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The CH-53E helicopter is being developed to provide the Navy and Marine Corps with a shipboard compatible helicopter having twice the lift capability of its predecessors. Operationally and technically, the CH-53E has demonstrated the potential to be an effective aircraft. The Navy has restructured the program to overcome problems encountered during development. Findings/Conclusions: Costs increased by $113.2 million (14%) from September 1976 to September 1977. The reduction from 70 to 49 aircraft increased program unit costs from $12.6 million to about $14.7 million, but total program costs decreased about $152 million to $777.7 million. Although recent tests have supported granting provisional approval for service use, they have revealed deficiences which need to be corrected and/or evaluated, including: main rotor blade bonding and rain erosion problems, power losses caused by exhaust gas reingestion, a faulty torque indicating system, low-frequency vibrations, electrostatic discharge, and downwash. Reliability and maintainability tests showed that the CH-53E exceeded four requirements and failed to meet two others. Although identified missions can use the CH-53E's greater lift capabilities, there are problems associated with several missions, and certain other conditions should be met or considered before a full-scale production decision is made. Recommendations: The Congress and the Secretary of Defense should determine whether the additional capability provided by 49 CH-53E helicopters warrants the planned expenditure. The Secretary of Defense should determine whether the deficiencies identified have been satisfactorily resolved prior to the initial production decision and make sure that the operational testing is successful before the Navy is allowed to exercise the option to purchase the 14 fiscal year 1979 aircraft. (RRS)

5817

BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

Is Production Of The CH-53E Helicopter Warranted?

The CH-53E is being developed to provide a shipboard compatible helicopter with lift capability twice that of its predecessors.

The Navy plans to purchase 49 aircraft at an average program unit cost of $14.7 million. The initial production contract is scheduled to be awarded in early 1978.

The Congress and the Secretary of Defense should determine whether the capability provided by the 49 CH-53E helicopters warrants the planned expenditure of $777 million.

PSAD-78-27
MARCH 23, 1978

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

B-163058

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

This report presents our views on the major issues of the CH-53E Helicopter Program. A draft of this report was reviewed by agency officials associated with the program and their comments are incorporated as appropriate.

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

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

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

ACTING Comptroller General
of the United States

D I G E S T

The CH-53E helicopter is being developed to provide the Navy and Marine Corps with a shipboard compatible helicopter having twice the lift capability of its predecessors.

Operationally and technically, the CH-53E has demonstrated the potential to be an effective aircraft. The Navy has restructured the development program to overcome problems encountered during development.

This report centers on testing, program costs, plans to award the initial production contract in early 1978, the status of the development effort, and the planned missions.

These were some of the problems noted by GAO:

--Since September 1976 program costs have increased $113.2 million to a total of $929.8 million primarily due to escalation and costs to complete the additional development effort. The program unit cost for 70 CH-53Es was estimated at $12.6 million. The recent reduction from 70 to 49 aircraft increased program unit cost to $14.7 million and reduced total program cost to $777.7 million. (See pp. 3 to 5.)

--Several problems characteristic of all helicopters continue to affect this program. These problems are either more severe or more likely to occur with the CH-53E. They include electrostatic discharge, downwash, and gas reingestion. (See pp. 9 to 10 and 18 to 19.)

--Navy test reports recommended certain deficiencies be corrected and that development of the CH-53E continue. Deficiencies identified included inflight oscillations,

electrical shock hazards, and lack of a dedicated main rotor blade manufacturing quality assurance program. (See ch. 3.)

--Two of the six interim reliability and maintainability goals were not met during testing. If final goals are similarly not achieved, additional maintenance and spares support will be required. (See pp. 19 to 21.)

--Operational testing showed that the CH-53E is extremely vulnerable to infrared missiles. (See pp. 24 and 25.)

--Testing completed in January 1978 supported provisional approval for service use. The number of aircraft to be purchased under provisional approval was increased from 6 to 20, and the full-scale production decision was delayed 4 months. (See pp. 17 to 18 and 21.)

--The Marine Corps position is that the CH-53E is specifically needed to lift assault echelon items that cannot be lifted by the CH-53D. Items weighing more than 7 to 8 tons that can be lifted by the CH-53E consist primarily of combat loaded trucks. GAO believes the need to airlift these items should be further evaluated. (See p. 25.)

--The CH-53E has the potential to perform the missions identified by the Navy and Marine Corps. However, additional development effort and testing is required to determine whether the aircraft can effectively perform all of these missions. Furthermore, several problems noted during testing have yet to be solved and the Navy needs to further evaluate the criticality of airlifting items in excess of current helicopter lift capability. (See ch. 4.)

These concerns and the recent reduction to 49 aircraft make procurement of the CH-53E debatable. GAO questions the merits of a 49-aircraft program and believes it should be reevaluated.

RECOMMENDATIONS

The Congress and the Secretary of Defense should determine whether the capability provided by 49 CH-53E helicopters warrants the planned expenditure.

The Secretary of Defense should determine whether the deficiencies identified during Navy testing have been satisfactorily resolved prior to the initial production decision. Similarly, the Secretary of Defense should make sure that the operational testing, scheduled to be completed in November 1978, is successful before the Navy is allowed to exercise the option to purchase the 14 fiscal year 1979 aircraft.

A draft of this report was reviewed by agency officials associated with the management of the program and their comments have been incorporated as appropriate.

