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The Army has begun a program to modernize the CH-47 helicopter fleet to sustain its medium life helicopter capability through the 1990's. Program objectives are to significantly improve the reliability, availability, and maintainability of the aircraft which will result in lower operating and support cost, to increase the lift capability of the aircraft, and to standardize the configuration of the fleet. Findings/Conclusions: The Army plans to modernize 361 aircraft and acquire about 190 new ones at a total estimated costs of \$2.8 billion. While the Army plans to study alternative sources for accomplishing modernization, current plans call for the initial modernization contract to be awarded to the Vertol Division of Boeing Company without the benefit of competition. Estimated program costs have remained constant except for the application of inflation indices and a \$3.4 million increase attributed to Boeing Vertol's reduced business base. The proposed modernization rate of three aircraft per month is not the most economical rate and will result in a lengthy (12-year) modernization rate. Development work is on schedule except for minor slippage relating to the engine and hydraulic systems. The Army's plan allows start-up of modernization without demonstrating that interim reliability goals have been achieved. Recommendations: The Secretary of Defense should: determine whether competition at the prime contractor level can be incorporated into the program, withhold approval to initiate modernization until interim reliability goals have been achieved, and evaluate the proposed modernization rate of three aircraft per month. (RRS)

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# REPORT TO THE CONGRESS



BY THE COMPTROLLER GENERAL  
OF THE UNITED STATES

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## Can The Army's \$2.8 Billion Program To Modernize The CH-47 Helicopter Be Improved?

The Army plans to modernize most of its CH-47 helicopter fleet and purchase new modernized CH-47s to provide medium helicopter capability through the 1990s.

If current plans are carried out, awards totaling \$2.8 billion will be made without the benefit of prime contractor competition.

The Secretary of Defense should determine whether or not competition at the prime contractor level yet may be carried out for this multibillion dollar program.

FEBRUARY 24, 1978



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

B-163058

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

This report presents our views on the major issues of the CH-47 Modernization 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 (21 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.

A handwritten signature in black ink, reading "James B. Stuckey".

Comptroller General  
of the United States

D I G E S T

The Army has started a program to modernize its CH-47 helicopter fleet used for logistical support. To sustain medium lift helicopter capability through the 1990s, the Army plans to modernize 361 aircraft and acquire about 190 new ones. Program objectives are to

- improve reliability, availability, and maintainability;
- reduce operating and support costs;
- increase lift capability of the CH-47A and B to 15,000 pounds; and
- standardize the configuration of the fleet.

The modernization and acquisition programs are estimated to cost \$2.8 billion.

Currently the program is in full-scale engineering development to be completed in March 1980. Plans call for the modernization contract to be awarded in October 1980.

GAO's review of the program disclosed the following issues:

- Alternatives considered were limited primarily to variations of the CH-47 helicopter. New helicopter developments were excluded because the Army assumed research and development would cost \$300 to \$500 million and program costs would exceed anticipated procurement funds in the 1980s. (See pp. 5 to 7.)

- Justification for the modernization program may now be the need to retain helicopter production capability of the Vertol Division of the Bosing Company. The Army does not agree with this opinion. (See pp. 7 to 8.)
- The Army's proposed modernization rate of three aircraft per month over a 12-year period may not be economical. (See p. 14.)
- The modernized aircraft are expected to reduce operating and support costs through better reliability and maintainability that has yet to be demonstrated. The current program allows the Army to proceed with modernization without demonstrating that the reliability goals can be met. (See pp. 11 and 20.)
- The Army estimates that modernization will cost \$1.6 billion in escalated dollars. This estimate does not include \$85.2 million for engine and rotor blade development. The Army also plans to purchase about 190 aircraft at a cost of about \$1.2 billion. (See pp. 9 and 11 to 12.)
- Development work is on schedule except for minor slippage relating to the engine and hydraulic systems which is not expected to affect the overall program schedule. (See pp. 12 and 17.)
- The modernized CH-47 is required to, but will not be able to carry external cargo using approved terrain flying techniques (less than 200 feet altitude) during night or adverse weather conditions that require use of instrument assistance. (See p. 15.)
- The modernized aircraft is expected to last an additional 20 years, however, no actual testing of airframe fatigue life is planned. (See p. 18.)

