-- U.S. GENERAL ACCOUNTING OFFICE

STAFF STUDY

C-5A AIRCRAFT

DEPARTMENT OF THE AIR FORCE

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CONTENTS

APPENDIXES

ABBREVIATIONS

AFLC	Air Force Logistics Command
AFSC	Air Force Systems Command
AGE	Aeronautical Ground Equipment
CIP	Component Improvement Program
GAO	General Accounting Office
GE	General Electric Company
IDE	Inertial Navigation Equipment
ISRT	Independent Structural Review Team
LDCS	Lift Distribution Control System
MAC	Military Airlift Command
MADAR	Malfunction Analysis Detection and Recording System
MTBO	Mean Time Between Overhaul
MMR	Multi-Mode Radar
NORM	Not Operationally Ready/Maintenance
NORS	Not Operationally Ready/Supply
RDT&E	Research, Development, Test and Evaluation
SAAMA	San Antonio Air Materiel Area
SAR	Selected Acquisition Report
SOR	Specific Operational Requirement
SPO	System Program Office
USAF	United States Air Force

STAFF STUDY
C-5A AIRCRAFT

WHY THE REVIEW WAS MADE

The General Accounting Office (GAO) reviewed the status of the C-5A program because of continuing Congressional interest in the program's cost, schedule, performance, and system's capability.

WHERE THE SYSTEM IS

System description and status

The C-5A is a large jet aircraft designed to airlift outsized equipment, military supplies, ballistic missiles, and combat and support units at high subsonic speeds. The C-5A is to be self-sufficient with high reliability, to permit global and remote area operation without resorting to prepositioned spares, support personnel, and equipment. The C-5A, with the C-141 aircraft, is to provide the capability to quickly deploy military forces in support of the Government's effort to eliminate, contain, and/or terminate international conflicts.

The aircraft are operating under an 80 percent limitation on all operating characteristics until a 100 percent structural flight demonstration is completed. That demonstration began in November 1972, and is scheduled to be complete in March 1973. The 80 percent limitation is not peculiar to the C-5A, but is applied to all new aircraft procured by the Air Force.

Deficiencies exist in the structure, landing gear, and avionics, preventing the C-5A from meeting several operational requirements. While the Air Force was solving many of the problems and was in the process of incorporating changes in delivered aircraft, several operational requirements of the aircraft may never be fully met, including the aircraft service (fatigue) life, payload capability, capability to fly at low levels, and capability to operate from support area fields.

Of 81 aircraft to be delivered on contract, 71 had been delivered as as of November 30, 1972. Two aircraft were destroyed by fire in 1970.

With deployment of the aircraft to the operating command, problems have been encountered with the reliability of certain subsystems and training of maintenance personnel. Those problems have contributed to a low rate of operational readiness.

As of January 1973, the C-5A had flown more than 90,000 hours in test, training, and cargo airlift missions, transporting more than 90,000 tons of cargo. In addition, the C-5 has flown more than 450 Special Assignment Airlift Missions, carrying more than 20,000 tons of cargo, predominantly outsized. Most of this cargo could not fit into any other active Air Force aircraft.

As an example of C-5A "outsize" capability, during an eleven day period in May 1972, the C-5 force flew 10 missions into Vietnam, each of which delivered three M-41 tanks (54,000 pounds each) or two M-48 tanks (98,000 pounds each) for a total airlift of over 1,650,000 pounds. The average ground times for the missions from touchdown to takeoff was 32 minutes.

More recently, the C-5A supported the disaster relief operations in Managua, Nicaragua. It is important to note that during this operation the C-5A carried outsized water purification units which could not be carried in any other aircraft.

Coming events

Major decisions are to be made by the Air Force in the near future concerning the C-5A. Those decisions may involve mission requirements, capabilities, and cost.

In December 1971, the Air Force formed an Independent Structural Review Team to study the structural problems of the C-5A and to recommend alternatives for corrective action. That report is scheduled for release in March 1973.

In April 1972, the Air Force directed Lockheed to perform a wing life improvement study and report the results and recommendations in June 1972. Since the wing life improvement study is directly related to the Independent Structural Review Team effort, Air Force officials said that report will not be available until March 1973.

The Secretary of Defense, in May 1972, directed the Secretary of the Air Force to make a study of the capability of the C-5A. One phase of the report has been completed. Air Force officials were uncertain when the final phase of the study might be completed.

Relationship to other systems

The acquisition of the C-5A has permitted the Air Force to phase out obsolete types of airlift aircraft from active and reserve forces and reduce procurement of C-141 aircraft from 20 to 14 squadrons.

WHAT WE FOUND

Aircraft deficiencies

The number of deficiencies in aircraft at the time of acceptance has been decreasing because of engineering changes being incorporated during production. For example, aircraft delivered between February and September 1971, were accepted with an average of 251 deficiencies. Aircraft number 63 was accepted in July 1972, with 126 deficiencies.

Below is a description of some of the Specific Operational Requirements (SOR) that the operational aircraft are currently unable to meet, or operations the aircraft are restricted from performing.

-The SOR and contract required the C-5A to have a 30,000 hour service life. The life of the aircraft is currently limited by the fatigue life of the wing. Modifications will be required if the aircraft is to achieve the originally specified service life.

-The design requirements and current payload capabilities of the aircraft are shown below.

	Load factor	Payload	Gross take off weight
Original design requirements	2.5 G	220,000	728,000
	2.25G	265,000	764,500
Air Force estimated capability 1/	2.5 G	190,000	728,000
	2.25G	230,000	764,500
	2.07 G	265,000	764,500
Current restriction (80 percent)	2.0 G	174,000	712,500

1/ With use of Lift Distribution Control System

-The SOR requires the C-5A to be capable of landing and taking off from support area fields. The capability of the aircraft is limited and testing was stopped before all test requirements were met.

-The SOR requires the C-5A to be capable of making a radar landing approach without ground aids. The aircraft is not currently capable of meeting that requirement using only the aircraft radar equipment. Testing is underway to determine if the use of other aircraft equipment such as inertial measuring components in conjunction with the radar, will make the landing approach without ground based aids possible. Preliminary results of the test indicate the problem can be solved.

-Contract specifications require low level cruising at altitudes of 300 to 1,500 feet. Because of problems with the Multi-Mode Radar, the aircraft will not be used to accomplish low level missions below 1,000 feet.

-The SOR requires 75 percent operational readiness. The C-5A force experienced only a 41 percent readiness in fiscal year 1972 because of unreliable aircraft components, and inadequate training and quantities of maintenance personnel. By November 1972, the rate increased to 53.9 percent because problem subsystems were being updated with changes to increase reliability, and maintenance practices were improved.

-The SOR requires the C-5A to have 95 percent system reliability, or probability of completing missions without abort. The Air Force informed us that the C-5A has exceeded the 95 percent abort reliability requirement for the last six months of 1972.

Cost to correct deficiencies

The Air Force estimated that $259 million will be required to correct the deficiencies in the C-5A, including:

- $166 million for deficiencies already identified in June 1972,

- $18 million for additional changes,

- $30 million for undefined deficiencies expected to occur based on C-141 experience, and

- $45 million for engineering changes to the structure of the C-5A expected to be generated by the Independent Structural Review Team established to recommend corrective action of structural problems.

The estimated costs do not include funds to increase the payload capability above 190,000 pounds at a load factor of 2.5Gs. Should the Independent Structural Review Team recommend a major wing redesign, the estimate could increase substantially.

The SAR

GAO concluded that the C-5A Selected Acquisition Report (SAR) is not adequate to apprise the Congress of the status of the program in terms of cost, schedule, or performance.

GAO found that the SAR did not include important information on technical characteristics of the aircraft and schedules for testing programs. In addition, the costs for correction of deficiencies were not highlighted. GAO also believes the logistic support and additional procurement cost section of the SAR needs substantial improvement.

We understand that officials of the Department of Defense plan to meet with the appropriate Congressional committees in early 1973, to review the purpose and content of the SAR, with special attention being given to the logistic support and additional procurement section.

Program cost

Total estimated costs have increased from $3,413.2 million for 120 aircraft estimated in October 1965 to $4,426.4 million for 81 aircraft as of June 30, 1972. The program cost in the June 30, 1972 SAR was slightly less than in the June 30, 1971 SAR. Unit cost estimates have increased from $28.4 million in October 1965 to $54.6 million in June 30, 1972. Costs will be incurred in addition to the program cost for actions taken to correct deficiencies in the aircraft and to provide component improvement programs, etc.

The cost estimates above do not include the $200 million loss nor the special unallowable costs to be absorbed by Lockheed.

Information provided by Office of the Secretary of Defense from the Congressional Data Sheets shows the current estimate through completion of this system as of December 31, 1972, to be $4,408.9 million.

Program milestones

Delivery of the first operational aircraft was in December 1969, six months after the originally scheduled date of June 1969.

Initial operating capability occurred in September 1970, nine months after the originally scheduled date of December 1969.

Delivery of the 81st production aircraft is scheduled for May 1973, about two years after the originally scheduled date.

Test and evaluation

The acquisition strategy employed by the Air Force for the C-5A called for concurrency of development, testing and production. Therefore, deficiencies properly discovered through testing are now being discovered while the program is nearing the end of full-scale production. Corrections of such deficiencies are resulting in increased costs.

GAO found that test schedules continued to slip in fiscal year 1972 because:

-failures in the engineering test program required tests to be stopped until test articles were repaired and necessary changes identified and

-the hardware needed to accomplish certain tests had not yet been fully developed.

Headquarters, USAF directed in August 1970, that all tactical mission testing by the Military Airlift Command be deferred until further notice.

Test requirements in some instances have been reduced in severity or deleted. In addition, some tests were stopped before the objectives were met.

Schedules for completion of tactical operational suitability tests have been deferred pending the completion of engineering and acceptance testing.

AGENCY REVIEW

A draft of this staff study was reviewed informally by selected Air Force Officials associated with the management of the program, and their comments were incorporated in the report as we believe appropriate. We know of no residual difference with respect to the factual material presented herein.

MATTERS FOR CONSIDERATION

Several major study efforts are underway dealing with the C-5A missions, capabilities, wing strength, and fatigue life. The studies may not be completed until after the last aircraft is delivered to the Air Force in May 1973, but it appears that corrective action resulting from the studies could have a substantial effect on future appropriations for procurement as well as for operations and maintenance. In that connection, we believe close surveillance should continue over the C-5A program, including its mission, capability, the impact of deficiencies on its capability, the cost to correct deficiencies and to operate and maintain the aircraft. The Congress should require the Air Force to apprise it of the results and effects of these studies.

CHAPTER 1

INTRODUCTION

REQUIREMENT FOR THE C-5A

The C-5A is a large jet aircraft designed to airlift outsized equipment, military supplies, ballistic missiles, and combat and support units at high subsonic speeds. The C-5A with the C-141 aircraft, provides the capability to quickly deploy military forces in support of the Government's effort to eliminate, contain, and/or terminate international crises or conflicts. In accordance with that concept of operation, the C-5A is to operate with maximum self-sufficiency and high reliability to permit global and remote area operation without resorting to prepositioned spares, support personnel, and equipment.

PROCUREMENT OF THE C-5A

Since the Secretary of Defense committed the C-5A to development and production in 1965, the Air Force Systems Command (AFSC), through the C-5A System Program Office (SPO) has had management responsibility for acquisition of the system. Air Force regulations require AFSC to transfer management support responsibilities for a system to the Air Force Logistics Command (AFLC) at the completion of acquisition or after it has been determined that the aircraft meets the specific operational requirements, whichever occurs later.

The Lockheed-Georgia Company, Marietta, Georgia, a division of the Lockheed Aircraft Corporation, is the contractor for the C-5A aircraft. The engines were manufactured by the General Electric Company, Evendale, Ohio, under separate contract with the Air Force and were supplied to Lockheed as Government-furnished equipment. The last production engine was delivered by General Electric in December 1971.

In June 1971, the contract with Lockheed was restructured and converted from a fixed-price incentive to a cost reimbursable type contract under which Lockheed agreed to accept a $200 million loss. Appropriations of $200 million in fiscal year 1971 and $321.5 million for fiscal year 1972, have specific restrictions, including a provision that costs for bids and proposals, independent research and development, and depreciation and intracompany profits are not allowable for reimbursement. Appropriations of 107.6 million for fiscal year 1973 included the same provision for unallowable costs, except that up to $4.4 million of depreciation costs was allowed. With the restructured contract, Lockheed agreed to (1) release and waive all claims arising from the terms of the initial contract, (2) accept additional Government management controls, (3) provide certain spare parts without profit or fee, and (4) accept the loss of potential performance incentives from the contract.[1]

The Deputy Secretary of Defense, in approving the restructure of the

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[1]The pertinent public laws are 91-441, 92-156, and 92-436.

Lockheed contract, asked the Secretary of the Air Force to personally review the management performance and to emphasize the following objectives in bringing the production program to completion:

--Complete all work within a contractor (Lockheed) cost of $3.7 billion. ($3.5 billion Air Force cost).