CH-53E HELICOPTER

PHOTO COURTESY OF THE U.S. NAVY

Contents

ABBREVIATIONS

AFCS	automatic flight control system
BIS	Board of Inspection and Survey
COD	carrier onboard delivery
COMOPTEVFOR	Commander, Operational Test and Evaluation Force
DMMH	direct maintenance man-hours
DOD	Department of Defense
DSARC	Defense System Acquisition Review Council
FH	flight hours
GAO	General Accounting Office
MQT	military qualification test
NATC	Naval Air Test Center
OPTEVFOR	Operational Test and Evaluation Force
PMQT	preliminary military qualifications test
SAR	Selected Acquisition Report
R&D	research and development
VOD	vertical onboard delivery

CHAPTER 1

INTRODUCTION

The CH-53E helicopter being developed for the Navy and Marine Corps has twice the lift capability of its predecessors. This helicopter was developed from the CH-53D and it has lifted over 16 tons. Designed to be shipboard compatible, the CH-53E occupies only 10 percent more deck or hangar space than the CH-53D. The CH-53E is configured to carry cargo and personnel internally; carry heavy, bulky equipment and supplies externally; and provide for tactical recovery of downed or damaged aircraft, including the retrieval of another CH-53E.

In September 1972, the Naval Air Systems Command issued a contract modification to Sikorsky Aircraft, Stratford, Connecticut, a division of United Technologies Corporation, to design and fabricate two YCH-53E helicopters. A later contract modification provided for the design, development, fabrication, and testing of the aircraft.

Flight testing of the first prototype began in March 1974. It was destroyed in a ground accident on September 15, 1974, due to a design defect in the main rotor head sleeve and spindle assembly.

In January 1975, the Naval Air Systems Command awarded a contract for the fabrication and testing of two production prototype CH-53E helicopters. Sikorsky Aircraft fabricated the two production prototypes and is performing ground and flight tests to demonstrate achievement of design and operational objectives. The Navy had expected to complete engineering development of the aircraft in November 1976 and to award a production contract in February 1977; however, in August 1976, the Navy restructured the program to allow for additional development effort.

A Defense System Acquisition Review Council (DSARC) meeting was held in January 1978. Based on the DSARC recommendation, the Secretary of Defense will decide whether to purchase the first six production aircraft. If the purchase is approved, the initial production contract, with a follow-on option for the planned fiscal year 1979 buy was expected to be signed in February 1978.

RESPONSE TO OUR FEBRUARY 10, 1977, REPORT

We recommended in our February 10, 1977, report (PSAD-77-33) that the Secretary of Defense make sure that needed improvements were fully developed and successfully tested prior to awarding an initial production contract and that the Government's liability for the purchase of long leadtime material be minimized. In response, the Department of Defense (DOD) directed the Navy to reduce concurrency of production and development and to delay release of long leadtime production funds.

To reduce concurrency, DOD eliminated $62 million of fiscal year 1978 production funds and requested and received $14 million of research and development (R&D) funds. Long leadtime funds planned to be released in April 1977 will be released after the award of the initial production contract in February 1978. We believe that DOD actions were responsive to our recommendation.

SCOPE OF REVIEW

We reviewed program documentation and interviewed Navy officials responsible for the CH-53E program management and testing at the Project Office, Arlington, Virginia; the Operational Test and Evaluation Force (OPTEVFOR) headquarters in Norfolk, Virginia; and the Sub Board of Inspection and Survey, Patuxent River, Maryland. We also interviewed contractor officials and reviewed records at Sikorsky Aircraft in Stratford, Connecticut.

Our review covered primarily the development effort and testing conducted since our last report. We evaluated reported cost and schedule changes for the period September 30, 1976, through September 30, 1977.

CHAPTER 2

PROGRAM STATUS

Program cost has decreased about $103 million to $777.7 million because the production quantity was reduced from 70 to 49 aircraft. Program unit costs have increased from $11.9 million to $14.7 million. The $93.5 million of fiscal year 1977 procurement funds will not be sufficient to purchase production tooling and the initial six aircraft unless the Navy can reduce the contractor's proposed target price of $110 million.

Operationally and technically, the CH-53E has demonstrated the potential to be an effective aircraft. Developing and testing of the digital automatic flight control system (AFCS) and the uprated transmission have proceeded with relatively few problems. Some have been corrected and others are expected to be corrected prior to the production decision. However, problems not necessarily peculiar to the CH-53E linger. The effect of rotor downwash requires additional testing and analysis, and no active electrostatic discharge system is imminently available. Navy and contractor officials believe that the downwash and static discharge conditions can be worked around if personnel are provided sufficient training. See chapter 3 for additional test results.

COST

The cost schedule on the next page compares the Selected Acquisition Reports (SARs) planning estimate of June 30, 1973, to SAR program cost estimates of September 30, 1976, June 30, 1977, and September 30, 1977.

	Planning estimate 6-30-73	Program cost estimate 9-30-76	6-30-77	9-30-77
		(millions)		
Development	$ 93.3	$119.0	$131.1	$131.8
Procurement	371.1	415.1	430.0	458.8
Total in 1973 dollars	464.4	534.1	561.1	590.6
Provisions for escalation	114.0	282.5	319.6	339.2
Total	$578.4	$816.6	$880.7	a/$929.8
Unit cost (4 preproduction and 70 production aircraft):				
In 1973 dollars	$6.3	$ 7.2	$ 7.6	$ 8.0
In escalated dollars	$7.8	$11.0	$11.9	a/$12.6

a/The 49-aircraft program including the 4 preproduction aircraft is estimated to cost $777.7 million or $14.7 million per aircraft.

Estimated program costs increased $113.2 million, or 14 percent, from September 30, 1976, to September 30, 1977, a total program increase of $351.4 million, or 61 percent, from the planning estimate of June 1973.

About 50 percent of the increase for the year ended September 30, 1977, was due to escalation resulting from procurement delays. The majority of the development increases represents a reestimation of the cost to complete development efforts. Procurement cost increases include

--airframe and changes,

--avionics and communication equipment prices, and

--training equipment and other support prices.

Reduction in quantity

During October 1977 the Navy proposed reducing the CH-53E aircraft production buy from 70 to 49. This reduction in quantity has decreased estimated program costs to $777.7 million. The unit cost increased because some costs, such as development and tooling, are nonrecurring. Unit cost estimates increased from $12.6 million to $14.7 million. The planned reduction is in response to a DOD request to provide funds for fixed wing carrier onboard delivery (COD) aircraft.

