pratt & Whitney started the modified 150-hour endurance test on April 1, 1973, issued a revised test plan on April 6, 1973, and successfully completed the test on April 17, 1973.

The events, including discussions or correspondence, between the Air Force and the contractor, leading up to the decision to exclude certain test criteria from MQT

In January 1973 Pratt & Whitney began the first 150-hour endurance test which was to conclude the official MQT by February 28, 1973, and result in Air Force acceptance of a test report by May 31, 1973. The test was suspended, however, on February 26, 1973, after completing 81.25 hours at sea level and 13 hours at altitude. Pratt & Whitney stopped the test after a turbine blade broke and caused substantial damage to the engine.

On March 14, 1973, while MQT was suspended, another development engine was being tested under high dynamic pressure conditions at Arnold Engineering and Development Center, Tullahoma, Tennessee. During this test an explosion occurred and a fire started in the engine. Pratt & Whitney engineers attributed this failure to a heavy rub between the first-stage fan stator and rotor, which are both made of titanium. Because of this problem, SPO agreed that all F-15 engine development problems should be reviewed before restarting MQT. Therefore, MCAIR, Pratt & Whitney, and the Air Force established an engineering team during the last week of March 1973 to examine development problems.

The engineering team found that the rubbing of the fan stator and rotor had been identified during the preliminary flight-rating test (PFRT) in February 1972 and on two other occasions during November and December 1972. In early 1972 Pratt & Whitney officials believed that increasing the clearance between the stator and the rotating blades would correct the problem. The rubbing identified later in 1972, however, required additional corrections, including (1) replacing the titanium seals with steel seals to lessen the possibility of fire should a rub occur and (2) stiffening of the first- and second-stage stators.

Because stiffened stators were not available for testing in March 1973, the engineering team recommended that SPO's Engine Qualification Test Review Board relax those test conditions known to create high pressure in the fan inlet which created the rubbing condition. The Review Board and the F-15 System Program Director both agreed on a modified test plan to minimize the risk of damaging the test engine. The System Program Director is the SPO official responsible for the overall management of the F-15 aircraft.

On March 30, 1973, SPO decided that the modified test should begin on April 1, 1973, allowing 24 hours for Pratt & Whitney to revise the test plan and review the program with the test crews. The test was successfully completed April 17, 1973.

The System Program Director had agreed with Pratt & Whitney that the Air Force would accept delivery of lot I engines after the test, recognizing that the fan and several

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other engine components were deficient, and would require correction under the provisions of the contract. The Secretary of the Air Force and the Office of the Secretary of Defense (OSD) believed, however, that previous commitments had been made to the Congress, which necessitated retesting the engine under the original requirements. The Air Force directed SPO to have Pratt & Whitney rerun the 150-hour endurance test according to the original requirements. Because of the commitment the Program Director made to Pratt & Whitney that the Air Force would accept the modified test, if successful, and exercise the lot II option and because the MCAIR contract would be broken if lot II engines were not delivered on schedule, the Air Force officials agreed that the engine and airframe programs must continue at the scheduled pace but with limited funding.

On April 25, 1973, the Deputy Secretary of Defense approved an increased funding allotment for MCAIR and Pratt & Whitney. These funds were made available to permit both contractors to continue their long-leadtime production efforts for the first wing of aircraft through September 1973 or until the engine successfully completed the 150-hour endurance test rerun, whichever occurred first. The Air Force limited its contractual liability with Pratt & Whitney for fiscal year 1973 production to \$38 million and with MCAIR to \$137 million through September 1973.

When it became apparent that the test could not be completed by September 30, the Deputy Secretary of Defense granted the Air Force an extension to October 31, 1973, and authorized additional partial funding of \$19 million to MCAIR and \$10 million to Pratt & Whitney. SPO officials stated that this decision was based on the results of several DSARC reviews. Of the \$19 million granted to MCAIR, \$11 million was to sustain 1973 efforts; \$8 million was to sustain 1974 efforts and was not connected with the delay.