--Eliminate unnecessary or unrealistic requirements of the original specifications and unnecessary reports and paperwork.

The contract provides for production of 81 C-5A aircraft, however, since two of the aircraft have been destroyed by fire, only 79 aircraft will be available for operations. As of November 30, 1972, 71 aircraft had been produced.

SCOPE OF REVIEW

To obtain information on the current status of the C-5A procurement in terms of cost, schedule, and performance, we reviewed Air Force and Lockheed program plans, specifications, correspondence and other records, and interviewed officials at Air Force Headquarters; Air Force Systems Command and the Aeronautical Systems Division; Air Force Logistics Command; Military Airlift Command; and Lockheed Georgia Company.

We reviewed the June 30, 1972 SAR to determine if it adequately presented the status of the C-5A acquisition and to obtain the reasons for changes since the June 30, 1971 SAR. We also considered other matters related to program and contract funding.

We reviewed the status of deficiencies in C-5As accepted by the

Air Force and their impact on cost and performance. Information concerning the cause and impact of the deficiencies was provided by officials of the System Program Office.

To determine the status of the testing program and obtain the results of testing during fiscal year 1972 (and in some instances prior to fiscal year 1972), we reviewed selected test plans and reports and discussed the testing program with Lockheed and appropriate Air Force officials.

Since the C-5A system is operational, we reviewed reports prepared by the Military Airlift Command (MAC) concerning operational readiness of the aircraft. We also discussed with SPO, MAC, and AFLC officials, some of the factors which have an impact on operational readiness.

We made no attempt to: (1) assess the military threat or the technology, (2) develop technological approaches, or (3) involve ourselves in decisions while they were being made.

Impending events

During our review, the Air Force was undertaking the following major reviews of the capabilities, mission requirements, and structure of the C-5A.

--In April 1972, the C-5A SPO directed Lockheed to make a wing life improvement study and make recommendations on alternate methods of improving wing life. SPO officials said a report should be available in March 1973.

--In December 1971, an Independent Structural Review Team consisting of over 100 personnel from the Air Force and Lockheed and other

aerospace firms was appointed to study the entire structure of the C-5A. SPO officials said a report should be completed in March 1973.

--In May 1972, the Secretary of Defense directed the Secretary of the Air Force to study and report to him on the capabilities of the C-5A. The Secretary also requested that mission objectives of the C-5A be re-examined. Air Force officials did not estimate when a final report will be available, however, information concerning the capabilities of the C-5A was furnished to GAO and is included in Chapters 3 and 4.

Since the potential decisions from the above efforts may involve the mission, system life, and cost of the C-5A, the Congress should be made knowledgeable of the results of the studies as soon as they are available.

CHAPTER 2

PROGRAM STATUS

The Selected Acquisition Report (SAR) is a congressional requirement instituted to keep appropriate committees informed of the status of major weapon acquisition programs in terms of cost, schedule, and technical performance. To satisfy that requirement, the Assistant Secretary of Defense (Comptroller) issued instructions establishing the format and content for quarterly SARs.

We reviewed the June 30, 1972 SAR for the C-5A program and identified the changes that have occurred since the June 30, 1971 SAR. The following sections separately cover the subjects of cost, schedule, and technical performance.

SYSTEM COST EXPERIENCE

The June 30, 1972 SAR reflects a total cost estimate to the Air Force for research, development, test and evaluation, (RDT&E), procurement, and construction of $4,426.4 million, a reduction of $28.8 million from the June 30, 1971 SAR. In addition, that SAR shows modification and competent improvement costs of $105.8 million, an increase of $12.0 million from the June 30, 1971 SAR.

In a letter dated May 25, 1972, the Assistant Secretary of Defense (Comptroller) issued new reporting requirements for the Logistics

Support/Additional Procurement Cost section of the SAR. The letter stated, in part, that in the interest of uniformity, and clarification and simplification of the reporting requirement, only modification and component improvement costs will be reported. The instructions also stated that the period covered by these costs will be from program inception through either the last year of the Five-year Defense Program or the last year of procurement of the basic system, whichever is later. These new reporting instructions resulted in a net decrease in reported costs on the C-5A program amounting to $220.5 million. This net reduction is attributed to (1) a decrease of $232.5 million as a result of implementing the new reporting instructions issued by OSD, and (2) an increase of $12.0 million in modification costs.

The Office of the Secretary of Defense is planning to meet with the House Appropriations Committee in early 1973 regarding the Committee needs for data in the SAR as cited in their report 92-1389, dated September 11, 1972. The Committee stated that considerable improvement was needed to the additional procurement cost section, including the need for firm baselines and the categories of costs to be reported. DOD Instruction 7000.3 will be revised to incorporate the results of this meeting.

The chart on the next page compares cost estimates in the June 30, 1971, and June 30, 1972 SARs. Also, the changes in logistic support/additional procurement costs for the C-5A are shown. The Air Force's explanation of the changes in the cost estimates follow the chart. The funding status of the program as of June 30, 1972, including amounts appropriated, programmed, reprogrammed, obligated, and expended by fiscal year is shown in Appendix I.

COMPARISON OF JUNE 30, 1971 AND JUNE 30, 1972 COST ESTIMATES
(Millions)

	Development estimate	June 30, 1971 estimate	June 30, 1972 estimate	Increase (decrease) from June 30, 1971, to June 30, 1972
Direct program:				
Development	$1,041.8	$1,029.2	$1,025.6	($ 3.6)
Procurement:				
Air vehicle	2,045.2	3,195.5	3,208.0	12.5
Initial spares	282.6	412.9	399.4	(13.5)
Construction	43.6	17.6	17.2	(.4)
Subtotal	$3,413.2	$4,655.2	$4,650.2	($ 5.0)
Lockheed loss	--	(200.0)[1]	(200.0)[1]	--
Special unallowable costs	--	--	(23.8)[2]	(23.8)
Total program estimate	$3,413.2	$4,455.2[1]	$4,426.4[1]	($ 28.8)
Logistic support and additional procurement costs:				
Modifications		$ 60.3	$ 72.3	$ 12.0
Component Improvement		33.5	33.5	--
		$ 93.8	$ 105.8	$ 12.0
Modification Spares		$ 198.2	Not Reported	($198.2)
Replenishment spares		7.6	Not Reported	(7.6)
Common AGE		25.6	Not Reported	(25.6)
Common AGE Spares		1.1	Not Reported	($ 1.1)
		$ 232.5		($232.5)
Subtotal		$ 326.3	$ 105.8	($220.5)
TOTAL		$4,781.5	$4,532.2	($249.3)

[1]The Lockheed loss is $200.0 million; $100.0 million has already been incurred. The Air Force total program funding requirement is $100 million more than the total program cost estimate because the Air Force accepted a promissory note for $100 million of the Lockheed loss which has not yet been sustained by the company.

[2]The fiscal year 1973 appropriation bill permits up to $4.4 million of these costs to be reimbursed to Lockheed. As a result, the special unallowable costs will be decreased and program cost increased by up to $4.4 million.

--Development costs were decreased by $3.6 million as a result of a congressional budget reduction.

--Air vehicle procurement costs were increased by $12.5 million to include additional costs associated with (1) a strike at a major subcontractor's plant, (2) engine pylon problems, and (3) incorporation of a Lift Distribution Control System to increase the load carrying capability and fatigue life of the aircraft.

--Initial spares cost was decreased by $13.5 million as a result of better estimating and the deletion of profit on initial spares under the restructured contract.

--The special unallowable costs of $23.8 million to be absorbed by Lockheed under the provisions of the contract and appropriation acts were recognized. These costs include otherwise allowable independent research and development, depreciation, bid and proposal costs, and intra-corporate profits.

--Modifications were increased by $12 million as a result of better estimating and definition of required changes.

The total cost estimate is revised by the Air Force semi-annually, and has remained relatively stable for the past few years because the program is nearing completion and the probable cost is more easily determined. The SPO continuously monitors Lockheed's performance against the estimate by reviewing detailed cost reports submitted by Lockheed and investigating variances from the estimate and/or the time phased schedule.

Correction of deficiencies

In June 1972, the SPO estimated that $259 million will be required to correct the deficiencies in the aircraft. The SPO determined that the funding for those costs should be provided partly with program funds (air vehicle procurement) and partly with "below-the-line" modification funding.

The chart below compares the SPO's July 1971 and June 1972 estimates for correction of deficiencies.

	(Millions)		
Funding	July 1971	June 1972	Increase
Program funds (air vehicle procurement)	$ 84	$126	$42
Below-the-line modification funds	80	133	53
Total	$164	$259	$95

Instructions from the Department of Defense regarding the SAR require that variances in cost estimates be explained. While the Air Force estimate for correction of deficiencies to be funded by the basic program increased by $42 million between July 1971 and June 1972, the SARs during that period did not fully explain that variance. The SARs explain only an increase of $12.5 million in air vehicle procurement costs.

In the logistic support and additional procurement costs section of the June 30, 1972 SAR, $72.3 million is included for modifications. Air Force Headquarters prepared that estimate based on a historical factor and it is substantially less than a more detailed estimate made by the SPO.

If the SAR were based on the SPO estimate, the June 1972 SAR estimate for modification/update would have included $133 million for correction of deficiencies. In addition, the SPO has received $11 million for several other modifications to the aircraft which was not related to the correction of deficiencies. Based on that information we concluded that the estimate in the June 30, 1972 SAR for modifications could be understated by about $72 million.

Since the cost to correct deficiencies in the aircraft is significant for the C-5A program and is subject to further change from the study of C-5A capabilities, we believe the program cost estimates and modification estimates on the SAR should be appropriately footnoted to highlight the amount included for correction of deficiencies.

It should be noted that the eventual cost of modifications will depend primarily upon decisions yet to be made concerning the C-5A such as wing life extension. Until these decisions are made there is no firm basis for any estimate of C-5A modifications costs.

Forecast of component improvement costs

The amount included in the SAR for the component improvement program of $33.5 million reflects the cost of improvement of the engine to be paid from procurement funds while the C-5A system is in the acquisition cycle.

The Air Force has also estimated that improvements costing $65 million will be made to the engine after the aircraft are deployed and will be funded from operation and maintenance funds.

Contract adjustment for nonrecurring costs related to commercial engine sales

The Air Force has recovered $816,000 through 1971, and could possibly recover up to $19.5 million as a result of a clause in the engine contract which requires the engine contractor to repay part of nonrecurring development and learning costs when engines are sold commercially.

The contract awarded to the General Electric Company (GE) by the Air Force for development and production of TF-39 engines, included a provision requiring the Government and the contractor to negotiate an

equitable adjustment to the Government for nonrecurring engine development and learning costs in the event the TF-39 or similar engines were developed and sold by GE to commercial and foreign sources.

In September 1970, the engine contract was renegotiated. As part of the negotiation specific amounts were negotiated for adjustment to the contract for nonrecurring costs for the potential commercial sales of engines similar to the TF-39. The Air Force objective was to recover an equitable part of the nonrecurring costs incurred by the Air Force for which GE received benefit in developing a commercial engine.

The renegotiation resulted in a potential recovery of $19.5 million based on commercial engine deliveries by GE as follows:

Quantities delivered	Unit adjustment	Total potential adjustment
First 500 engines	$6,000 each	$3,000,000
Next 1,000 engines	7,500 each	7,500,000
Next 1,000 engines	9,000 each	9,000,000
Any subsequent engines	No payment	
Total		$19,500,000

The Air Force records of negotiations indicate that the increase in the unit adjustment amount on those engines after the first 500 is in recognition of a cash flow problem which the GE engine division had in the early 1970s.

The revised contract, which remained a fixed-price incentive type, provided for an adjustment to be determined annually, with two options for settlement. The settlement options specified either;

--a reduction in contract target profit, target price and target ceiling, or

--a payment to the Treasurer of the United States.

SPO officials said the Armed Services Procurement Regulations in effect in 1970 provided that the settlement be handled by the first method until the contract is finally settled and by the second method after final settlement of the contract.

In calendar years 1970 and 1971, GE reported that 136 commercial engines subject to the adjustment clause had been delivered. The Air Force elected to recover the costs as a credit to the target profit, target price, and target ceiling on the contract. The adjustment of the contract by $816,000 for deliveries in 1970 and 1971 became available obligational authority which the Air Force used for other C-5A effort. Had the Air Force directed GE to make a payment to the Treasurer, however, that obligational authority would not have been available for the C-5A program.

We believe the Congress should be informed of the amount of the contract adjustment since it could have an effect on the amount appropriated for the C-5A program.

Financial status of Lockheed contract

By June 30, 1972, the Air Force had obligated $3.26 billion on the Lockheed contract, of which $3.15 billion had been expended. The obligations and expenditures shown below include all funds on the contract at June 30, 1972, including those programmed in prior years and those funds subject to the restrictions of the pertinent Public Laws.