Design-to-cost

The September 30, 1977, SAR shows a design-to-cost goal of $4.36 million in constant 1973 dollars. This figure represents the unit fly-away cost for 70 aircraft. While it is recognized that this estimate, established in May 1975, needs to be updated to reflect current program costs, a revised design-to-cost goal has not been approved. Data available indicates that the current unit fly-away cost, in constant 1973 dollars, is estimated at $5.34 million for 70 aircraft and $6.11 million for 49 aircraft.

Use of fiscal year 1977 procurement funds

The contractor has proposed a target price of $110 million for the fiscal year 1977 buy. Unless the Navy can reduce the proposed price, the $93.5 million of fiscal year 1977 funds will not be sufficient to purchase production tooling and six aircraft. The Navy estimated a shortfall of about $9.2 million and, consequently, a loss of 1 aircraft from the 49 aircraft program. Production funds which were initially scheduled to be released in April 1977 were rescheduled for release in February 1978.

The program office is presently evaluating the contractor's CH-53E production proposal. Contract negotiations for the fiscal year 1979 purchase option of 10 to 18 aircraft will start shortly. The contractor's proposal states that,

for the option to remain in effect, the contract must be signed on or before February 28, 1978, and the option exercised on or before November 15, 1978. Program officials stated that the contractor indicated that the November date is negotiable. Plans call for future buys to be contracted annually.

SCHEDULE

Since December 31, 1976, scheduled milestones leading up to the initial production decision have generally remained unchanged. The DSARC meeting was held in January 1978. The Initial Operational Test and Evaluation completion date of July 1978 has slipped to November 1978 so that needed improvements may be evaluated. The scheduled approval for service use has been delayed from October 1978 to January 1979 to conform to the current program schedule. The procurement and delivery schedules have been extended since our last report. The following table shows the schedule revisions for the 70-aircraft program and for the reduction to 49 aircraft.

Fiscal year	Procurement schedule		
	As of December 1976	As of December 1977	
1977	6	6	6
1978	12	-	-
1979	16	16	14
1980	18	18	15
1981	18	18	14
1982	-	12	-
Total	70	70	49

Fiscal year	Delivery schedule		
	As of December 1976	As of December 1977	
1979	6	-	-
1980	12	6	6
1981	16	16	14
1982	18	18	15
1983	18	18	14
1984	-	12	-
Total	70	70	49

PERFORMANCE

In order to accomplish the 50-nautical mile mission while carrying a 16-ton external payload, the CH-53E must be qualified to carry additional weight. Qualification includes structural and stress analysis and flight testing. According to program officials, the contractor started testing the aircraft on September 14, 1977, with an expected completion date of February 28, 1978. All analyses and tests to qualify the aircraft have been completed except the ongoing flight testing. Program officials state that this is a low-risk effort since the aircraft is designed to structural limits in excess of 75,000 pounds and has previously demonstrated performance capabilities of greater than 73,000 pounds. This effort will increase program cost about $0.5 million.

STATUS OF PROBLEMS PREVIOUSLY REPORTED

To reduce program development and production concurrency, DOD issued a Program Budget Decision in January 1977 eliminating fiscal year 1978 procurement funds. The primary reason for eliminating these funds was to insure that the digital AFCS and uprated transmission were developed and flight tested prior to the scheduled January 1978 production decision. The digital AFCS has gone through contractor developmental flight testing and a Navy technical and operational evaluation. The uprated transmission completed the military qualification test (MQT) at 11,570 shaft horsepower in December 1977.

Other technical deficiencies noted in our February report (PSAD-77-33) included downwash, static discharge, and structural vibration. These conditions still exist.

Digital automatic flight control system

Because of poor flight handling characteristics and high failure rates experienced with the analog AFCS, the Navy issued a contract modification requiring the design of a digital AFCS for use in the CH-53E. For example, during the Board of Inspection and Survey (BIS) trials, the analog AFCS caused eight deficiencies which degraded mission accomplishment. Advantages expected of the digital AFCS include high reliability and low maintainability, lighter weight, less volume, and less power consumption.

Qualification tests for the digital AFCS components are expected to be completed by March 1, 1978. Because the subcontractor had production problems with three computers, the computer qualification testing lags. However, contractor officials expect to recover the lost time. (See pp. 12, 17, and 18).

Uprated transmission

During the contractor's developmental testing, the main gear box experienced several problems. The problems were successfully corrected and testing continued without interruption until completion.

At the completion of developmental testing, Navy and contractor inspections revealed only minor problems. Design modifications of prior problem areas proved adequate, and no safety-of-flight items were found. Subsequently, the uprated transmission was released for flight testing on the production prototypes.

The preliminary military qualification testing (PMQT) at 11,570 shaft horsepower commenced in late August 1977 and was finished in late September 1977. Upon PMQT completion, the Navy and the contractor again inspected the main gear box. According to a Navy official, there were no safety-of-flight discrepancies. All recommended changes have been or are being incorporated by the contractor.

MQT of the main gear box at 11,570 shaft horsepower started in early November 1977 and was completed in December 1977. Four unscheduled interruptions occurred during MQT, but no gear box problems were found. Following MQT the Naval Air Propulsion Center inspected the main gear box. Finding only two subassembly parts needing redesign, they recommended that the redesigns be verified during the 13,140 shaft horsepower development phase and the uprated transmission be accepted as qualified at 11,570 shaft horsepower. (See pp. 12, 17, and 18).

Structural vibrations

In February 1977, we reported that structural vibrations occurred at less than maximum speed and with internal loads at a forward center of gravity. The vibrations occurred at airspeeds between 150 and 170 knots and were caused by an overly sensitive interaction between the engine fuel control and feedback from the engines. An interim, modified fuel

control designed to correct this problem was flight tested, but only to a forward air speed of 160 knots.