## CONCLUSIONS AND RECOMMENDATIONS

Present Federal procurement policies stress development of competing alternatives to meet defined needs. If the Army's current plans are carried out, awards for modernization and new aircraft purchases totaling about \$2.8 billion will be made without the benefit of competition.

The Army's plan allows start-up of modernization without demonstrating that interim reliability goals have been achieved. Attainment of these goals is essential to achieving reduced operating and support costs which justified the selection of this program.

The Secretary of Defense should

- determine whether competition at the prime contractor level can be incorporated into this multibillion dollar program;
- withhold approval to initiate modernization until interim reliability goals have been achieved; and
- evaluate the proposed modernization rate of three aircraft per month.

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



CH-47 HELICOPTER

PHOTO COURTESY U.S. ARMY

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### ABBREVIATIONS

<b>GAO</b>	General Accounting Office
<b>RAM</b>	reliability, availability, maintainability



## CHAPTER 1

### INTRODUCTION

The Army has begun a program to modernize the CH-47 helicopter fleet to sustain its medium lift helicopter capability through the 1990s. Program objectives are to significantly improve the reliability, availability, and maintainability (RAM) which will result in lower operating and support costs of existing models. The performance levels of the CH-47A and B model aircraft will be upgraded to the 15,000 pound lift capability of the CH-47C model. Modernization will also standardize the configuration of the fleet. The Army is modernizing the following eight systems

- rotor blades,
- transmission/drive system,
- hydraulic system,
- auxiliary power unit,
- electrical system,
- advanced flight controls,
- cargo suspension system, and
- engines.

The Army emphasized that engine development is being funded under a separate component improvement program. Key components in achieving RAM objectives are the transmissions, hydraulics, and engines.

The CH-47 is a dual rotor transport helicopter used for logistical support. Its missions include artillery movement, missile transport, personnel movement, aircraft recovery, medical evacuation, transport of liquid and dry bulk cargo, and other combat service missions during day, night, and adverse weather conditions. The CH-47 can carry cargo both internally and externally. Most cargo consists of ammunition or fuel which is carried externally.

## CURRENT PROGRAM

The Army currently plans to modernize 104 model A, 74 model B, and 183 model C aircraft. The proposed modernization rate is three aircraft per month over a 12-year period. Approximately 51 earlier CH-47A aircraft are not presently included in the modernization program because of configuration problems. The Army advised that a final decision on whether to modernize these aircraft will be made later in the program. The Army's current estimate of total program acquisition cost is \$1.6 billion.

The CH-47 modernization program is in full-scale engineering development which the Army expects to complete in March 1980, with the modernization decision scheduled for September 1980. The Army awarded a sole source, engineering development contract to the Vertol Division of the Boeing Company (Boeing Vertol) in June 1976 with a target price of \$71.3 million. Design specifications for most of the modernized components have been completed and the manufacture of component parts has started. Component testing has begun.

A separate component improvement program has been initiated to improve engine reliability and maintainability. Testing problems have resulted in slippage of the engine schedule. (See p. 17 for engine status.)

At present the Army also plans to buy approximately 190 new aircraft for about \$1.2 billion to fill the projected authorized acquisition objective. (See pp. 11 and 12.)

## SCOPE OF REVIEW

Our review centered on the Army's selection of modernization over other alternatives, the procurement strategy being applied to this program, and the status of this development effort.

The report is based on interviews and our review of records at the CH-47 Project Manager's Office, St Louis, Missouri; the New Cumberland Army Depot, New Cumberland, Pennsylvania; the U.S. Army Training and Doctrine Command, Fort Eustis, Virginia; and the Boeing Vertol Company, Ridley Park, Pennsylvania.