	Unrestricted	Restricted
Obligations	$2,789,178,786	$473,840,824
Expenditures	2,761,184,890	386,756,555
Unliquidated obligations	$ 27,993,896	$ 87,084,269

The restructured contract provides that after the initial payment of restricted funds through the special bank account, all payments shall be made from the restricted appropriations and be subject to the restrictions and exclusions of the pertinent Public Laws as amended. That provision has resulted in an unliquidated obligation balance of about $28 million in the prior unrestricted funds which the Air Force does not plan to use for payment until restricted appropriations are exhausted.

SYSTEM SCHEDULE EXPERIENCE

The June 30, 1972 SAR indicates that the 81st (last) aircraft is scheduled for delivery in May 1973, about two years later than originally planned. The June 30, 1971 SAR showed a scheduled delivery of the last aircraft in February 1973; however, a strike at a major subcontractor's plant caused a shutdown of the C-5A production line and a change in the estimated delivery for the last aircraft to May 1973.

Although there has been no further slippage of the airframe delivery schedule, there have been additional schedule slippages in the testing program. These slippages are not reflected in the SAR. Additional information on the schedule slippages in the testing program is in Chapter 3.

SYSTEM PERFORMANCE

The technical section of the SAR deals with six characteristics of the aircraft; cruise speed, engine thrust, range, takeoff distance, landing distance, and weight.

Only one change has been made in the technical section since the June 30, 1971 SAR. The range of the aircraft with a 100,000 pound payload was reduced from 5,800 to 5,650 nautical miles because of increased drag introduced with the use of a Lift Distribution Control System. That control system was designed to improve the load carrying capability and fatigue life of the aircraft.

The SAR for the C-5A continues to be deficient by not including data on system reliability, cost per ton mile and productivity indexes based on speed, cargo carrying capability and utilization. We also reported on these matters in our previous C-5A staff studies dated February 1970, March 1971, and March 1972.

In our March 1972 staff study we reported that the SAR did not reflect an accurate picture of the C-5A performance status, in that (1) stated performance which is not based on actual hardware demonstration is not so noted, (2) deficiencies in the landing gear and wing are not discussed, and (3) continuation of the 80 percent operational restriction is not noted. The June 30, 1972 SAR also omits a discussion of these same points.

The House Appropriations Committee, in a report on the fiscal year 1973 Defense appropriations bill stated that some mention should be made in the SAR as to the probability of a weapon system achieving its primary mission or meeting original contract specifications. In addition, the report stated that performance characteristics should be tailored to the specific key points of the weapon system, rather than uniform performance characteristics by class of weapon system.

Chapter 4 includes a comparison of major SOR requirements, the contract specifications and the Air Force's current estimated technical performance of the C-5A.

CONCLUSION

Even though the C-5A SAR may generally meet the requirements of the applicable directives from the Assistant Secretary of Defense, we do not believe it is an adequate presention of the status of the C-5A procurement in terms of cost, schedule, or performance.

In our opinion the C-5A SAR could be substantially improved by:

- highlighting the Air Force estimates of the cost to correct deficiencies in the aircraft and explaining the variances that may occur in those estimates from period to period,

- including estimates for the reported logistic support and additional procurement costs in the SAR, with a static baseline against which the estimates can be measured,

- including a realistic forecast of component improvement costs in the SAR,

- including in the SAR schedule section, information on the current estimated dates of completion for important testing milestones and

- including information on required technical performance characteristics and the current estimated ability of the aircraft to meet those requirements. We suggest characteristics be added to the SAR such as system life, operational readiness, reliability, and payload capability. These same items were reported in the March 1972 staff study.

We understand that officials of the Department of Defense plan to meet with the House Appropriation Committee early in 1973, to review the SAR reporting policy.

CHAPTER 3

TEST AND EVALUATION

A well planned test and evaluation program is a key ingredient in a successful system acquisition. Test results assessing technical risks should be made available to managers at key decision points in the acquisition cycle.

The strategy for acquisition of the C-5A aircraft contemplated a test and evaluation program to be conducted concurrently with aircraft development and production. Contractor engineering testing consisting of static, fatigue, and flight testing, and Air Force acceptance and operational suitability testing, was to be conducted during full-scale production. Accordingly, test results could not have been made available to the managers before the key decision points.

By September 1972, the test schedules had slipped as much as 45 months because of test failures, late development of hardware required to complete certain tests, and deferral of testing as directed by Headquarters USAF. The last (81st) aircraft is currently scheduled for delivery in May 1973. Final test results will not be available before delivery of the last production aircraft, and changes defined in the remainder of the test program will have to be incorporated in the aircraft after delivery.

Descriptions of engineering, acceptance and operational suitability testing, and some test results follow. A summary of the status of test schedules begins on page 44.

ENGINEERING TESTING[1]

The primary purpose of engineering testing conducted by the contractor is to demonstrate that the aircraft will perform as intended. The tests consist of development testing and evaluation of individual components, subsystems, and in certain cases, the complete system. The engineering test program consists of the following categories of tests.

Static tests - Structural elements of the aircraft are tested to determine their stress capabilities up to 150 percent of design load.

Fatigue tests- Structural elements of the aircraft are tested to determine their endurance levels to four lifetimes.

Flight tests - Operational aircraft are tested to determine their capabilities to meet contract specifications and performance characteristics.

Static and fatigue tests are accomplished on nonflying test articles which are instrumented and subjected to certain test conditions by artificial means. Flight tests are accomplished on production aircraft. Until all engineering flight tests are complete, the Air Force policy is to operate delivered aircraft under an 80 percent restriction on all operating features.

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[1]Generally this was referred to as Category I testing by the Air Force at that time.

Although most of the engineering testing is complete, several required tests have been further delayed or deleted from the test program. The status of each type testing is described below.

Static tests

The original test plan provided for testing the airframe to 150 percent of its design load limit by March 1970. Static testing was completed in June 1972.

On September 13, 1971, the wing suffered a failure at 126 percent of design load limit. An Air Force Ad Hoc Committee formed to investigate the failure and assess its impact on the C-5A program found that the test was valid and that the failure was caused by excessive tension in the lower surface of the left wing. The committee recommended that no additional static testing be conducted because, even with certain engineering changes which were defined, the wing would not demonstrate a significant increase in static strength. The committee recommended that a Lift Distribution Control System (LDCS) be installed in the wing to improve its load carrying capability and fatigue life. The Ad Hoc Committee determined that the existing 80 percent limitation on aircraft operations was adequate because the wing strength demonstrated before the failure at 126 percent of design limit, was greater than any loads that would result under the operating restrictions. The SPO agreed with the committee's recommendations. No additional static tests will be conducted on the existing wing design, and an LDCS will be used on all aircraft.

Fatigue tests

Fatigue testing is accomplished by cycling or subjecting the test article to the probable lifetime conditions of the aircraft in use. The probable lifetime use of the aircraft is described in mission profiles developed by MAC and incorporated in the contract specifications.

In September 1965, 15 mission profiles were identified based on the intended use of the aircraft at that time. In May 1970, MAC, the using Command, completed an updated study of the intended use of the aircraft. Subsequent evaluation of the revised profiles showed that there was a beneficial effect on fatigue life. Since fatigue testing should duplicate the expected use on the C-5A force as accurately as possible, SPO officials said the revised profiles were incorporated into the fatigue test program. Appendix II contains a description of the revised profiles.

The chart below shows the impact of changing the planned mission profiles on the expected use of the aircraft.

	Original	Revised	Change (decrease)
Flight hours	30,000	30,000	-
Total landings	12,000	12,000	-
Substandard field landings	469	107	(362)
Low level cruise hours	1,800 @350 knots	900 @250 knots	(900 hrs. 100 knots
Percentage of total hrs.	6	3	(3)
Aerial refueling-number	375	121	(254)
Aerial refueling-hours	160	41	(119)
Airdrop-number	422	2,136	1,712
Airdrop-hours	14	142	128
Pressurization cycles	5,950	6,023	73
Maximum payload (pounds)	200,000	182,206	(17,794)

The comparison shows that the current anticipated use of the C-5A is substantially reduced for missions such as low level flying, aerial refueling, and substandard (support area) field landings. Payload requirements were also reduced.

The SOR and specifications require that the major airframe components demonstrate a fatigue life of 30,000 hours and 12,000 landings. To accomplish that goal, the specifications require fatigue testing to four lifetimes, or 120,000 hours and 48,000 landings. SPO officials said testing to four lifetimes incorporates a safety factor which is needed because the fatigue lives of metals and alloys are not always consistent. It is important that the fatigue test program be ahead of the flight hours accumulated on operational aircraft so any fatigue problems can be identified in advance. SPO officials said the C-5A test program is ahead of operations.

The required and actual cyclic test hours at November 30, 1972, are shown below for the five major test articles.

Test article	Requirement	Completed in fiscal year 1972	Cumulative at November 30, 1972	
			Hours	Percent Completed
(1) Right wing and partial left wing	120,000 hours	3,000 hours	42,000 hours	35
(2) Wings and fuselage	120,000 hours	3,000 hours	15,000 hours	13
(3) Nose landing gear	48,000 landings	17,885 landings	48,000 landings	100
(4) Main landing gear	48,000 landings	9,775 landings	39,000 landings	81
(5) Empennage and aft fuselage	120,000 hours	44,200 hours	120,000 hours	100

Information on the status of the test program for each article follows:

Right wing and partial left wing

The right wing and partial left wing was added to the test program in December 1970, to expedite wing fatigue testing. SPO officials said this article gives an indication of fatigue life, but the entire wing and fuselage is the basis for determining actual fatigue life. In a routine inspection of the fatigue article after 33,000 cyclic hours, several fatigue cracks were discovered in the wing and testing was discontinued until repairs could be made and engineering changes could be incorporated. Testing was resumed in July 1972, using the revised mission profiles. Upon completion of the Independent Structural Review Team (ISRT) study, changes may occur in the test program.

Wings and fuselage

No test hours have been accumulated on the wing and fuselage article since September 21, 1971, because fatigue damage was being repaired and engineering changes were being incorporated. Several fatigue cracks were identified in the wing at 9,000 cyclic test hours. Engineering changes were incorporated in the test article and testing continued to 15,000 cyclic hours. In December 1972, the SPO was planning to have Lockheed resume testing in January 1973, after the Independent Structural Review Team completes its review and to complete that testing in December 1975. The revised mission profiles will make fatigue testing less demanding of the wing because payloads have been reduced and the requirements have been reduced for some missions that had an adverse affect on fatigue life.

Landing gear

Fatigue testing on the nose landing gear was completed in fiscal year 1972. We found that one of the major components of the main landing gear, the thick-wall bogie, failed in April 1972, after about 43,000 of the required 48,000 cyclic test landings. SPO officials said the 43,000 cyclic test landings accomplished on that component equate to about 48,000 landings when the planned reduction in support area landings reflected in the revised mission profiles is taken into consideration. No further fatigue tests will be conducted on the thick-wall bogie. Fatigue testing on the main landing gear was completed in December 1972.

Empennage and aft fuselage

The empennage and aft fuselage article was down for repairs and incorporation of engineering changes four times during fiscal year 1972. As a result, the estimated test completion date slipped 8 months, from February 1972 to October 1972. According to Lockheed officials, the slippage was due primarily to the small staff assigned to repair the article.

Lockheed officials determined that testing on this article held a lower priority than on the other fatigue articles, because it had accumulated far more test hours than any aircraft in the C-5A force and a relatively high number of test hours as compared to other test articles. Lockheed officials believed the available personnel could be more effectively used for articles which had not been tested so extensively.

Flight tests

Lockheed officials said engineering flight tests have been completed except the structural flight demonstration which was delayed until completion of certain component testing on the wings and pylons. That test is designed to prove that the aircraft can perform its assigned missions at 100 percent of its load limit requirements. Until that demonstration is complete, the aircraft is being operated with an 80 percent restriction on all operating features. This is normal procedure for all aircraft procured by the Air Force.

The flight demonstration began in November 1972, on a test aircraft equipped with a Lift Distribution Control System (LDCS) and is scheduled to be complete in March 1973. The demonstration consists of 10 maneuvers to demonstrate a gross weight of 728,000 pounds and a payload of 190,000 pounds. By November 30, 1972, four of the 10 maneuvers had been completed.

Combined engineering and acceptance tests

The contractor engineering[1] and Air Force acceptance tests[2] to demonstrate support area suitability for the C-5A aircraft were combined

[1]Category I testing
[2]Category II testing

to conserve resources. The tests conducted between May and August 1970, consisted of taxis, takeoffs, turns, and landings on both bare clay and mat runways.

The specifications required that the C-5A be capable of making 130 passes (one pass consists of one takeoff and one landing), on a support area field with a California Bearing Ratio of 9 (CBR, a measure of soil strength) without repairing the field. The specifications also required the aircraft to land under those conditions in 4,000 feet.