According to program officials, the contractor has flight tested the new fuel control to 170 knots but no test results are available. They also stated that the engine manufacturer's analyses predict that the improved fuel control will eliminate the vibration.

Electrostatic discharge

Electrostatic discharge buildup occurs in all aircraft, but it is an operational hazard when the aircraft is not grounded. An aircraft grounds itself when it lands, but a helicopter involved in an external lift mission must be physically grounded. Because the amount of static discharge is proportional to helicopter size, the need to neutralize the charge in large helicopters is greater than in small ones.

Since this could be potentially fatal to ground crews, electrostatic discharge has been noted as an operational deficiency of the CH-53E. As with other helicopters, the CH-53E has been passively grounded by using a shepherd's crook (grounding wand) or similar device. The grounding device must be long and flexible enough for the crewmen to maintain constant contact, for the CH-53E is continually charged. During the OPTEVFOR trials, the ground crewmen, although wearing high-voltage safety gloves, received numerous mild shocks because of the continual aircraft and external pendant movement. OPTEVFOR reported that the use of an interim passive discharge method was marginally satisfactory.

BIS also reported problems similar to those noted in the OPTEVFOR report. The report states that the shepherd's crook was poorly designed. Consequently, constant contact could not be maintained between the deck and hoist or cargo cable. As their only safety-of-flight discrepancy, BIS recommended that "the electrical shock hazard to aircrewmen and ground personnel be corrected prior to further Navy testing of the external cargo and utility hoist."

The electrical shock hazard to aircrewmen has been eliminated by insulating the aircrew from all discharge paths. According to the Navy project manager, the ground personnel shock hazards associated with the passive system (ground wand) are expected to be corrected before the planned tests

begin in September 1978. Planned improvements include a new grounding wand which will more effectively capture and maintain contact with the external hoist.

Although R&D continues on an active discharge system (one which would discharge the static electric charge through the air), no near-term solution is seen by program officials. Until that time, all helicopters must be physically grounded with a shepherd's crook or a similar device.

Downwash

Operational tests have cited the CH-53E downwash as being operationally inhibiting (i.e., personnel were not able to perform normal duties and nearby aircraft were damaged). The September 21, 1977, OPTEVFOR report noted that two downwash incidents occurred during shipboard trials. One involved a loose object being blown into and causing damage to another aircraft, and the other involved a crewman being slightly injured when blown down by downwash. All other operations were accomplished with little effect from downwash.

The OPTEVFOR report stated that proper fleet training will be required to eliminate downwash damage, injuries, and surprise. The report further stated that the CH-53E, at a 68,000 pound gross weight and at a 75 foot height or less, can seriously injure personnel moving within 80 feet of the aircraft.

BIS tests results show that, at a gross weight of about 41,000 pounds, the RH-53D generates greater downwash forces than the CH-53E at 51,000 pounds. However, the CH-53E downwash forces are greater at gross weights over 56,000 pounds. Specifically, the September 16, 1977, BIS report stated that "postural stability could not be maintained by medium weight (170 lbs.) personnel under the aircraft at hover weights above 56,000 lbs." The September 6, 1977, Naval Air Test Center (NATC) report stated that "the downwash forces generated by a 70,000-lb. aircraft were beyond the postural stability limits of all test personnel."

Since the CH-53E will be qualified to carry gross weights of 69,500 pounds internally or 73,500 pounds externally, its economic use requires gross weights exceeding 56,000 pounds for most missions. BIS recommended additional analysis and testing of the CH-53E rotor downwash. OPTEVFOR and BIS recommended further testing to determine whether the downwash

will place operating restrictions on other aircraft. NATC also recommended that operational guidelines to minimize potential downwash hazards be incorporated into the CH-53E training and operating procedures manual.

Contractor and program officials maintain that if personnel are sufficiently trained the downwash effect can be minimized. In fact, a contractor official disputed the downwash effects.

USE OF REPROGRAMED R&D FUNDS

In August 1976, the Navy restructured the CH-53E program to overcome problems encountered during development. Program R&D was extended 10 months (from March 1977 to January 1978) to complete development efforts--especially for the uprated transmission and digital AFCS. To fund the additional development requirements, the Navy received congressional approval in September 1976 to reprogram $20 million of fiscal year 197T procurement funds to support planned development efforts. The program office provided internal plans which indicated how the $20 million was to be spent and that $14.5 million had been obligated as of December 13, 1977. The Navy emphasized that this breakout was not in the reprograming request.

	Amount	Obligated as of 12/77
	(millions)	
AFCS	$ 6.0	$ 4.9
Improved transmission	2.8	1.0
Crashworthy fuel system	2.3	2.3
IR suppression	1.6	-
Fatigue testing	1.6	-
Development contract cost growth	4.8	4.9
Other	0.9	1.4
Total	$20.0	$14.5

The following is a recap of the current status of these development efforts.

Automatic flight control system

In September 1976 the Navy directed Sikorsky Aircraft to replace the analog AFCS with the digital. A subsidiary of the contractor's parent company is building the digital computers, and the contractor is programing and flight testing the computer. The digital AFCS was installed in one production prototype in September 1977. Qualification and development testing of the components and system started during October 1977. Flight testing is scheduled to be completed before the Navy evaluates the digital AFCS. (See pp. 17 and 18.)

Uprated transmission

The uprated transmission was installed in both production prototypes in August 1977. Contractor flight testing began in September 1977. MQT of the transmission at 11,570 shaft horsepower was successfully completed in December 1977. A limited operational evaluation (5-flight hours) was completed on January 9, 1978. The Navy test agency noted that an oil overheating problem appeared defined and fixed, but a final determination cannot be made until flights are made during higher temperature conditions. An extensive operational evaluation is planned before the Navy exercises its option of the scheduled 1979 buy of 14 aircraft. (See p. 18.)

Crashworthy fuel system

The crashworthy fuel system is in the design stages. Sikorsky has submitted the drawings to the Navy for approval. There are no standard items being currently produced for the system, and therefore, each item will be specially made. No system qualification is planned, but all system components are required to be individually qualified. MQT of the components is scheduled for completion during the first quarter of fiscal year 1980.