The Air Force said that two reasons for the delay were (1) shutdowns required to clean rust from the engines ingested from test facility walls and (2) the need to replace cracked cooling tubes in the turbine blades. The Air Force considered the latter problem to be a manufacturing problem rather than a design deficiency. An independent Air Force laboratory team and a Department of Defense team formed to study the continued

failure of the F-100 and Navy F-401 engines to meet endurance test objectives confirmed these assessments.

On the basis of the results of the review of the F-15 engine test program status by DSARC and a technical examination of the engine's test results by the Director of Defense Research and Engineering (DDR&E) and by DDR&E, Test and Evaluation the Deputy Secretary of Defense, on October 17, 1973, authorized full funding of both the F-15 engine and airframe programs. The engine contractor was also allowed to begin CIP.

The question of whether or not announced standards are implicit in some binding way in MQT and, if so, the impact of these reduced standards on the contract

The contract specifies that the contractor shall develop the F-15 engine according to contract specification CP 2903, which, by reference, is part of the contract. The specification, besides establishing performance requirements for the engine, also identifies the types of tests to be conducted. SPO officials said the reduced test conditions were handled as part of a testing plan which SPO considers to be part of the contract when approved by the Air Force rather than as part of the specification, since the contractor was still required to meet the specification by later testing of the engine fan stator. The test conditions included in the specification remain a part of the contract and are binding upon the contractor. Rerunning the test to meet contract specifications was necessary to satisfy the terms of the contract.

The question of necessity, extent, and degree of risk taken by the Air Force in April when it was decided to continue engine production while working on a fix for the engine fan stator assembly problem schedule to be completed in September

Several alternatives were available to the Air Force in April. The decision to continue engine production on a limited funding basis while correcting engine problems was made to maintain engine delivery schedules which would satisfy Air Force commitments to MCAIR. If the MCAIR contract was opened for negotiations, SPO expected that a large increase

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would occur in the airframes' cost because engines would not be delivered on time. SPO, however, did not determine what the increase would have been on the basis that it would not have been possible to do so due to the complex relationship between MCAIR and its various subcontractors and that the only way to determine the costs would have been through renegotiating a new contract with MCAIR. Under the contract terms with MCAIR, it would not have been possible, without a significant waiver of deviation, to accept airframes deliveries without engines, since the contract is structured to provide for the delivery of a fully integrated F-15 weapon system.

Under the engine contract terms, three courses were available to the Air Force.

1. Terminate the contract--SPO officials said this course was not reasonable because the F-15 weapon system was needed in countering the projected enemy threat and because the engine was successful in ground and flight testing. In addition, terminating the contract for a major subsystem, such as the engine, would have a major impact on the program.
2. Exercise the fiscal year 1973 production option--SPO officials said this alternative was not desirable before MQT was successfully completed because prior commitments concerning contractual testing requirements made to congressional committees had to be fulfilled. Also, meeting those testing requirements would demonstrate that the engine was ready for initial production.
3. Delay exercising the fiscal year 1973 production option--SPO officials said this approach appeared to involve the least amount of financial risk in view of the success the engine achieved in ground and flight testing. The Air Force believed that an engineering fix could be arrived at for the fan stator design deficiency by September, which would enable the engine to satisfy the original endurance testing requirements.

The Deputy Secretary of Defense ordered a delay in exercising the option for lot II engines. So that Pratt & Whitney could

maintain the same delivery schedule for those engines and prevent renegotiating airframe delivery schedules and prices, the Deputy Secretary authorized funds for both Pratt & Whitney and MCAIR to continue production efforts until September 30, when it was expected that MQT would be completed and full funding authorized. When it became apparent that the test could not be completed, the Deputy Secretary of Defense authorized additional funds to continue production through October 31, 1973.