The Lockheed test report of the support area landings concluded the following:

> "The bare clay soil tests showed that the C-5A is capable of limited operation on a Support Area Airfield with a CBR of not less than 15, up to a gross weight of 571,000 pounds. The number of passes that may be performed on a bare clay surface cannot be defined, since only limited tests were performed during the preliminary phase, at which time testing was halted due to excessive engine temperature precipitated by dust ingestion.[1] Operations on a bare surface must be monitored closely for field deterioration while using recommended techniques such as minimum braking, no reserve thrust, take-off on one side of strip, land on other side of strip, shallow taxi turns with no braking and taxiing away from dust clouds."

During the landings on bare clay, it also became obvious that with continued operations, certain hydraulic and electrical lines beneath the main landing gear could be damaged by sticks, stones, or other flying debris.

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[1]The excessive engine temperature occurred on the eighth landing.

The tests on landing mats were stopped after four landings because the mats failed and caused damage to the aircraft and 10 tires. The report recommended that with the present mat design, construction and maintenance standards, C-5A operations on mat surfaces be prohibited.

The 4,000 foot landing distance required by the specifications was measured on a dry concrete runway rather than on a support area field because of the difficulty of controlling the test conditions. The SAR includes information on that aspect of the support area operations.

Tests of support area and other tactical operations were deferred indefinitely by Headquarters, USAF in August 1970, and no plan exists for additional testing. The limited test results were, however, considered sufficient by the Air Force to prepare a support area operations manual for MAC, in the event such an operation must be performed. By November 1972, the SPO had not completed the manual.

Air Force officials said that support area operations testing had not been completed and no further testing of this nature is contemplated at this time. Information on the SPO's position relative to support area capability is in Chapter 4.

ACCEPTANCE TESTING[1]

The purpose of acceptance testing is to demonstrate that the state and quality of the system fulfill the requirements agreed to by the buyer and seller. It involves testing and evaluation, spanning the integration of subsystems into a complete system and development tests of the completed system in as near an operational configuration and environment as possible. The current planned completion date for

[1]Referred to by the Air Force as Category II - System Development Test and Evaluation.

acceptance testing is June 1973, a delay of about three years from the original schedule. The Air Force attributed the delay in the program to failures and to the lack of fully developed and integrated production hardware such as Automatic Flight Control, Multi-Mode Radar, and Flight Director Systems. The Automatic Flight Control system is the pacing item and should be available in February 1973. The tests are scheduled to be completed in June 1973.

Air Force acceptance testing from March 1972 through November 1972, was for the purpose of completing outstanding tests and evaluating engineering changes made to certain subsystems. Some of these subsystems were the landing gear hydraulics, Multi-Mode Radar and Automatic Flight Control Systems. SPO officials said many subsystems and aircraft functions were tested successfully, the only significant failures being in making a radar approach to landing without ground based aids (Multi-Mode Radar). SPO officials said they had only preliminary results and no test reports have yet been submitted.

SPO officials said the following items of equipment and functions were successfully tested. We did not attempt to verify the SPO's statements.

Inertial Navigation Equipment
Multi-Mode Radar (terrain following at 1,000 feet, contour mapping)
Automatic Flight Control System (automatic landing, altitude hold, terrain following at 1,000 feet)
Aerial Delivery System (air drop) and computed air release point
Landing gear (hydraulic kneeling)
Malfunction Analysis Detection and Recording System
Propulsion system (air starts)

Integral Weight and Balance System
Navigation equipment
Service Loads Recording Program
Flight Director System
Aft cargo complex
Cargo handling equipment.

Reliability demonstration

The contract specifications require the C-5A to demonstrate reliability under the following two criteria.

-A probability that 90 percent of the time, a mission will be completed without a major subsystem failure.

-A probability that an additional 8 percent of the time, a mission will be completed without abort, even though a major subsystem failure may occur.

SPO officials said these criteria were based on an assumption that one mission abort would take place for every five major subsystem failures. Actual data shows one abort for every two major subsystem failures. As a result, they said a 94 percent reliability of major subsystems is required to attain a 98 percent mission abort reliability.

The specifications also required that, before the completion of acceptance testing, the aircraft demonstrate an 87 percent probability that a mission would be completed without a major subsystem failure. The test was to be accomplished for a 10-hour mission, simulating a combination of the missions described by MAC for the C-5A. In total 1,080 test hours were to be accumulated.

The C-5A System Program Director, because of the limited resources and aircraft available, restructured the test to achieve an 85 percent reliability for a 10-hour mission simulating the MAC operation. There were to be 720 test hours rather than 1,080. The test was conducted from December 1970 through March 1971, but only 564 test hours were accumulated. The test data demonstrated an 84 percent reliability, which the SPO considered acceptable for the acceptance testing time period. The primary reason for failure to meet the test criteria was related to landing gear failures.

The reliability demonstration was conducted with many systems and subsystems still in the development stage, however, it was imperative that the demonstration be accomplished before completion of acceptance testing.

In addition to the required 87 percent reliability demonstration, the contract required a complete demonstration of reliability in accordance with the 90 percent major subsystems failure criteria and 98 percent mission abort criteria, to begin two years after initial operating capability. Initially, that demonstration was planned to begin September 1972, but a more realistic estimate is January 1973 which permits testing of a more up to date configuration of the hardware. The demonstration, based on analysis of data from operational aircraft is to be complete in July 1973. Although that demonstration has not begun, Lockheed accumulated reliability data on all aircraft from the time they were delivered through November 30, 1972. A summary of that data follows:

	SOR Requirement	Contract requirement	Achieved
Meantime to mission abort	95 percent	98 percent	96.0 percent
Meantime to major subsystem failure	--	90 percent	91.7 percent

According to that data, the achieved meantime to mission abort exceeds the SOR requirement but does not meet the contract specification.

Maintainability demonstration

The maintainability demonstration involves organizational, field, and depot maintenance. SPO officials told us the organizational, field and depot maintainability demonstrations have met specifications, but the reports for field and depot maintainability demonstrations will not be available until January 1973.

The demonstration of organizational level maintainability was conducted between November 1969 and September 1970, and the demonstration was to be made under controlled conditions with trained maintenance personnel and adequate supplies. In that connection, Lockheed identified the average time which should be required for each specific task to be undertaken. Overall, the time required to complete 211 observed tasks, was less than the requirement.

Other demonstrations

A turnaround time demonstration and a 1 hour engine change demonstration required by test plans were not accomplished.

The turnaround time demonstration was waived because certain loading equipment was not available when the demonstration was scheduled to begin. SPO officials said operational experience proved the turnaround time requirement and it was unnecessary to conduct the test.

The engine change demonstration was to be accomplished using a 22-ton crane. That crane, however, did not provide the capability to make small movements of the engine accurately. SPO officials said a pylon-mounted hoist was substituted for making the change. MAC is experiencing an engine change time of about $3\frac{1}{2}$ hours which MAC representatives said is acceptable and not detrimental to operations.

OPERATIONAL SUITABILITY TESTING[1]

Operational suitability testing is performed in the field with all involved military departments to demonstrate that the C-5A aircraft can perform the mission for which it was intended as part of an integrated combat operation. This testing is conducted by the operating command in as realistic an environment as possible and provides an opportunity to deploy a significant number of C-5A aircraft in an operational environment.

Operational suitability testing is being conducted primarily at Charleston Air Force Base, South Carolina. The test program contemplates four major phases.

[1]Referred to by the Air Force as Category III - System Operational Test and Evaluation.

1 - Conversion, transition, crew upgrading and training.

2 - Logistic transport operation.

3 - Rapid deployment.

4 - Operational effectiveness.

Phase 1

The effectiveness of converting maintenance and flight crews from other aircraft systems to the C-5A was evaluated beginning with the delivery of the first aircraft to Charleston Air Force Base in June 1970. A report on the evaluation issued in December 1971, indicated that personnel transitioned to the C-5A, regardless of their background or experience, had adapted well and had experienced no unusual problems.

The report indicated that all test objectives had been successfully accomplished except for incomplete evaluations of the air transportable loading dock and the flight simulator. The loading dock was not tested during phase 1 because it was not available in the latest configuration, the aircraft was experiencing problems with the landing gear in raising and lowering the fuselage for loading and unloading (kneeling), and the joint test force wanted to test the dock in a more realistic operational environment. That evaluation was deferred to phase 3. The flight simulator was being updated to a current configuration and testing was deferred until an updated configuration was available, probably during phase 4 evaluation.

Phase 2

The evaluation of logistic transport operations was conducted between June 1970 and March 1972. The specific objectives required evaluation of many aspects of the system such as the effectiveness of several major subsystems, loading and unloading procedures, causes of hardware failures, and hot and cold weather procedures. A report on phase 2 was issued in August 1972.

Overall, the report concluded that the aircraft demonstrated outstanding potential and was capable of performing its airlift mission, but spares supply, systems reliability, and the quantity and quality of trained personnel have plagued the operation of the aircraft since it has been introduced into the MAC inventory.

Specific recommendations were made in the report, and corrective action had been initiated on many of the recommendations by the time the report was issued.

Phase 3

Phase 3, rapid deployment testing, involves the development of optimum tactics and techniques for employment of the C-5A system in a combat airlift mission and deploying Army units in an airdrop or landing operation.

Between April 1971 and July 1972, MAC and 24 different types of Army units evaluated all facets of the joint airlift operation, except for the actual flight (Static Air Transportability Operations).

The scope of the exercises involved static loading and unloading of equipment, use of aircraft systems, and taxi operations. Special loading tests were conducted to develop loading procedures for certain outsize pieces of equipment, and special evaluations were conducted to develop emergency egress procedures.

The exercises showed that only three of the 24 Army units could be completely transported in C-141 aircraft. The C-5A outsize capability was required to transport at least some of the equipment in 21 types of Army units. MAC representatives said all objectives of the Static Air Transportability Operation have been met.

Tactical mission testing of formation flying and airdrop operations scheduled to start June 1972, has slipped until a release is obtained from Headquarters USAF for that type testing. Tactical mission testing is also being delayed due to non-availability of updated Automatic Flight Control, and Multi-Mode Radar systems in the aircraft.

Completion of formation flying and airdrop testing of the phase 3 evaluation is dependent on a release from Headquarters USAF pending consideration of the findings of the ISRT.

Phase 4

According to test plans, operational effectiveness testing was scheduled to start in October 1972, and to be completed in January 1973.

The original operational suitability test program was scheduled to be completed by November 1971, but that schedule has slipped at least 16 months because of delays in engineering and acceptance test

programs and because updated avionics is not available. A MAC representative said the test program should officially end when all test objectives are achieved, however, since most testing has been completed and because of the uncertainty of future test plans the joint test force will be disbanded in March 1973. MAC officials told us that testing yet to be done after that time will be accomplished by a MAC operational test and evaluation group when updated avionics equipment is available. MAC officials were not able to estimate when all test objectives will be complete.

SUMMARY OF SLIPPAGE IN COMPLETING TEST PROGRAMS

One of the major problems described in our March 1972 staff study was the slippage in test completion dates since the beginning of the program. Our comparison of the test completion dates reported in the March 1972 staff study with those projected by the SPO in September 1972, disclosed further slippage in the testing program as follows:

Major tests	Original test completion date	Projected[1] completion dates as of December 1971	Months slippage	September 1972 projected completion date	Additional months slippage	Total months slippage
Engineering						
Static tests	March 1970	March 1972	24	June 1972	3	27
Fatigue tests[2]	February 1972	October 1975	43	December 1975	2	45
Flight tests	July 1970	April 1972	21	January 1973	9	30
Acceptance						
Flight tests	July 1970	April 1972	21	June 1973	14	35
Operational suitability						
Flight tests	November 1971	March 1973	16	Unknown[3]	Unknown	Unknown

[1]As reported in GAO C-5 staff study dated March 1972.

[2]Dates shown represent estimated completion dates for the last article scheduled to complete fatigue testing. (See page 26).

[3]The joint test force is to be terminated in March 1973. Remaining tests will be accomplished by a MAC operational test and evaluation group. (See page 43).

CONCLUSION

Test schedules have slipped because of:

-failures in the engineering test program requiring tests to be stopped until test articles were repaired and necessary changes identified,

-the lack of fully developed hardware needed to accomplish certain tests, and

-a directive from Headquarters USAF deferring tactical operational suitability testing.

In some instances, test requirements were reduced or deleted or the testing was stopped before the objectives were met. For example, the severity of the wing fatigue testing was reduced to more accurately reflect the planned use of the aircraft, tests to demonstrate a one-hour engine change were deleted, and support area suitability tests were stopped before the test objectives were met. As of January 1973, the Air Force Headquarters had not authorized MAC to continue tactical mission testing.

The Air Force expects to complete engineering testing in March 1973, except for fatigue tests of the wings and fuselage. The fatigue tests on the main test article restarted in January 1973.

The Air Force expects to complete acceptance testing in June 1973. That completion date is dependent upon receiving production Automatic Flight Control Systems in February 1973.

Since most operational suitability testing has been completed, MAC representatives said the joint test force will be terminated in March 1973, and remaining operational testing of the C-5A will be the responsibility of a MAC operational test and evaluation group. Since the scope of the remaining testing has not been defined, MAC representatives could not estimate a completion date.