## CHAPTER 2

### EVOLUTION OF THE MODERNIZATION PROGRAM

The CH-47 has been the Army's primary medium lift helicopter since its introduction in the early 1960s. Since that time Boeing Vertol, as the CH-47 contractor, has provided the Army with its medium lift helicopter technology. Numerous changes have been made to the CH-47A to correct deficiencies and improve performance which have resulted in two additional models, the CH-47 B and C. Despite those changes, the Army's current model, the CH-47C, still has shortcomings primarily in RAM, survivability, and safety. When the Army decided to modernize the present CH-47 fleet, it relied on input from Boeing Vertol, the developer of the CH-47.

### PAST PROBLEMS WITH CH-47 AIRCRAFT

In 1965 the Army, recognizing a need to correct development deficiencies and to increase performance and lift capabilities on the CH-47, initiated product improvement programs with Boeing Vertol. Numerous changes to the CH-47 were undertaken but some problems continued. In 1969, the U.S. Army Audit Agency outlined those problems in a report which concluded that the CH-47 had to undergo several changes due to the Army accepting engineering changes before the worthiness of the modified changes were tested.

Operational shortcomings continued on the CH-47 fleet and the Army planned on replacing it with a new aircraft development. That project, however, was not initiated because the CH-47C met the Army's requirements and procurement funds projected for the early 1980 time frame were not available.

Also, the Army advised that the CH-47C met the lower performance bands of the proposed new aircraft development. In 1971, Boeing Vertol submitted an unsolicited proposal to modernize the CH-47 A and B model aircraft. That proposal was rejected, but some of the basic concepts evolved into the CH-47 modernization program.

### ESTABLISHMENT OF MODERNIZATION PROGRAM

A required operational capability document, approved by the Army in October 1974 and revised in October 1975, required substantial improvements in RAM, flight safety,

and survivability, while maintaining current CH-47C performance requirements. The program was designated as a high dollar cost program requiring Defense Systems Acquisition Review Council review and approval.

In November 1974, the U.S. Army Training and Doctrine Command was directed to prepare the Concept Formulation Package and other studies for the Defense Systems Acquisition Review Council. The Concept Formulation Package contained studies that considered the technical approaches to meet the Army's needs and a cost and effectiveness analysis in which alternative systems were compared.

The Army used Boeing Vertol's 1971 proposal for modernization of the CH-47A and B models as input in its technical studies. In those studies preferred modifications were selected and modernization of aircraft components needing improvements were recommended. The nature of the modifications and level of improvements were identified, and cost considerations were also covered. The Army concluded in its cost and effectiveness analysis that modernization of the CH-47 fleet was the preferred alternative. (See ch. 3 for discussion of the analysis.)

## CHAPTER 3

### ALTERNATIVES CONSIDERED AND SELECTION OF THE CH-47 MODERNIZATION PROGRAM

Current Federal procurement policies stress development of competing alternatives to meet the Army's needs. To determine the preferred method of meeting medium lift helicopter requirements, the Army conducted a cost and effectiveness analysis which excluded developing new aircraft because research and development was estimated to cost \$300 to \$500 million and a lack of anticipated procurement funds in the 1980s. While the Army plans to study alternative sources for accomplishing modernization, current plans call for the initial modernization contract to be awarded to Boeing Vertol.

#### ALTERNATIVE ANALYSIS

The Army evaluated seven basic and four variant alternatives in its analysis. The basic alternatives included:

##### --Alternative 1

Baseline case, retain existing CH-47A, B, and C models and replace attrition with new CH-47Cs.

##### --Alternative 2

Modernize CH-47A and B models, retain CH-47Cs, and replace attrition with new modernized CH-47s.

##### --Alternative 3

Modernize CH-47A, B, and C models and replace attrition with new modernized CH-47s.

##### --Alternative 4

Procure new CH-47Cs to replace CH-47A and B models and replace attrition with new CH-47Cs.

##### --Alternative 5

Procure new modernized CH-47s to replace CH-47A and B models and replace attrition with new modernized CH-47s.

--Alternative 6

Procure new CH-53E helicopters to replace CH-47A and B models and replace attrition with CH-53Es.