Because of the initial funding authorization, the Air Force amended its contracts with Pratt & Whitney and MCAIR. The Air Force limited the Government's liability for production engines to \$38 million in case of termination and allotted \$8.75 million for long-leadtime items in addition to \$10 million allotted in October 1972. The Air Force limited the Government's liability for airframe production to \$137 million through September 1973 in case of termination and increased the allotment to \$117 million for the production of 30 airframes and related equipment. SPO officials emphasized that both contractors had continued their efforts under the interim funding authority as if they had received an unconditional go-ahead.

In summary, of the three courses available under the terms of the engine contract, the Air Force chose to delay exercising the lot II option. Delaying the option, according to the contract, allows the contractor to demand an equal delay in the engine delivery schedules. The Deputy Secretary's funding plan, however, permitted maintenance of original delivery schedules yet did not require the Air Force to commit itself fully to either major engine or airframe production. SPO officials said that action resulted in the same risk as exercising the full options, since the termination liability under the partial or full commitment was the same at September 30, 1973. The Air Force did have the opportunity to make additional changes at September 30.

Since the Air Force did not determine the potential cost increase for delaying airframe deliveries, we could not assess what the cost impact would have been if the Air Force had delayed both engine and airframe options and had not maintained the original engine and airframe schedules.

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SPO officials indicated that Pratt & Whitney successfully completed testing on the modified fan stators assembly on July 25, 1973. The full MQT started on July 31, 1973, on a test engine with a modified fan stator assembly. On August 21, 1973, the test engine was destroyed after completing about 132 hours of the endurance test. At the time of failure, the engine was operating at simulated conditions of Mach 2.3 at 40,000 feet, a test point which was relaxed in the second MQT conducted in April. SPO officials said the fan did not cause the problem and was not damaged. They believe certain components in the turbine (hot) section of the engine overheated and caused the failure. To prevent overheating in future tests, cooling air was redirected to those components. This correction, according to SPO officials, was a permanent correction and was approved for production incorporation.

Another engine was made available and the fourth endurance test began on September 13, 1973, and was completed October 12, 1973. The Air Force, however, ran the more difficult altitude portion of the test before the sea-level portion and rearranged certain parts of the altitude portion to prevent problems related to the test facility. The plan was modified to combine high-speed running to reduce the number of severe facility transients.¹ The reduction in facility transients was made to reduce the possibility of human error and the probability of causing certain acoustical phenomena associated with facility transients. In addition, it was to reduce the ingestion of iron oxide (rust) into the engine from the test facility. SPO officials said the change was not in conflict with the original test requirement and that various congressional committees had been informed of the changes that were made.

The question of what possible advantages accrue to the engine contractor and the Air Force as a result of the April MQT

Although the April MQT did not achieve the contract demonstration milestone, it was a successful development

¹The transition from one simulated flight point (mach and altitude) to another which is made by adjusting facility temperature and pressure.

test and included 68.75 engine operating hours at simulated altitude conditions. Because of the test, some advantages accrued to both the engine contractor and the Air Force.

The Air Force was able to continue engine production and to maintain the same delivery schedule for lot II engines, thus precluding a change to the MCAIR contract. In addition, the test provided a basis for accepting lot I engines with deviations to support MCAIR's delivery of flight test aircraft. As of July 31, 1973, Pratt & Whitney had delivered 10 of 31 engines due from lot I and had been assessed a penalty of \$702,000 in profit for delinquent deliveries according to contract terms.

Pratt & Whitney received an added \$8.75 million allotment to continue production for lot II and the ceiling price for lot II was increased by \$3 million. Had the April test not been run and had the Air Force not provided the added funds, Pratt & Whitney could have demanded a change in the lot II delivery schedule. Pratt & Whitney, however, would not have been able to demand a change in negotiated prices for lot II engines even though the engines were to be delivered at a later time. Consequently, Pratt & Whitney might have absorbed any additional costs by the late delivery. Under the fixed-price-incentive-contract arrangement, the Government may have had to absorb some of those costs.