IR suppressor

Although advance development work funded through other programs is being conducted, a specific CH-53E IR suppressor development effort has not been initiated. Sikorsky has estimated a planned development effort of $8 million for the CH-53E IR suppressor system. Sikorsky's IR suppression study states that, in order to be prepared to operate in a

hostile environment by 1985, developing the suppressor system must begin by 1979 and continue without delay until completed. Navy and contractor officials stated that Sikorsky will make structural provisions for the placement of the IR suppressor on the aircraft. The Navy program manager advised us that the Navy plans to pursue a lower-cost system than the one proposed by Sikorsky.

Structural fatigue testing

Sikorsky has not begun structural fatigue testing. Sikorsky officials said that airframe fatigue testing of the CH-53E would not be cost-effective because the airframe design is similar to previous CH-53 models. Sikorsky officials further stated that the CH-53E airframe strength has already been substantiated by static tests, a flight stress survey, a fatigue resistant detail design, and a fail safe design. They question the need for structural fatigue testing of the CH-53E airframe. Navy officials have not decided whether fatigue testing will be done.

Two-point suspension system

According to contractor officials, the two-point cargo suspension system will enhance load stability and, therefore, allow the aircraft to fly at greater speeds. This will increase aircraft productivity. Ground testing of the two-point system began in December 1977 and is expected to be completed in February 1978. Flight testing is scheduled to begin in March 1978.

CHAPTER 3

TESTING

Navy tests have continued to disclose technical deficiencies such as main rotor blade disbonding, main rotor blade rain erosion, power losses caused by exhaust gas reingestion, a faulty torque indicating system, and additional low-frequency vibrations. Tests also noted that some current fleet carrier elevators were incapable of lifting a fully-fueled CH-53E. Reliability and maintainability tests showed that the CH-53E exceeded four requirements and failed to meet two others--mean flight hours between failures and direct maintenance man-hours per flight hour (DMMH/FH). If these two requirements are not met, additional maintenance and spares support will be required. Certain problems previously reported still remain uncorrected. (See pp. 7 to 11.)

The BIS/Initial Trials Phase and the OPTEVFOR both recommended continuation of the CH-53E development program. BIS recommended that the inflight oscillation and the electrostatic discharge shock hazard be corrected. BIS categorized the electrostatic discharge shock hazard as a safety-of-flight item and recommended that it be corrected before the Navy evaluates external lifts. Commander, Operational Test and Evaluation Force (COMOPTEVFOR) recommended that the Chief of Naval Operations grant provisional approval for service use after the limited December 1977 and January 1978 operational tests have been completed successfully and a dedicated main rotor blade manufacturing quality assurance program has been established.

After the 5-flight hour test of the transmission and digital AFCS, COMOPTEVFOR stated that the initial evaluation of the results supported the recommendation of provisional approval for service use. COMOPTEVFOR also recommended that undesirable digital AFCS characteristics (including pilot-induced oscillations) be eliminated and followed by an abbreviated digital AFCS demonstration.

A limited Navy technical evaluation was conducted concurrently with the operational tests. These flight tests only evaluated the digital AFCS. NATC recommended continuation to a production configuration following correction of 13 deficiencies. After operational evaluation of the production digital AFCS, NATC believes that the digital AFCS will be acceptable for continuation to service acceptance trials.

RECENT TESTS

During the last year, BIS, NATC, OPTEVFOR, and the contractor have all tested the CH-53E. Comments on these tests follow.

Board of Inspection and Survey

Between November 20, 1976, and March 23, 1977, BIS conducted the Initial Trials Phase of Service Acceptance Trials of the CH-53E helicopter. Tests were conducted to evaluate CH-53E's flying qualities and performance, shipboard compatibility, reliability and maintainability, rotor downwash, and service suitability of the primary aircraft system. NATC at Patuxent River, Maryland, provided the primary support, including test pilots. In total, 126 flight hours were accumulated.

The BIS report concluded that the CH-53E

--demonstrates increased capability compared to existing CH-53D aircraft,

--is capable of performing defined missions,

--has outstanding rotor lift capability,

--may lose significant lift capability due to exhaust gas reingestion,

--has analog AFCS problems (see pp. 7 and 8),

--has an unacceptably high static discharge hazard,

--is compatible with current fleet carriers (LPHs), and

--can potentially achieve maintainability and reliability goals.

BIS recommended that development of the CH-53E should continue if the problems can be corrected.

The only safety-of-flight item reported by BIS was electrical shock hazard to aircrewmen and ground personnel.

BIS recommended that it should be corrected before the Navy further tests the external cargo utility hoist operation. No active electrostatic discharge system is imminently available. (See pp. 9 to 10.)

Operational Test and Evaluation Force

To determine the CH-53E's operational effectiveness and suitability, OPTEVFOR conducted initial operational testing from January 6, 1977, through May 3, 1977. A Marine helicopter squadron from Quantico, Virginia, provided the flight crews and maintenance personnel. Flight testing totaled 151 hours and revealed two problems with the main rotor blades (i.e., blade debonding and rain erosion of leading edge of rotor blades).

The main rotor blade bonding problems were attributed to a poor manufacturing environment and lack of process control. The erosion problem occurred because of insufficient leading edge protection. Consequently, the test report recommended establishing a dedicated main rotor blade manufacturing quality assurance program before preliminary approval for service use. According to the Navy program manager, a quality assurance program for all titanium composite rotor blades (including the CH-53E's) has been defined. However, the contractor has dismantled and stored the CH-53E prototype main rotor blade production equipment, and a new CH-53E blade manufacturing facility will not be dedicated until a production contract is signed. Using present estimates, production blades will be available during calendar year 1979. At that time, the main rotor blades will undergo fatigue and environmental testing. If the test results are satisfactory the CH-53E main rotor blade manufacturing process will be qualified.