CHAPTER 4

STATUS OF AIRCRAFT ACCEPTED WITH DEFICIENCIES

In our staff studies issued in March 1971 and March 1972, we reported that the Air Force had accepted aircraft with deficiencies, some of which precluded the C-5A from meeting the Specific Operational Requirement (SOR). The aircraft has been used in cargo missions with load restrictions and is currently restricted from performing tactical missions by direction of Headquarters USAF. Nevertheless, Air Force officials said the aircraft has an outstanding potential and has been used in several critical cargo missions. The aircraft meets Air Force requirements for handling outsize cargo.

Problems and deficiencies have been identified through testing programs, and in some instances, through operational experience. In addition to deficiencies precluding the aircraft from meeting the SOR, certain deficiencies have an impact on reliability of aircraft systems which contributes to frequent maintenance and less than desirable operational readiness.

The number of deficiencies in accepted aircraft has decreased because engineering changes to correct certain deficiencies have been incorporated into production. Appendix III shows the number of deficiencies in aircraft at the time of acceptance. The Air Force continues to be in the position of trying to obtain an aircraft that can meet the requirements of the operating command, and except for a $200 million fixed loss and special unallowable costs to be absorbed by Lockheed, is responsible for paying the cost for correction of the deficiencies.

COMPARISON OF SOR, SPECIFICATIONS, AND DEMONSTRATED PERFORMANCE

While the C-5A has demonstrated performance which meets or exceeds certain requirements of the SOR and the specifications, and has provided the Air Force with a unique capability, there are deficiencies in the aircraft which prevent it from meeting certain other SOR and contractural requirements, and consequently, certain mission requirements.

The missions the operational aircraft are restricted from performing are training or tactical missions involving air drop, landing on support area fields, low level flying, and aerial refueling. In that connection, SPO officials told us that the Air Force was directed in May 1972, by the Secretary of Defense, to make a study of and report to him on the capability of the C-5A. Headquarters USAF officials said that the study can not be released until decisions resulting from the study have been made.

SPO officials however, did provide us with information regarding the capabilities of the aircraft. This information appears on the charts on pages 48 and 49 and compares the major SOR requirements and specifications with the demonstrated performance of the C-5A through November 1972. These officials also provided the explanation of those items not meeting SOR and/or specification requirements that follow the chart.

COMPARISON OF SPECIFIC OPERATIONAL REQUIREMENT
CONTRACT SPECIFICATIONS, DEMONSTRATED AND EXPECTED PERFORMANCE
OF THE C-5A AS OF NOVEMBER 30, 1972

Specific Operational Requirement		Contract specification	Demonstrated performance	Performance expected by the Air Force
Factor	Requirement			
Service life	30,000 flying hours, and 12,000 landings	30,000 flying hours, and 12,000 landings	7,500 flying hours, and 3,000 landings	20,000 to 30,000 flying hours, and 12,000 landings with modifications
Payload/range				
with load factor 2.5[2]	100,000 lbs/5,500 nautical mi.	100,000 lbs/5,800 nautical mi.	100,000 lbs/5,650 nautical mi.[1]	100,000 lbs/5,650 nautical mi.
with load factor 2.5	200,000 lbs/2,700 nautical mi.	220,000 lbs/3,050 nautical mi.	190,000 lbs/3,560 nautical mi.	190,000 lbs/3,560 nautical mi.
with load factor 2.25	265,000 lbs/2,500 nautical mi.	265,000 lbs/2,700 nautical mi.	230,000 lbs/2,700 nautical mi.	230,000 lbs/2,700 nautical mi.
Low level flying (Terrain following/ avoidance)	1,500 to 1,800 flying hours at low altitudes	Low level clearance altitude of 300 to 1,500 feet	Restricted to a 1,000 foot minimum	1,000 foot minimum level
Support area operations	100 passes on a support area[3] airfield without repairing landing area	130 passes without repairing[3] landing area which has a CBR 9	Tests deferred after 8 passes	Unknown
		Landing distance of 4,000 feet. Contract changed to reflect 3,150 ft. landing on dry concrete; this is equivalent of 4,000 ft. bare soil.	2710 feet on dry concrete	Demonstrated 2,710 feet on dry concrete
Landing without ground based aids (Radar approach to landing)	Capability to land with 500 foot ceiling and one mile visibility	Capability to land with 500 foot ceiling and one mile visibility	Demonstrated in engineering testing. Failed in acceptance testing	Capability can be attained by using IDNE in conjunction with the radar
Aerial refueling	Compatible with KC-135 aircraft	Compatible with KC-135 aircraft	Demonstrated successfully with certain changes	Full capability with incorporation of changes

[1]With use of a Lift Distribution Control System (LDCS)

[2]A load factor of 2.5 means 2.5 Gs or 2.5 times the force of gravity

[3]One pass is one takeoff and one landing; CBR, California Bearing Ratio, is a measurement of soil strength (CBR 9 equals bare soil)

Factor	Requirement	Contract Specification	Demonstrated performance	Performance expected by the Air Force
Aerial delivery	(1) Capability to position the aircraft with accuracy of 100 meters without reference to the ground (2) Capability for airdrop will be provided	(1) Capability to position the aircraft with accuracy of 100 meters without reference to the ground (2) Capability to airdrop 50,000 pound unit loads	(1) Demonstrated 100 meter capability (2) Airdrop of unit loads of 40,000 pounds	(1) Full capability with incorporation of changes (2) Unit loads to be airdropped will not exceed 40,000 pounds
Ballistic missiles	Capability to transport ballistic missiles	Capability to transport ballistic missiles	Titan Atlas Centaur	Titan Atlas Centaur Minuteman
Reliability	95 percent probability of completing a mission without abort	(1) 90 percent probability of completing a mission without a major subsystem failure (2) 98 percent probability of completing a mission without abort (3) 87 percent probability completing a 10 hour mission without major subsystem failure to be demonstrated before completion of Air Force acceptance testing. Contract changed to 85 percent	(1) 91.7 percent based on delivered aircraft (2) 96.0 percent based on delivered aircraft (3) Demonstrated reliability for 10 hour mission of 84 percent	(1) 92 percent (2) 96 percent
Operational readiness	75 percent	75 percent	Experienced 36.8 to 53.9 percent from November 1971 through November 1972	Unknown
Takeoff at payload of:				
100,000 pounds	8,000 feet	8,000 feet	7,860 feet	7,860 feet
265,000 pounds	10,000 feet	9,100 feet	8,710 feet	8,710 feet

Service life and payload

The C-5A is required by the SOR to have a 30,000 hour service or fatigue life, and to be capable of airlifting a 200,000 pound payload at a load factor of 2.5G (force of gravity), and a 265,000 pound payload at a load factor of 2.25G. Because of problems with the wing, SPO officials said neither the payload capability at specified load factors nor the service life requirement will be fully met with the current wing design.

SPO officials told us that the wing failed to meet the full requirement for both strength and fatigue life in the contractor's engineering test program. The wing was to be tested for strength to 150 percent of its design limit, but failed after reaching about 126 percent of the limit. In addition, the wing was required to demonstrate a fatigue life of 30,000 hours. Fatigue cracks were discovered after demonstrating 2,250 hours (9,000 cyclic test hours.) Structural modifications were incorporated in the test article and testing continued to 3,750 hours (15,000 cyclic test hours).

The test failures resulted in several engineering changes, and development of a manual Lift Distribution Control System (LDCS) which causes an inward shift of wing lift by raising the ailerons at the ends of the wings during flight. SPO officials said the addition of LDCS aids the load carrying capability and fatigue life of the wing. In addition, the severity of future fatigue tests will be reduced by using revised mission profiles (see Chapter 3) which were developed by MAC and incorporated into the test

program in February 1972. The 3,750 hour service life demonstrated is, according to SPO officials, equivalent to about 7,500 hours with the addition of LDCS and use of the revised mission profiles.

With the incorporation of certain engineering changes and the use of LDCS, SPO officials said they believe the C-5A will demonstrate a service life of at least 15,000 hours, and possibly greater than 20,000 hours. With regard to payload capability, the C-5A is limited to airlifting 174,000 pounds (at 2.0G). On completion of the 100 percent structural flight demonstration, this limitation will be raised to 190,000 pounds (at 2.5G).

The following chart depicts the current payload capability of the C-5A.

	Load factor	Payload	Gross take off weight
Original design requirements	2.5 G	220,000	728,000
	2.25G	265,000	764,500
Air Force estimated capability[1]	2.5 G	190,000	728,000
	2.25G	230,000	764,500
	2.07G	265,000	764,500
Current restriction	2.0 G	174,000	712,500

[1]With the use of LDCS.

As of February 1972, LDCS was available and used in the entire C-5A force. Hardware changes are being incorporated to make the use of LDCS a semi-automatic rather than a manual operation. The semi-automatic feature is scheduled to be installed in all aircraft by June 1973. The cost of developing and installing the system is estimated to be $1.8 million.

Structural changes will also be made to the wing to increase the fatigue life of the wing to attain a 7,500 hour service life. The estimated cost of these major changes is over $13 million.

The Air Force, in April 1972, authorized Lockheed to begin a wing life improvement study and to report the results in June 1972. The study was to consider the effect of LDCS and the revised mission profiles in improving fatigue life. The recommendations were to include alternative solutions of improving the wing life with consideration of cost, aircraft downtime, implementation schedule, and estimated performance. SPO officials did not make the Lockheed report available to GAO because the Air Force had not evaluated the report, and the effort had been extended.

In connection with the structural problems of the C-5A, an Independent Structural Review Team (ISRT) was established on December 1, 1971, to make a review of the aircraft structure, criteria, and usage, and to recommend corrective action for known and potential structural problems. The ISRT is composed of engineering personnel from the Air Force, Lockheed, and other aerospace companies. The ISRT effort, estimated to cost about $3.4 million is scheduled for completion in December 1972, with a report to be issued by March 1973.

Range

The SOR described two missions for the C-5A. The description of the missions involved payload, range, and load factor as follows:

Type mission	Payload	Load factor	Range (nautical miles)
Basic	100,000 lbs	2.5	5,500
Emergency deployment	265,000 lbs	2.25	2,500

The contract specifications, however, required a range of 5,800 nautical miles for the basic mission and 2,700 nautical miles for the emergency deployment mission.

LDCS, which is to be added to the aircraft to partially alleviate wing stress and fatigue problems, introduces drag and degrades the range for the basic mission about three percent below the contract specification. The June 30, 1972 SAR reported an estimated basic mission range of 5,650 nautical miles, which exceeds the SOR, but is below the contract specification.

SPO officials said the 2,700 nautical mile range for the emergency deployment mission can be achieved by the C-5A, but because of problems with wing strength, the maximum payload is 230,000 at 2.25G rather than 265,000 pounds. The Air Force informed us that the C-5A can carry 265,000 at 2.1G.

Low level flying

The SOR requires that the C-5A be capable of flying 1,500 to 1,800 hours of low level (terrain following) missions. The contract specifications call for a low level clearance altitude of 300 to 1500 feet. The aircraft are restricted from flying low level missions at 300 feet because the Multi- Mode Radar is not operable for terrain following below 1,000 feet.

SPO officials said there are no changes known, short of complete redesign, to permit the radar to function at 300 feet, and they do not plan such a redesign. At the 1,000 foot level, some problems were identified requiring certain changes to be made. SPO officials said the changes have been incorporated and successfully demonstrated in a test aircraft. The changes are scheduled to be incorporated in operational aircraft by October 1974.

Support area operations

One of the main purposes for procuring the C-5A was to achieve a capability to deploy military forces and equipment anywhere in the world, whether or not ground support is available. The contract specifications require the C-5A to be capable of landing on a 4,000 foot support area field and making 130 passes (takeoffs and landings) before repair of the field is necessary. The support area field was to have at least a California Bearing Ratio (CBR) of 9.

Test landings on support area fields in June 1970, were described in Chapter 3. The tests were terminated because dust ingested into the engines caused the engines to overheat. At that time, it was recognized that electrical and hydraulic lines and a junction box on the underside of the main landing gear bogie were subject to damage by sticks, stones, and other flying debris with continued passes on a support area field. SPO officials said the test program proved the capability of limited operation on support area fields in the event such an operation must be performed.

for refueling capability. The MAC C-5A force has been restricted by Air Force Headquarters from performing missions requiring aerial refueling.

In aerial refueling tests conducted in December 1971, a nozzle separated from the refueling boom (part of the KC-135 tanker) when the boom was being retracted from the C-5A receptacle. An investigation revealed that certain metal parts of the nozzle and receptacle were binding, causing a problem. The receptacle on a test aircraft was modified and successfully tested in February 1972. A formal engineering change proposal was submitted by Lockheed in August 1972 and approved by the SPO. The change to the C-5A receptacles, estimated to cost about $120,000 for the C-5A force, is scheduled to be incorporated in all aircraft by March 1974. The first change kit is to be installed in the MAC force in December 1972.