Negotiations after the April test resulted in several changes to the engine contract.

- Long-leadtime funding was extended.
- Lot II quantities were reduced from 78 to 72 engines with appropriate reductions in delivery schedule quantities.
- The computed ceiling price of lot II engines was increased from \$113 to \$116 million.
- Part of the contract was modified. This part dealt with component improvement requiring the Air Force to procure and obligate funds for CIP after MQT was completed if the Air Force elected to exercise the production option.

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In addition, several other agreements were reached which had not been contractually implemented as of August 31, 1973. One of those agreements was that CIP for the first year after MQT would cost \$106 million, instead of the \$56.1 million initially negotiated in 1970.

What would have been the results for the engine contractor and the Air Force if the engine had failed MQT or if the test had not been conducted until the engine fan stator assembly problem had been fixed?

The question addresses the situation which actually occurred in that (1) the modified MQT conducted in April 1973 did not constitute the official MQT concerning lot II production decisions and (2) the official MQT was not conducted until the fan stator assembly problem had been corrected. Pratt & Whitney was required to:

- Continue development for COD under the cost-plus-incentive fee (CPIF) development portion of the contract which, by July 1973, exceeded the target and was at the minimum fee of 2 percent of target cost.
- Finance development costs due to a delay in exercising the CIP and the lot II production option from May 15, 1973. This was the time when the amount paid to the contractor equalled the total funds allotted under the LOGO clause for completing development. As of June 30, 1973, these costs amounted to \$16.2 million and SPO officials estimated that Pratt & Whitney would incur additional costs of about \$23 million by September 30, 1973. Pratt & Whitney had the understanding that it would be reimbursed for all allowable costs which exceeded LOGO limitation.

On July 11, 1973, the F-15 SPO negotiated a delay in the lot II exercise date while still maintaining basically the same lot II delivery schedule which, if the contractor had demanded, would have slipped. The results of the negotiations were:

- An increase of \$3 million in the lot II ceiling price.

- An increase in long-leadtime funding for production from \$10 million to \$18.75 million. It is understood that \$10 million, in addition to these amounts, was later granted to cover long-leadtime production from September 30, 1973, through October 31, 1973.
- A substantial increase in CIP funding from a 1970 negotiated cost of \$56.1 million for 10 months after MQT to a total of \$106 million for the first year after MQT, under a cost-plus-fixed-fee pricing arrangement with an 8-percent fee based on target cost. SPO officials said the increase in CIP funding was to compensate for the Navy's share of CIP which was withdrawn from the program when the Navy decided not to go into production of the F-401 engine and not jointly fund the F-100 and F-401 CIP program. Our review of the contract, however, showed that \$56.1 million was a combined amount for both the F-100 and F-401 engines. We believe, therefore, that the increase in CIP funding was to continue development in the areas in which problems had been encountered during development.

According to SPO officials, the intent of CIP is to improve engine reliability, maintainability, and producibility, and not to correct deficiencies or improve engine performance, although such improvements could be a byproduct. The proposal for the \$106 million CIP program, however, indicates a good part is for developmental problems. Specifically, the proposal listed several tasks or work areas in which Pratt & Whitney encountered development problems. Some of these tasks were for (1) reducing engine weight, (2) improving fan stability to prevent engine stalls, (3) eliminating augmentor rumble, and (4) improving augmentor ignition reliability and avoidance of augmentor blowout. The proposed CIP program supports compelling evidence that an engine is usually not fully developed at the time it passes MQT but that it requires additional development to bring it up to the desired capability. This practice has been historically followed by military services and has been acknowledged by officials familiar with aircraft engine development as a normal situation.

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The legal right of the Air Force
to certify by MQT an engine
at standards below those it has set
for final acceptance

The F-15 DCP represents DOD's minimum requirements for F-15 and includes thresholds which the Air Force must be able to meet. SPO officials indicated that the contractual arrangements with MCAIR and Pratt & Whitney require an aircraft that will exceed threshold requirements, but the System Program Director, according to Air Force regulations, has authority to reduce the contract requirements to threshold levels, when necessary.