As evidence of the contractor's ability to produce defect-free main rotor blades, contractor and program officials note that the contractor is presently producing similar blades (i.e., titanium composite rotor blades) for military and commercial helicopters. According to contractor officials, these blades have not had production problems. The bonding problem is expected to be solved by using a new adhesive system and a more exact curing cycle. The rain erosion problem is expected to be solved by using a polyurethane abrasion strip to modify the leading edge. After the leading edge protection was installed, flight testing

was conducted in light rain and, according to program officials, no further rain erosion occurred.

COMOPTEVFOR has expressed concern that the production process main rotor blades will not be available for the final operational tests scheduled for September to November 1978.

Contractor

The contractor conducted flight tests of the digital AFCS and the transmission's main gear box. Testing of digital AFCS included 52 hours of developmental flight tests. During the tests, the contractor was to demonstrate that the digital AFCS can function as well as the analog. The contractor also planned to demonstrate that the digital AFCS will rid the CH-53E of inflight, low-frequency vibrations. (See pp. 7 and 8 for details.) According to program officials, the contractor tests have shown improved flight handling qualities and have eliminated all low-frequency vibrations previously noted, but no test results were available.

The main gear box testing began in early November 1977. To complete the 11,570 shaft horsepower MQT, the contractor conducted 165 hours of testing. The 11,570 MQT was completed in early December 1977. (See p. 8.)

Tests conducted in December 1977 and January 1978

During December 1977 and January 1978, NATC conducted a technical evaluation of the digital AFCS and OPTEVFOR conducted an operational evaluation of both the digital AFCS and the uprated transmission. The CH-53E was flown in three separate configurations, with NATC flying about 11 hours and OPTEVFOR about 5 hours.

NATC noted in their interim report that the quantitative comparison of the digital AFCS with the analog AFCS has not been completed and would be addressed in the final report. NATC concluded that "the prototype digital AFCS will be technically ready for continuation to a production configuration following correction of 13 deficiencies." Further, NATC concluded that "the digital AFCS will be acceptable for contin-

uation to service acceptance trials and operational evaluation following NATC evaluation of the production digital AFCS." The digital AFCS needs to have the software encoded in "hard memory." According to program officials, this production configuration will then undergo contractor and Navy testing this year to verify that the flight handling qualities are the same as those demonstrated in the prototype digital AFCS.

COMOPTEVFOR reported that the preliminary evaluation of the test results confirmed the recommendations of provisional approval for service use and continued development and testing of the digital AFCS and growth transmission. COMOPTEVFOR also recommended that undesirable digital AFCS characteristics (including pilot-induced oscillations) be eliminated.

Regarding the growth transmission, COMOPTEVFOR noted that, although oil overheating problems have apparently been defined and fixed, the correction must be evaluated during higher temperature conditions. Further operational tests by OPTEVFOR on the uprated transmission are scheduled during the fall of 1978. Completion of this testing is needed before deciding whether to exercise the fiscal year 1979 procurement option.

OTHER PROBLEMS REQUIRING RESOLUTION

As mentioned in chapter 2, the electrostatic discharge and downwash remain deficiencies. In addition, questions concerning the main rotor blade manufacturing process will remain until the production blades are produced and tested in 1979 and 1980. However, by the start of the CH-53E production, the Navy and the contractor believed that its accumulated experience should make the main rotor blades a low-risk item. Other deficiencies are as follows.

Exhaust gas reingestion causes power loss

Under the conditions of little or no wind (0-5 knots) and heavy gross weights, the engines' exhaust gases can be recirculated and reingested by the engines. When the engines ingest the hotter gas, a power loss occurs which could limit the payload or cause mission cancellation.

According to program officials, solutions to the reingestion problem are available but involve a performance penalty. Further study is underway and aircraft hardware will be tested to measure the performance impact. The cost-effectiveness of correcting this problem has not yet been determined.

Engine torque indicators are faulty

During testing, engine torque indicating system errors ranged from 4.4 to 9.0 percent. Contractor officials attribute part of the error to faulty calibration by poorly trained technicians. Although considered an easily correctable deficiency, the faulty torque meters have been a problem during the last two series of evaluations. The BIS report indicated that if the aircraft engines and transmission are overtorqued, excessive component wear and potential structural failures in the power or drive train could occur. Project office officials advised that the 9-percent error would not overtorque or damage either piece of equipment.

Low-frequency vibrations are occurring

During the BIS trials, additional vibrations were discovered. The contractor has apparently diagnosed the cause of these vibrations. Further, OPTEVFOR noted that an oscillation was occuring as the main rotor blades spun. Program officials state that oscillation and vibration problems have been resolved, but no test results are available.

Elevators are incapable of lifting a fully-fueled CH-53E

Because CH-53Es will be frequently based aboard LPHs (current fleet carriers), the inability of LPH elevators to lift fully-fueled CH-53Es is a problem. Stored with full auxiliary fuel tanks, the CH-53E weighs 50,300 pounds. However, LPH elevators are currently rated between 35,000 and 50,000 pounds and, thus, must be recertified to handle the CH-53E. The program office advised us that the newer class carriers' elevators can handle the CH-53E's weight.

RELIABILITY AND MAINTAINABILITY REQUIREMENTS WERE NOT COMPLETELY MET

The CH-53E was required to meet six specific reliability and maintainability parameters during the BIS/OPTEVFOR tests. The CH-53E exceeded four requirements and failed to meet two others.

Requirement	Observed result	Required result
1. Mission reliability (note a)	a/.89	a/.87
2. Direct corrective DMMH/FH	4.93	12.0
3. Mean time to repair	1.42	2.6
4. Mean elapsed turn-around time	.93	1.7
Failed		
5. Mean flight hours between failures	.51	.65
6. DMMH/FH	17.70	15.0

a/At a 90 percent confidence level.