Airdrop of cargo

The SOR requires the C-5A to have a capability to position in space with an accuracy of 100 meters for airdrop operations. To accomplish this airdrop mission, an aerial delivery kit, consisting of guide rails, cables, and parachute is installed in the aircraft. The system is required by the specifications to airdrop 200,000 pounds of which no individual load will weigh more than 50,000 pounds.

SPO officials said a demonstration of the requirement to position the aircraft in space to an accuracy of 100 meters was successfully completed in November and December 1972. They said a test report will not be available for several months.

The delivery system has not been tested with unit loads in excess of 40,000 pounds. The Army informed the C-5A SPO in June 1971 that it had no requirement for airlift of unit loads in excess of 35,000 pounds. With addition of airdrop rigging equipment, the Army considered a 40,000 pound capability sufficient.

The Air Force has restricted the use of the aerial delivery system until several changes are incorporated to improve the system's ability to meet specified performance. Some of the problems involve malfunctioning rail locks, conveyors, and a control mechanism.

In our staff study of March 1972, we reported the aerial delivery system was essentially qualified, needing minor corrections to fully meet specified performance. SPO officials said the corrective changes were installed in a test aircraft and successfully tested in November and December 1972. No test report was available in December 1972. As of November 30, 1972, SPO officials said three of the updated aerial delivery kits have been provided to MAC. All kits are scheduled to be updated by January 1974, at a cost of about $1.1 million.

Capability to airlift ballistic missiles

SPO officials said that the C-5A is generally capable of airlifting ballistic missiles, as required by the SOR. The missiles include the Atlas Centaur, Titan, and Minuteman. Because of a potential compatibility problem, however, the C-5A is restricted from transporting the Minuteman Missile, in any of three available transport trailers.

The C-5A has the capability to transport the Minuteman including adequate

space, floor strength and tie down points, but necessary tests have not been accomplished to evaluate the movement of the missile in its transport trailer or the tiedown capability of the trailer. Without those tests, it is uncertain whether an airlift of the Minuteman would result in damage to either the missile or the aircraft. The tests required of the Minuteman were not done because the Minuteman SPO did not have the necessary funds to carry out the program. As a result, the C-5A SPO informed AFSC that a requirement of the SOR would not be met, and that the compatibility effort would be cancelled.

In June 1972, MAC objected to the cancellation of the Minuteman/C-5A compatibility effort since they believed it was to the Air Force's advantage to qualify at least one of the three Minuteman transport trailers in the C-5A. MAC believed that the qualification would provide more flexibility in planning for Minuteman transportation and would furnish an alternate means of air transport if the C-141 force became incapable of performing the mission because of increases in Minuteman weight or grounding or reduction of the C-141 force. In November 1972, SPO officials said they believed the compatibility tests would eventuallly be accomplished.

Reliability

SPO officials told us that they expect the aircraft to eventually have a 96 percent reliability, which exceeds the SOR requirement of 95 percent.

The reliability demonstrations completed through November 1972, are further described in Chapter 3.

Operational readiness

The SOR requires 75 percent of the C-5A force to be operationally ready at all times. The operationally ready rate of the aircraft delivered to MAC increased from 36.8 percent in November 1971, to 53.9 percent in November 1972. The steady increase was attributed to the incorporation of engineering changes to improve subsystem reliability and improved maintenance practices. Charts showing the trends of operational readiness are included in Chapter 5.

The contract provided that a calculation be made of operational readiness to determine if the contractor met contractual requirements. The contractor successfully demonstrated through the calculation that the aircraft meets the contractual requirements. The demonstrated and actual experience in the field are not comparable because the calculation was not required to consider the Air Force functions required to maintain operational readiness, over which the contractor had no control.

OTHER DEFICIENCIES IN EQUIPMENT

SPO officials identified several other major problems that did not directly prevent the C-5A from meeting SOR requirements. Some of those deficiencies are described below.

Pylon problem

In September 1971, an engine and pylon, which attaches the engine to the wing, separated from aircraft number 13 as it was preparing for takeoff. An inspection disclosed that a pylon structural member had broken. As a

result of that finding, the C-5A aircraft were not flown as a precautionary measure. Immediate corrective action was taken by replacing the connections which were cracked or had been operational for a comparatively long period of time. As a safety measure, steel straps were installed on certain pylons with high accumulations of flight time. SPO officials said that the change to the pylon structure to correct this deficiency was to be incorporated into production with aircraft number 70. The update of the C-5A force is scheduled to be completed in August 1973. In 1971, Lockheed estimated that the cost of making corrections to the pylons would be about $13 million. In July 1972, the Air Force increased that estimate to about $18 million.

Automatic Flight Control System

The Automatic Flight Control System was designed to make the C-5A capable of automatic flight. The flight crew monitors the performance of the system by visual displays, and at any time, can take over command of the airplane to complete a mission.

Generally, the system does not allow automatic flight with the required accuracy. Problems have been experienced with the system in maintaining the proper attitude (aircraft position in relation to the ground), following the specified navigational paths, and providing aircraft stability.

Engineering changes have been identified to correct the deficiencies in the system. The cost of the changes for the C-5A force is estimated to be $26.4 million. All aircraft are scheduled to be updated by December 1974, but as of November 30, 1972, no aircraft had the changes incorporated.

Malfunction Analysis Detection and Recording System

The Malfunction Analysis Detection and Recording System (MADAR) was designed to assist flight crews and maintenance personnel in the detection and isolation of malfunctions in the aircraft. It was also designed to furnish trend data related to subsystem degradation for use in prediction of impending failures.

The MADAR has experienced low reliability because high charges of electricity interfere with proper operation of the system, and necessitate frequent repairs.

Diodes are to be added to the system to correct the problem. The estimated cost of adding the diodes to all MADAR systems is about $36,000. The C-5A force is scheduled to be retrofitted by July 1974, and as of June 30, 1972, one aircraft had the diodes installed.

Inertial Navigational Equipment (INE)

The INE was designed to be self-contained navigational aid. Difficulty in field operations with the INE resulted in excessive removals of this equipment. A team consisting of officials from the SPO, MAC, SAAMA and Lockheed attributed the INE problems to:

--faulty INE test sets,

--the lack of comprehensive troubleshooting procedures,

--incomplete and erroneous technical data,

--lengthly repair turn-around time,

--inadequate training,

--turnover of personnel with critical skills,

--defective wiring interfaces, and

--low INE hardware reliability

Below is a further explanation of several of the problem areas and actions being taken to improve INE performance.

SPO officials said the INE test set erroneously identified certain INE components as faulty, and there was a lack of comprehensive troubleshooting procedures to aid in pinpointing problems. Those deficiencies resulted in the return of good components to the depot for repair, secondary failures in systems which interface with the INE, and taking INE components from one aircraft and using them on another. SPO officials said an engineering change is to be submitted to correct deficiencies in the INE test set, and troubleshooting procedures have been prepared to reduce the unnecessary removals.

Technical data to support the INE test sets was found to be incomplete and, in some instances erroneous, making it difficult for technicians to determine INE faults. SPO officials said the technical data is being revised.

Certain INE components found to be faulty are returned to the subcontractor for repair. The time to send a component to the subcontractor, get it repaired and returned to the C-5A force, was found to be too long. Special handling procedures for reducing Air Force delays in repair turn around time have been initiated. In addition, the INE subcontractor has submitted a proposal to reduce vendor turn around time by 25 percent.

Personnel problems have been caused by the failure to use available training, constant turnover of maintenance personnel, and employment of personnel to handle too many systems. Provisions to ensure the use of available training are being made. In addition, INE technicians are being rotated in a manner to ensure that there is a cadre of experienced technicians at each base.

In August 1972, the SPO approved engineering changes proposed by Lockheed to improve the reliability of six INE components. The estimated cost of making the change in the C-5A force is $2.1 million. The C-5A force is to be updated with this change as the INE components fail, therefore, SPO officials could not estimate when the C-5A force will be completely updated.

ESTIMATED COST TO CORRECT DEFICIENCIES

In February 1972, the SPO estimated that $259 million will be required to correct the deficiencies in C-5A aircraft. In making that estimate, the SPO assumed that:

--changes will not be made to attain a 220,000 pound payload capability at 2.5 Gs.

--the Multi Mode Radar will not be redesigned to permit low level flying at 300 feet

--the unknown problems that will be identified in the future, will follow trends of experience on the C-141 aircraft.

--there will be additional major structural work as a result of static and fatigue test failures in 1971, and as a result of the ISRT effort.

--the ISRT will recommend modifications to the present wing as opposed to a major redesign.

--the changes will be incorporated at Lockheed and at the San Antonio Air Material Area (SAAMA), the C-5A system logistic manager. The work at SAAMA will be in conjunction with the depot level maintenance program to realize economies in aircraft downtime and processing costs.

--the changes involved will be identified and approved by May 1973, the estimated date of transition of the aircraft to AFLC.

--all changes will be incorporated by late fiscal year 1975.

The SPO broke out the $259 million in June 1972 as follows:

	Amount (millions)
Engineering changes approved	$166
Changes in work	18
Correction of undefined problems based on C-141 experience	30
Changes to be generated by the ISRT	45
Total	$259

The SPO's previous estimate of the cost to correct deficiencies in July 1971 (see the March 1972 staff study) was $164 million. The increase in the estimate to $259 million resulted from static and fatigue test failures in 1971, pylon failures in September 1971, forming of the ISRT, extension of the update schedule to late fiscal year 1975, a changed mix of update work to be done at Lockheed and SAAMA, definition of a requirement to update delivered spares, and a better definition of change requirements.

CONCLUSION

Because of problems in the structure, landing gear and avionics of the

C-5A, the aircraft delivered to MAC are currently unable to meet several requirements of the SOR. In addition, SPO officials do not expect the C-5A in the future to meet several SOR requirements including the following major areas.

--The life of the production aircraft is currently limited by the fatigue life of the wing. Modifications will be required if the aircraft is to achieve the originally specified service life of 30,000 hours.

--The payload capability at 2.5 G will be 190,000 rather than the 200,000 pound requirement.

--The capability to fly low level missions is limited to 1,000 feet which does not meet the complete low level requirement (the contract specifies low level altitudes of from 300 to 1500 feet.)

--The aircraft has not met all of the SOR requirements for support area landings, but has demonstrated a limited capability.

--The aircraft in the MAC force are currently restricted from performing missions involving aerial delivery, and transportation of the Minuteman ballistic missiles, but SPO officials said the C-5A will be capable of meeting those requirements after certain engineering changes have been incorporated in the aircraft and the missile transporter.

System reliability and operational readiness requirements, according to SPO officials, have been demonstrated based on analytical data. According to data from operations, the reliability of the C-5A force exceeds the SOR requirement, but the operational readiness of the C-5A force lags behind the requirement and the demonstrated capability.

With respect to the cost of correcting deficiencies, the $259 million estimate is based on several assumptions. If events subsequent to the estimate differ from the assumptions, significant changes in the cost estimate could result.

CHAPTER 5

OPERATIONAL EXPERIENCE AND SYSTEM TRANSITION

During fiscal year 1972, the C-5A aircraft assigned to MAC successfully completed many airlift missions. MAC officials cited the following examples of missions undertaken by the C-5A which illustrate its unique capability.

--In July 1971, two C-5As participated in a joint airlift exercise with C-141 aircraft. One C-5A transported 15 trucks, trailers, and vans and the other carried 14 other vehicles from MacDill Air Force Base, Florida to Texas. It would have required an additional 14 missions by the C-141 force to airlift that equipment carried in the two C-5As.

--In February 1972, an awkward, whale-shaped Navy sonar dome-19 feet wide, 42 feet long, and weighing 25 tons--was shipped by C-5A from Akron, Ohio to Long Beach, California. The dome was too large for truck or rail transport and shipping by barge would have required roads to be closed and a voyage of two months.

--In July 1972, an F-15 flight test aircraft was airlifted in a C-5A from St. Louis, Missouri, to Edwards Air Force Base, California, for the beginning of F-15 flight tests.

--In May 1972, C-5As flew 10 missions into Vietnam, each of which delivered 3 M-41 tanks (54,000 pounds each) or 2 M-48 tanks (98,000 pounds each) for a total airlift of 1,650,000 pounds. Since the tanks weigh 98,000 pounds each, a waiver from the 80 percent operating restriction (174,000 pound payload at 2.0G load factor) had to be obtained. The C-5A SPO provided an authorization for the payload at 1.8Gs which is equivalent to the basic restriction.

MAC officials also provided a listing of numerous other commodities that have actually been airlifted, that are outsize to any other aircraft, such as a 75-ton rock crusher, a 74-ton turbine generator, and a CH-47 helicopter.

Although the C-5A has been successful in fulfilling missions involving high gross weights and cargo, outsized to other aircraft, the aircraft assigned to MAC are subject to certain operating limitations and have encountered problems with maintenance and subsystem reliability. The Air Force Systems Command and the Air Force Logistics Command (AFLC) are negotiating transfer of the C-5A to AFLC, but as a result of some remaining deficiencies, exceptions will be made to a complete transition of the weapons system. A tentative agreement on transition is described later in this chapter.