The threshold values in DCP do not specify exact conditions for the engine but rather, are total F-15 weapon system requirements. Those overall requirements are affected by engine capabilities.

SPO officials indicated that the reductions in test requirements were within DCP threshold values, and if necessary, the Air Force could have accepted the engine passing the modified April endurance test and still have been able to meet the DCP thresholds.

As for legal authority under the contract, the changes clause in the F-15 engine contract provides that the contracting officer may at any time, by a written order, make changes within the general scope of the contract, including drawings, designs, and/or specifications. Therefore the Air Force has the legal right to change the specification under which MQT is to be completed.

Although the April test was conducted under reduced conditions, the Air Force did not modify the engine specifications and the test was not accepted as fulfilling the contractual MQT requirement. Rather, the endurance test completed October 12, 1973, fulfilled that contractual requirement.

The nature and extent of any conflict between
the Air Force and the Navy
on the joint engine development program

We were unable to identify any significant conflicts between Navy and Air Force representatives in the joint development of the F-100 and F-401 engines. Both services should have been aware of engine problems, such as the fan stator assembly, at essentially the same time since they both had representatives in the Joint Engine Project Office (JEPO) and at the Pratt & Whitney plant.

JEPO, under the direction of the F-15 System Program Director, is responsible for managing the joint engine development program. The Naval Air Systems Command (NAVAIR) is represented in JEPO. The F-15 System Program Director indicated that NAVAIR representatives have access to the same information as SPO personnel and should likewise be familiar with all problems.

The Navy plant representative at the Florida Research and Development Center in West Palm Beach, Florida, has been responsible since October 1970 for administering the F-100 and F-401 engine contract. A team of F-15 SPO personnel at FRDC, has assumed contract administration responsibility for all engineering and testing on the F-100 engine since October 1, 1972, through a mutual understanding with the Navy plant representative.

Regarding the fan stator assembly problem, the Air Force and Navy were first aware of the fan stator rub during PFRT, which both JEPO and Navy plant representatives observed. After the test, Pratt & Whitney issued two reports describing the problem--The PFRT report dated April 1, 1972, and the Technical Performance Status Report (TPSR) Number 8 dated March 31, 1972. These formal reports were sent to SPO, NAVAIR, and other Air Force and Navy organizations. Pratt & Whitney also issued quarterly TPSRs explaining subsequent stator problems and the attempted solutions to those problems.

The impact on the taxpayer resulting from
the Air Force decision on the F-15 engine MQT

Although the stator problem and other development problems have had an impact on the F-15 program cost and

APPENDIX I

consequently on the taxpayer, the immediate impact from the Air Force decision to run a modified test and to continue production appears to be the costs to rerun the test, which the Air Force estimated to be \$500,000 to \$1 million. There were some benefits from the test since it gave the Air Force information about operation of the engine. If the program had been terminated, the taxpayer would have absorbed termination costs for both the engine and airframe production commitments (about \$170 million). Those costs would have been absorbed from funds already appropriated.

Other costs to the Government are (1) \$3 million increase in the ceiling price for lot II engines which resulted from the delay in the completing MQT and from the Air Force's desire to maintain the original engine production delivery schedule, (2) \$49.9 million increase for CIP, to continue development in problem areas which had been encountered during development, and (3) increase in additional development costs incurred after the first MQT in January 1973 which is believed to have been associated, in part, with the attempts of Pratt & Whitney to pass MQT. Those latter costs amounted to about \$53.7 million between February 28 and August 31, 1973 for both F-100 and F-401 development effort.