The reliability and maintainability results reflect data collected from 277 hours of BIS and OPTEVFOR flights. Test officials believe the results represent an accurate picture of the CH-53E's present reliability and maintainability characteristics. However, contractor officials believe that based solely on BIS results, higher mean flight hours between failure have been demonstrated.

The Navy project manager advised that, although the DMMHs exceeded the 15.0 hour requirement, monthly statistics showed a constant decline.

Month	DMMH/FH
January	22.3
February	15.9
March	12.8
April	9.8

If the two requirements are not met in the future, operating units will be required to exercise additional maintenance and spares support to maintain operationally ready aircraft. In our opinion, failure to meet interim reliability and maintainability requirements raises the question of whether the mature aircraft requirements will be achieved. For example,

during BIS and OPTEVFOR, the CH-53E mean flight hours between failure index was .51 versus a mature system goal of 1.0 hours. Program officials state that 19 percent of the reported failures were due to a single problem (a hydraulic line clamp failed) which has been corrected. Further, they believe that the system goals for the first production aircraft can be met.

APPROVAL FOR SERVICE USE AND THE FULL-SCALE PRODUCTION DECISION

Plans call for the Chief of Naval Operations to grant provisional approval for service use for 20 aircraft. This will result in the initial contract for 6 aircraft being awarded and the fiscal year 1979 option for 14 aircraft being exercised before final approval for service use is granted. Previously, the follow-on option was to represent the full-scale production decision and was scheduled after full approval for service use was granted. The full-scale production decision has been delayed until January 1979 (4 months).

According to program officials, the follow-on contract will not be signed until the final operational tests are completed. They explained that the Department of the Navy Systems Acquisition Review Council will be held to judge the merits of not exercising the option, based on the preliminary operational test results.

OPTEVFOR's final operational evaluation and BIS's final trials are scheduled for completion in November 1978 and January 1979, respectively. Approval for service use, based on the operational test results, is scheduled for January 1979. These tests are particularly important because they will be the Navy's first extensive flight testing of the following items

--two-point suspension external cargo system,

--the uprated transmission,

--auxiliary power plant clutch, and

--production digital AFCS with permanent [illegible] program.

The test results will provide the decision base for approval for service use and the full production decision.

We believe that DOD should review the test results before the Navy is allowed to exercise the option to purchase the 14 fiscal year 1979 aircraft.

CHAPTER 4

CH-53E MISSIONS

Studies have identified four Navy and three Marine Corps missions for the CH-53E. We were told that four additional missions are expected. Although seven missions were identified, the CH-53E use in several missions has not been fully tested. Furtner, the need to airlift items that exceed current helicopter lift capability has not been evaluated.

The Navy plans to deploy the CH-53E to provide a vertical onboard delivery (VOD) capability in the Mediterranean and Western Pacific. The Marine Corps plans to use the CH-53E to support the fleet or Marine amphibious forces. Initial Marine Corps deployment calls for two 15-aircraft squadrons--one to be stationed on each coast. The 70-aircraft program includes 35 aircraft each for the Marine Corps and Navy. Under the program cutback to 49-production aircraft and the two preproduction prototypes, the Marines will receive 33 aircraft and the Navy 18.

PLANNED USE OF THE CH-53E

Navy

Studies have identified the following four missions for the CH-53E

--VOD of cargo and personnel,

--transfer of battle damaged/unflyable aircraft,

--movement of mobile construction battalion equipment, and

--the movement of priority container cargo.

The Navy anticipates two additional requirements--airborne minesweeping and transportation of nuclear weapons--for the CH-53E.

The VOD mission is defined as providing individual combatants and task groups not in the vicinity of an aircraft carrier the rapid delivery of items critical to ships' readiness. Present deployment plans call for the CH-53E to be land based in the Mediterranean and Western Pacific and provide VOD support. Because the VOD and COD missions are now con-

sidered complementary and funds are limited, DOD directed the Navy to buy a mix of COD (fixed wing) and VOD (rotary wing) aircraft. A Navy official stated that CH-53E is expected to provide COD augmentation. Consequently, the quantity proposed for the Navy was reduced from 35 to 18. Under current plans, 13 aircraft will be used for VOD, 3 for training, and 2 as replacements.

An OPTEVFOR official stated that testing to evaluate the CH-53E VOD capability has not been done. Consequently, the major portion of VOD testing will be conducted during OPEVAL which is scheduled to begin in September 1978.

To assure completion of the long-range, 500-nautical mile VOD mission, particularly in bad weather, the CH-53E needs a long-range navigational system. Because the Doppler/Omega system, originally proposed for the CH-53E, had technical and cost problems, the program office is presently researching and evaluating other alternatives.

To demonstrate aircraft retrieval capability, the CH-53E lifted six different aircraft during the OPTEVFOR trials. However, the CH-53E did not lift the F-4 and F-14 because the structure aft of the wing was not strong enough to accept the lift bands. Of the six lifts, two resulted in slight aircraft damage and two others had problems with drogue chutes. To improve the efficiency of the CH-53E in the aircraft retrieval mission, aircraft recovery kits and drogue chutes will have to be developed and qualified and/or the aircraft structures strengthened.

Because OPTEVFOR's external lifts did not include a sufficient number of items of equipment representative of a construction engineer battalion, OPTEVFOR will conduct additional lifts during OPEVAL. Program officials do not anticipate difficulty in lifting any construction equipment items that are within the CH-53E lift capability.

The CH-53E did generally exhibit the necessary performance, stability, and handling during the external lifts conducted. One deficiency was the operational unsuitability of the single-point suspension when lifting a military van (containerized cargo). The van was preloaded with a mid-center of gravity or else the load was unstable. Excessive rigging time, short duration, low-speed flights, and the need for nonturbulent/nongusty conditions all detracted from the CH-53E's use in movement of containerized cargo. Economical container movement requires the two-point suspension

system currently being ground tested. OPTEVFOR plans to flight test the two-point system during its final operational evaluation.