OPERATIONAL EXPERIENCE

Air Force statistics show that C-5As assigned to MAC were operationally ready for missions only 41.2 percent of the hours for fiscal year 1972 the aircraft were under control of MAC operational and test squadrons. The SOR and contract specifications require a 75 percent operational readiness.

The chart below summarizes fiscal year 1972 operational status.

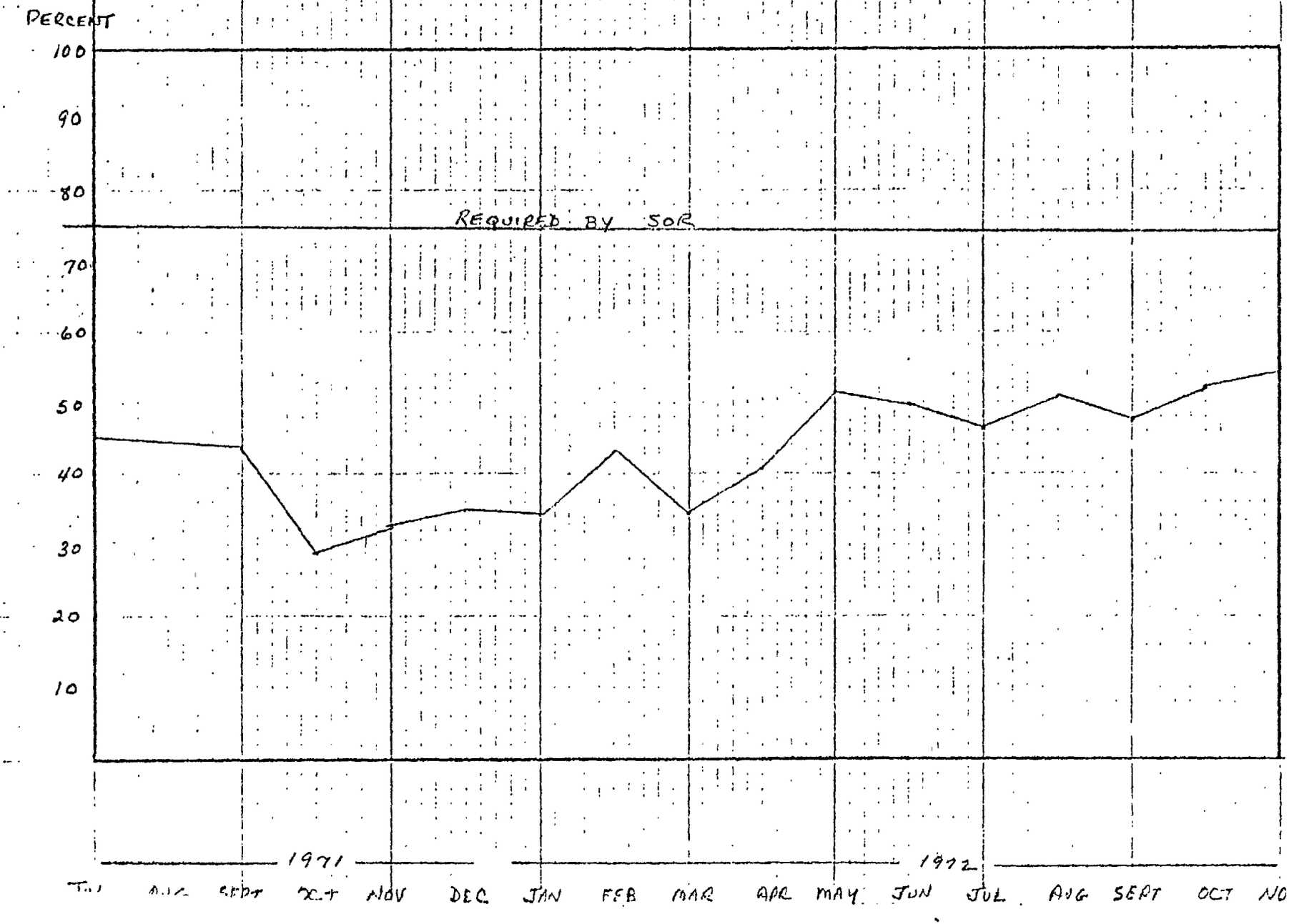
Status	Hours	Percent of total
Operationally ready	128,890	41.2
Not operationally ready/maintenance (NORM)	130,556	41.7
Not operationally ready/supply (NORS)	53,394	17.1
TOTAL	312,840	100.0

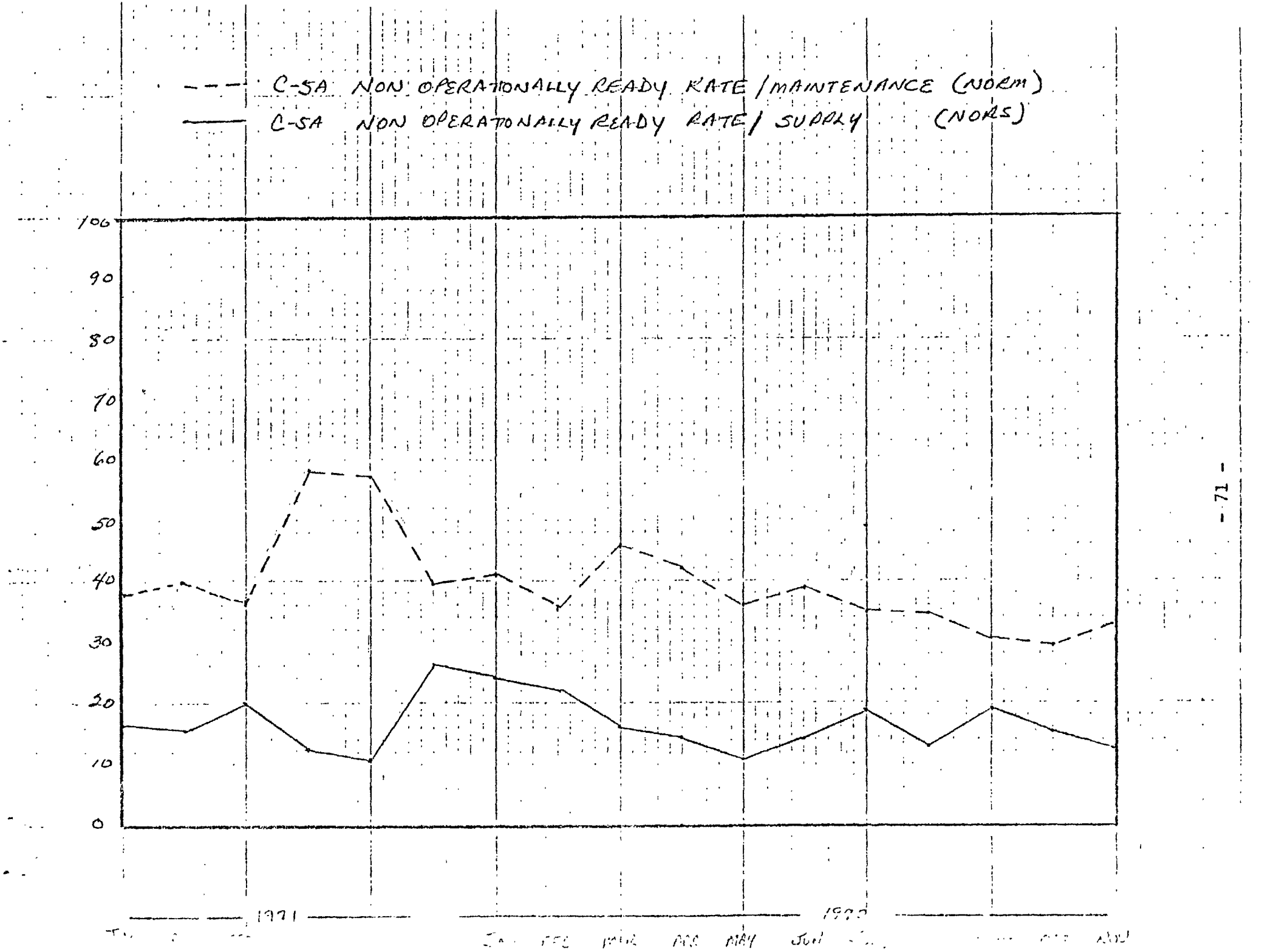
The aircraft were not operationally ready because they were either undergoing maintenance (NORM) or repair parts were not available (NORS). Air Force officials attributed the high NORM and NORS rates to the

inadequate reliability of certain aircraft subsystems and the inadequate quantity of trained maintenance personnel. If components must be replaced more often than provided for, Air Force officials said the aircraft will be undergoing maintenance more often than planned and eventually the supply of replacement parts will be depleted. In addition, AFLC officials said improvement is needed in identifying the causes of malfunctions in subsystems. In that connection, SPO officials said many subsystems are removed from C-5A aircraft and it is later discovered that the subsystem did not malfunction. SPO officials did not clarify how often that situation occurred.

Air Force officials also explained that operational readiness is beginning to improve and will continue to improve when engineering changes designed to improve subsystem reliability have been incorporated into aircraft and as maintenance personnel gain experience with the C-5A. In that connection, we found that in August 1972, the C-5A force had an average of 225 changes to be incorporated at MAC bases, Lockheed, or SAAMA. Those changes, however, are not scheduled to be completed on all aircraft until late fiscal year 1975, therefore, a significant increase in operational readiness may not be a reality for several years. The charts on pages 70 and 71 show the trends of operational readiness and nonoperational readiness caused by maintenance (NORM) and supply (NORS).

C-5A OPERATIONALLY READY RATE




C-5A NON OPERATIONALLY READY RATE / MAINTENANCE (NORM)
C-5A NON OPERATIONALLY READY RATE / SUPPLY (NORS)
100
90
80
70
60
50
40
30
20
10
0
1971
1972
MAY
JUN

The NORM rate increased from 35.6 percent in September 1971 to 57.6 percent in November 1971. A MAC representative said the increase was the direct result of pylon cracks discovered in September 1971 and of not flying the aircraft until all pylons were inspected and corrective measures taken where necessary. The pylon problems are discussed in Chapter 4.

TENTATIVE PLAN FOR TRANSITION OF THE C-5A SYSTEM TO AFLC

Air Force regulations provide for transition of system management responsibility from AFSC to AFLC at the end of system acquisition. That point in the acquisition cycle is defined as "the point in time when the last operating unit in a certain series is accepted by the user or when the Specific Operational Requirements (SOR) have been demonstrated through acceptance testing, and all updating changes resulting from the testing have been identified, approved, and placed on procurement, whichever occurs later."

In July 1972, AFSC and AFLC prepared a tentative plan for transition of the C-5A to AFLC for logistic support and related engineering and management responsibility. The plan identified 13 subsystems acceptable for transition and 42 subsystems not acceptable for transition.

Since July 1972 discussions between AFSC and AFLC in system transition have continued and in February 1973 AFSC estimated that of 154 identified subsystems, all but 44 were transferable. The 44 subsystems not acceptable for transfer include some of the items discussed as having deficiencies in

chapter 4. AFSC said that further discussions with AFLC would take place in March 1973 and additional subsystems would be identified as transferable. It is expected that some subsystems will still not be transferable as of May 1973.

CONCLUSION

The C-5A has provided the Air Force a unique capability for airlifting cargo, in terms of size and payload. Although the aircraft meets total system reliability requirements, the lack of adequate subsystem reliability in some instances, has had a detrimental affect on both the operational readiness of the aircraft and the ability of AFSC and AFLC to complete a smooth transition of management responsibility. In addition, the inadequate quantity of trained maintenance personnel has caused the C-5A force to not be operationally ready to the rate required. Since engineering changes may be made to the aircraft for two or more years after delivery of the last production aircraft and maintenance personnel must react to those changes, it appears that an increase in operational readiness rate will be slow. It also appears that transition may be a long process and that C-5A system management will be difficult with both AFSC and AFLC involvement.

STATUS OF FUNDING FOR C-5A AIRCRAFT PROGRAM AT JUNE 30, 1972
(Millions)

	Program year	Appropriated	Reprogramming (+ or -)	Current Program	Obligated	Expended
RDT&E	1972*	$ 22.4	$ --	$ 22.4	$22.4	$ 22.4
	1971	11.6	--	11.6	11.6	9.4
	1970	34.2	--	34.2	34.2	33.9
	1969	128.0	- 2.0	126.0	126.0	126.0
	1968	305.2	+36.7	341.9	341.9	341.9
	1967	258.2	+20.4	278.6	278.6	278.6
	1966	157.0	+ 1.9	158.9	158.9	158.9
	1965	7.0	+35.0	42.0	42.0	42.0
	1964	--	+10.0	10.0	10.0	10.0
Subtotal		923.6	+102.0	1,025.6	1,025.6	1,023.1
PROCUREMENT (Including initial spares)	1972*	299.1	--	299.1	284.0	164.6
	1971*	200.0	--	200.0	200.0	200.0
	1971	409.2	-28.4	380.8	328.3	312.5
	1970	865.8	- .3	865.5	862.9	856.9
	1969	625.9	--	625.9	625.9	624.0
	1968	492.8	+16.6	509.4	509.4	509.4
	1967	415.3	-20.0	395.3	395.3	395.3
Subtotal		3,308.1	-32.1	3,276.0	3,205.8	3,062.7
CONSTRUCTION	1971	1.3	- .4	.9	.6	.6
	1970	9.4	--	9.4	8.0	8.0
	1969	.1	--	.1	.1	.1
	1968	6.8	--	6.8	6.8	6.8
Subtotal		17.6	- .4	17.2	15.5	15.5
Grand total		$4,249.3	+$69.5	$4,318.8	$4,246.9	$4,101.3

* Denotes "restricted" funds appropriated by Public Laws 91-441 and 92-204.