As reported in this year's GAO staff study to the Congress on the F-15 aircraft program, the estimated cost as of October 1972 to complete F-100 and F-401 development was \$394 million, without fee, or about 45 percent over the original target cost of \$271.5 million. Since that time continuing development has resulted in additional increases of \$77.7 million as of August 31, 1973, and the estimated cost to complete the development program, as of August 31, 1973, was \$471.7 million. It is believed that \$24 million of the \$77.7 million was incurred because more work was needed to solve a series of durability problems so that the MQT could be conducted on schedule. The other \$53.7 million of the increase is believed to have been incurred since February 28, 1973, and is associated, in part, with Pratt & Whitney's attempts to pass MQT.

AIR FORCE (F-100 ENGINE PROGRAM)

ACTUAL AND PLANNED CONTRACTUAL AUTHORIZATIONS

AS OF JUNE 30, 1973

Type of work and contract type (note a)	Authori- zation date	Target cost	Target fee	Target price	Ceiling price	Government- contractor sharing ratio
----- (000,000 omitted) -----						
Research, development, test, and evaluation and two experimental engines (CPIF)	3-1-70	\$134	\$11	\$145	\$ -	90:10
Component improvement (CPIF) for 6 months	-	17	1	18	-	-
Research, development, test, and evaluation and 21 prototype flight test engines (FPIF)	3-1-70	65	5	70	82	77:23
Production engines (FPIF):						
Lot I (59 engines for flight test)	3-1-70	96	9	105	120	75:25
Lot II (78 engines)	(b)	93	8	101	123	85:15
Lot III (196 engines)	^c 3-1-74	(d)	(d)	(d)	278	(d)
Lot IV (359 engines)	^c 12-1-74	(d)	(d)	(d)	485	(d)
Lot V (355 engines)	^c 12-1-75	(d)	(d)	(d)	472	(d)

^aContract types are CPIF and FPIF--fixed-price-incentive fee.

^bEstimated--authorization is scheduled upon completion of the MQT test.

^cEstimated--authorization is scheduled to be 17 months before the first required engine delivery.

^dTo be determined in future negotiations.

APPENDIX III

PROGRAM AND CONTRACT MILESTONES

	Month and year of		
	OSD program commitment	Pratt & Whitney contract milestones	MCAIR contract milestone
DEVELOPMENT GO-AHEAD:	Dec. 1969		
Preliminary design review		^a May 1970	^a Sept. 1970
Critical design review		^a Feb. 1971	^a Apr. 1971
Engine-inlet stability margin test defined		^a Feb. 1971	
Avionics equipment development review			^a June 1971
First experimental engine acceptance		^a Sept. 1971	
First prototype engine acceptance		^a Feb. 1972	
Engine-inlet compatibility test		^b May 1972	^a Mar. 1972
Preliminary flight rating test			^a June 1972
Structural test of major airframe subassemblies			^a July 1972
First flight			^a Sept. 1972
Bench avionics integration com- plete			^a Sept. 1972
Initial aircraft performance demonstration			^a Sept. 1972
LONG-LEAD TIME RELEASE:	Oct. 1972		
Initial airborne avionics performance			^a Dec. 1972
Fatigue test one lifetime			^a Jan. 1973
Static test, two critical conditions			^a Jan. 1973
First production engine acceptance		Feb. 1973	
Engine qualification test		^b May 1973	
FIRST WING RELEASE:	Feb. 1973		
Armament ground test			^a June 1973
One G-flight envelope			^a Aug. 1973
Fatigue test, three lifetimes			^a Dec. 1973
Air Force evaluation summary			Dec. 1973
RELEASE RATE TOOLING:	Jan. 1974		
Equipment qualified			Mar. 1974
Category II test aircraft and equipment in place			Mar. 1974
External stores flutter release			Aug. 1974
Training equipment in place			Oct. 1974
Fatigue test, four lifetimes			Oct. 1974
Aerospace ground equipment in place			Oct. 1974
Category I tests essentially complete			Nov. 1974
First aircraft to Tactical Air Command			Nov. 1974

^aSuccessfully completed on or before milestone date.

^bThe test was to be completed in February so that the report could be prepared and approved by May.