Another problem with helicopter external container movement occurs because the containers are subjected to increased gravitational forces during flight. Because of these stresses, the containers cannot be loaded to capacity. As a Center for Naval Analyses study notes, this means that even when the CH-53E is carrying the most dense stores, it can only use 64 to 78 percent (or 10 to 12.5 tons) of its lift capability. This results in less than full use of the CH-53E lift capability.

Marine Corps

Studies have identified three missions for the CH-53E

--amphibious assault lift,

--tactical movement of heavy weapons and equipment, and

--retrieval of downed aircraft and recovery of damaged/threatened equipment.

The Marine Corps also advised they anticipate that the CH-53E will be used to support the vertical/short takeoff and landing concept and for special operations (such as evacuations). Planned CH-53E deployment of the Marine Corps 33 production aircraft provides for two 15-aircraft squadrons--one deployed on each coast of the continental United States. Three CH-53Es will serve as replacement aircraft.

During a Marine Corps amphibious force assault, the initial helicopter mission will be to lift the assault elements shortly after initiating the force landing. The CH-53E's primary role will be to assist in the rapid build up of forces, equipment, and cargo. For example, the 155 mm howitzer must be delivered ashore. Although the CH-53D can lift a 155 mm howitzer ashore, the CH-53E can simultaneously lift the 155 mm howitzer with gun crew and ammunition. Marine Corps officials stated that the CH-53D will not be able to lift the next generation 155 mm howitzer nor the Mobile Protected Weapon System now in exploratory development by the Marine Corps.

If the CH-53E is used in an amphibious assault in an area where missiles are present, the CH-53E's vulnerability

is apt to be severe. In the only survivability and vulnerability tests conducted to date, OPTEVFOR showed the CH-53E to be extremely vulnerable to infrared missiles. The test report noted that once acquisition and lock-on was made, it was seldom lost until the aircraft was well beyond the maximum range of the missiles. Because an infrared plume suppressor will not be available in the near future, vulnerability/survivability is a problem. (See pp. 12 and 13.)

The Marine Corps said that night operations, evasive tactics, and countermeasures will permit the CH-53E to overcome the infrared threat in the event an effective suppressor system is not available.

Although the CH-53E can lift substantially more than its predecessors, we question the need to airlift these items. Seventy-six percent of assault echelon items beyond the CH-53D's lift capability and within the CH-53E's capability consists of trucks which will be combat loaded. Whether the airlift of trucks would substantially affect the outcome of an amphibious assault has not been documented and should be further evaluated. A Marine Corps official stated that every item of assault echelon equipment has been selected and screened due to limited ship space. He added that determining the criticality of items is difficult without knowing the particular combat situation or ground commander's planned maneuvers.

The retrieval of aircraft or damaged or threatened equipment are overlapping missions. The idea is to rapidly recover and repair aircraft or equipment and return them to the field. Because the CH-53E has over twice the CH-53D's lift capability, the CH-53E can recover items not previously recoverable.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Costs increased by $113.2 million, or 14 percent, to $929.8 million from September 30, 1976, to September 30, 1977. The reduction from 70 to 49 aircraft increased program unit costs from $12.6 million to about $14.7 million. Total program cost decreased about $152 million to $777.7 million.

Although recent Navy tests have supported granting provisional approval for service use, they also have revealed deficiencies which need to be evaluated and/or corrected. These included main rotor blade bonding and rain erosion problems, power losses caused by exhaust gas reingestion, a faulty torque indicating system, low-frequency vibrations (oscillations), electrostatic discharge, and downwash. The effect of rotor downwash requires additional testing and evaluation and no active electrostatic discharge system is imminently available. Navy and contractor officials believe the downwash and static discharge conditions can be worked around if personnel are properly trained.

Reliability and maintainability tests showed that the CH-53E exceeded four requirements and failed to meet two others. If the mean flight hours between failures and DMMH/FH requirements are not met, additional maintenance and spares support will be required to support the aircraft.

Because the CH-53E demonstrated the operational and technical potential to be an effective aircraft, Navy test agencies recommended continuing the development program. However, this was contingent upon correcting certain deficiencies, such as inflight oscillations, electrical shock hazard, and an unsuitable main rotor blade manufacturing process quality assurance program.

To evaluate the digital AFCS and the uprated transmission, the Navy conducted limited technical and operational tests before the initial production decision. COMOPTEVFOR supported provisional approval for service use, but recommended that undesirable digital AFCS characteristics (including pilot-induced oscillations) be eliminated. NATC recommended that the digital AFCS be continued to a production configuration following correction of 13 deficiencies.

Although identified missions can use the CH-53E's greater lift capabilities, there are problems associated with several missions. The long-range VOD mission accomplishment requires a long-range navigational system. To improve the CH-53E efficiency to retrieve aircraft, recovery kits and drogue chutes must be developed and qualified or aircraft structures strengthened. Economical container movement is dependent upon developing containers which can absorb external flight stresses. Vulnerability to infrared missiles is a deterring factor to use during an amphibious assault.

Certain other conditions should be met or considered before a full-scale production decision is made. First, the two-point suspension system, essential to cost-effective container movement, must be ground and flight tested. Second, the CH-53E's VOD capability must be tested. Third, the criticality and need to lift items beyond the lift capability of existing aircraft should be further evaluated. We question the merits of a 49-aircraft program and believe it should be reevaluated.

RECOMMENDATIONS

We recommend that the Congress and the Secretary of Defense determine whether the additional capability provided by 49 CH-53E helicopters warrants the planned expenditure.

In light of deficiencies noted during testing, we also recommend that the Secretary of Defense determine whether the deficiencies identified have been satisfactorily resolved prior to the initial production decision. Similarly, we recommend that the Secretary of Defense make sure that the operational testing, scheduled to be completed in November 1978, is successful before the Navy is allowed to exercise the option to purchase the 14 fiscal year 1979 aircraft.

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