Resume of C-5A's Revised Fatigue Spectrum Missions

Purpose: The purpose of the 14 mission profiles or fatigue article test spectrum, is to reflect the planned life time use of the C-5A. Missions 1-10 are logistic missions; Missions 11-14 are training or tactical missions.

Mission 1 - Airlift

Range	825 nautical miles
Fuel weight	95,235 lbs.
Cargo weight	51,537 lbs.
Speed	0 to M.74
Altitudes	0 to 30,000 feet
Runways	Standard
Mission flight hours	2.1 hours
Total missions	948
Total flight hours	1,977 hours
Total landings	948

Mission 2 - Airlift

Range	2,310 nautical miles
Fuel weight	134,729 lbs.
Cargo weight	64,021 lbs.
Speed	0 to M.74
Altitudes	0 to 30,000 ft.
Runways	Standard
Mission flight hours	5.5 hours
Total missions	161
Total flight hours	885 hours
Total landings	161

Mission 3 - Airlift

Range	2,429 nautical miles
Fuel weight	210,958 lbs.
Cargo weight	70,104 lbs.
Speed	0 to M.74
Altitudes	0 to 30,000 ft.
Runways	Standard
Mission flight hours	7.5 hours
Total missions	351
Total flight hours	2,631 hours
Total landings	351

Mission 4 - Airlift

Range	5,476 nautical miles
Fuel weight	314,000 lbs.
Cargo weight	9,713 lbs.
Speed	0 to M.74
Altitudes	0 to 30,000 feet
Runways	Standard
Mission flight hours	12.8 hours
Total missions	19
Total flight hours	243 hours
Total landings	19

Mission 5 - Airlift

Range	1,318 nautical miles
Fuel weight	95,471 lbs.
Cargo weight	120,647 lbs.
Speed	0 to M.74
Altitudes	0 to 30,000 ft.
Runways	Standard
Mission flight hours	2.9 hours
Total missions	294
Total flight hours	858 hours
Total landings	294

Mission 6 - Airlift

Range	1,844 nautical miles
Fuel weight	160,880 lbs.
Cargo weight	144,622 lbs.
Speed	0 to M.74
Altitudes	0 to 30,000 ft.
Runways	Standard
Mission flight hours	4.4 hours
Total missions	761
Total flight hours	3,363 hours
Total landings	761

Mission 7 - Airlift

Range	3,378 nautical miles
Fuel weight	222,556 lbs.
Cargo weight	146,479 lbs.
Speed	0 to M.74
Altitudes	0 to 30,000
Runways	Standard
Mission flight hours	8 hours
Total missions	672
Total flight hours	5,400 hours
Total landings	672

Mission 8 - Airlift

Range	3,899 nautical miles
Fuel weight	259,934 lbs.
Cargo weight	120,506 lbs.
Speed	0 to M.74
Altitudes	0 to 30,000 ft.
Runways	Standard
Mission flight hours	9.2 hours
Total missions	196
Total flight hours	1,812 hours
Total landings	196

Mission 9 - Airlift

Range	2,748 nautical miles
Fuel weight	94,250 lbs.
Cargo weight	162,301 lbs.
Speed	0 to M.74
Altitudes	0 to 30,000 ft.
Runways	Standard
Mission flight hours	3.4 hours
Total missions	451
Total flight hours	1,530 hours
Total landings	451

Mission 10 -Airlift

Range	3,071 nautical miles
Fuel weight	204,581 lbs.
Cargo weight	182,206 lbs.
Speed	0 to M.74
Altitudes	0 to 30,000 ft.
Runways	Standard
Mission flight hours	7.4 hours
Total missions	697
Total flight hours	5,124 hours
Total landings	697

Mission 11 -Local transition

Range	749 nautical miles
Fuel weight	130,000 lbs.
Cargo weight	19,713 lbs.
Speed	0 to M.610
Altitudes	0 to 20,000 ft.
Runways	Standard
Mission flight hours	4 hours
Total missions	777
Total flight hours	3,108 hours
Total landings	1,554 full stop 4,423 touch & go

Mission 12 -Low level aerial delivery and formation training

Range	1,268 nautical miles
Fuel Weight	150,000 lbs.
Cargo weight	26,713 lbs.
Speed	0 to M.557
Altitudes	0 to 20,000 ft.
Runways	Standard
Mission flight hours	5 hours
Total missions	535
Total flight hours	2,673 hours
Total landings	1,069
Other	Includes 900 contour flying hours during C-5A life

Mission 13 -Sub-standard air field landing

Range	1,188 nautical miles
Fuel weight	110,000 lbs.
Cargo weight	19,713 lbs.
Speed	0 to M.456
Altitudes	0 to 10,000 ft.
Runways	Standard and substandard
Mission flight hours	4 hours
Total missions	53
Total flight hours	213 hours
Total landings	373
Other	Includes 107 support area landings during C-5A life

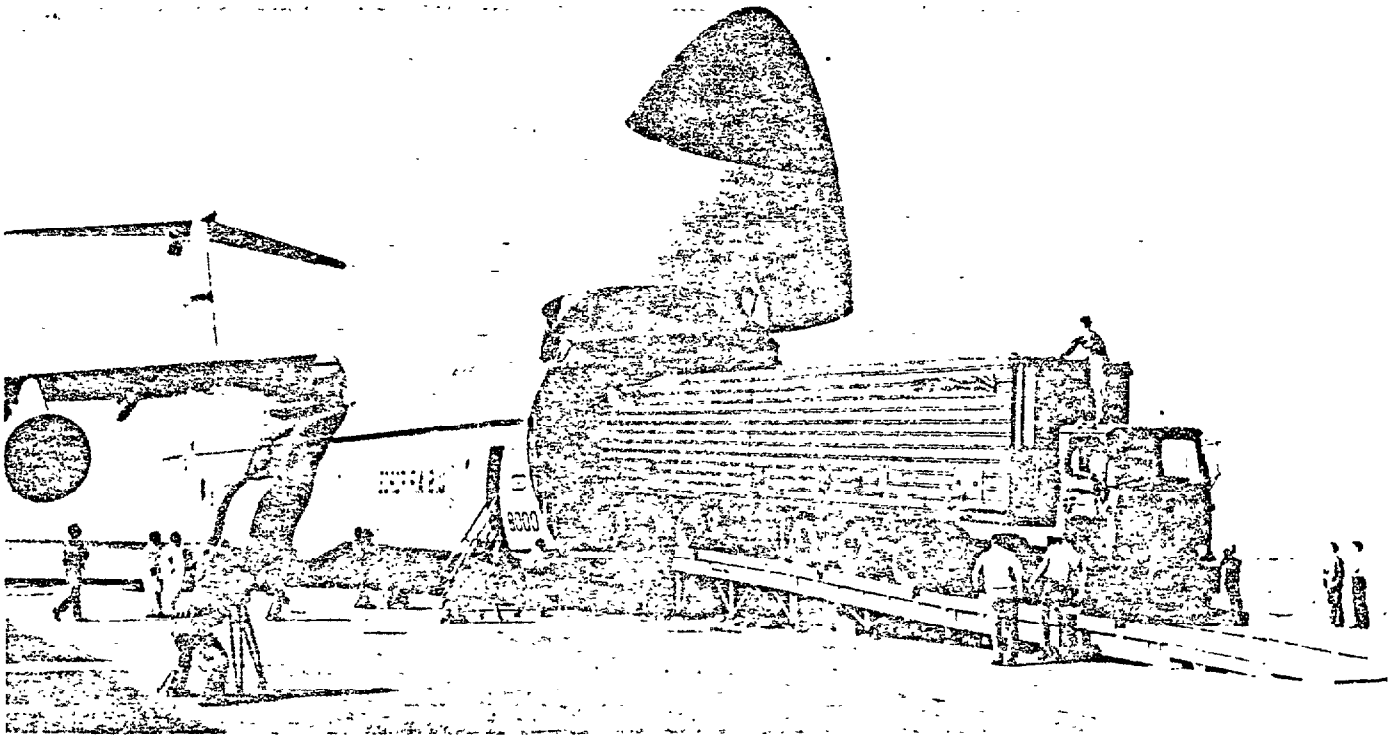
Mission 14 -Aerial refueling

Range	2,426 nautical miles
Fuel weight	170,000 lbs.
Cargo weight	19,713 lbs.
Speed	0 to M.610
Altitudes	0 to 20,000 ft.
Runways	Standard
Mission flight hours	6 hours
Total missions	31
Total flight hours	183 hours
Total landings	31
Other	Includes 41 hours of aerial refueling during C-5A life. Each mission includes 4 aerial refuels.

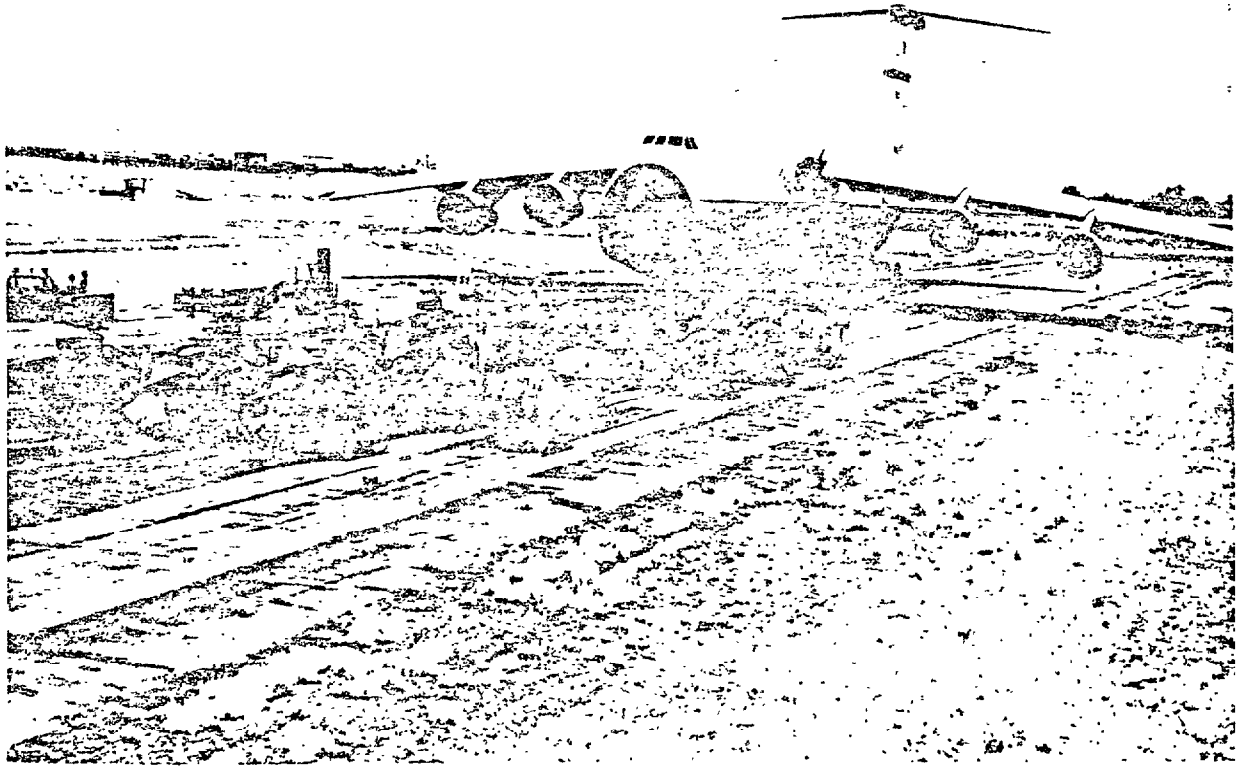
NUMBER OF DEFICIENCIES IN PRODUCTION AIRCRAFT AT THE TIME OF ACCEPTANCE

Aircraft numbers [1]	Average number of deficiencies at acceptance
9 and 10	135
12 through 21	309
22 through 31	322
32 through 41	293
42 through 51	232
52 through 61	143
62 through 71	121

[1] Aircraft numbers 1 through 8 are test aircraft.
Aircraft numbers 1 and 11 were destroyed by fire in 1970.



A 57 foot Minuteman III transporter being loaded into a C-5A.



A group of OH-6 light observation helicopters which can be carried at one time by the C-5A.