--Alternative 7

Modernize CH-47A and B models using engines from CH-47Cs and install CH-47A and B engines on CH-47Cs. Replace attrition with new modernized CH-47s.

Variant alternatives included:

--Alternative 1B

Same as alternative 1 except aircraft are retired and replaced with CH-47C aircraft after 20 years' service life.

--Alternative 3A

Same as alternative 3 except modernization is accomplished on an extended production schedule.

--Alternative 3B

Same as alternative 3 except that aircraft are retired and replaced with CH-47 modernized aircraft after 20 years' service life.

--Alternative 6B

Same as alternative 6 except that aircraft are retired and replaced with CH-53E aircraft after 20 years' service life.

RESULTS OF THE ARMY'S ANALYSIS

The Army, in its study, emphasized threat assessment, construction of mission and flight profiles, and analyses of effectiveness and costs. The results were evaluated and the alternatives ranked as follows:

<u>Rank</u>	<u>Alternative</u>
1st	3-most preferred
2nd	2
3rd	5
4th	7
5th	6
6th	4
7th	1-least preferred

The analysis concluded that modernization of the CH-47 fleet provided the most cost-effective means of improving the safety, RAM, and lift capability of the future medium lift helicopter fleet. The analysis also concluded that the preferred method of meeting medium lift helicopter requirements in the 1980s and 1990s was to modernize the CH-47A, B, and C models and to procure new modernized aircraft to fill authorized acquisition objectives and replace attrition losses (alternative 3).

#### Shortcomings identified with alternative analysis

Current Federal procurement policies stress development of competing alternatives to meet the needs. However, the Army's analysis considered the CH-53E helicopter being developed by the Navy and six alternatives using variations of the CH-47. The CH-53E, with capabilities exceeding the Army's requirements, was not selected because of its substantially higher cost. New helicopter developments were not considered because the Army assumed that program costs would exceed anticipated procurement funds in the 1980s and require research and development effort estimated to cost \$300 to \$500 million.

#### ALTERNATIVE MODERNIZATION SOURCES AVAILABLE

Prior to the engineering development phase, the Army considered three options for performing the modernization phase of the program. The options included

- Army depots,
- Boeing Vertol, and
- a contractor selected through competitive procurement procedures.

The Army also considered the possible loss of production base capabilities at Boeing Vertol. The Army did not conclude who should do the work, but that the matter should be studied prior to the production decision. The project manager stated that such a study will be performed.

Although a study of modernization options will be made, the initial modernization contract most likely will be awarded to Boeing Vertol. Army officials advised that the initial contract will validate design-to-cost, producibility, and performance of the modernized CH-47. The Army also will have to consider other factors such as the availability of contractor engineering support, tooling, facilities, definitive work specifications, and the necessity of maintaining a production base at Boeing Vertol. The last point has become acute during the past year with Boeing Vertol's unsuccessful bids to produce two helicopter systems--the Army's utility tactical transport aircraft system and the Navy's light airborne multi-purpose system. Both systems were awarded to another contractor. The modernization program represents Boeing Vertol's only major military helicopter development program. The Army advised that justification for the modernization program is not to retain a production base at Boeing Vertol.

#### CONCLUSIONS AND RECOMMENDATION

The Army's analysis of alternatives to modernize the CH-47 did not include new helicopter developments. The CH-53E was included, but it was not a viable candidate because its capabilities significantly exceeded the Army's requirements and correspondingly its acquisition costs were high. In effect, the Army's analysis only considered versions of the CH-47 aircraft. This conflicts with current Federal procurement policies which stress development of competing alternatives to meet defined needs.

If current plans are carried out, awards for modernization and new aircraft purchases totaling about \$2.8 billion will be made to Boeing Vertol without the benefit of competition.

We recommend that the Secretary of Defense determine whether competition at the prime contractor level can be incorporated into this multimillion dollar program.



## CHAPTER 4

### PROGRAM STATUS

The Army has estimated the cost to modernize 361 CH-47 aircraft at \$1.6 billion. The development program began in 1975 when Boeing Vertol was awarded contracts for engineering development on three component systems. Full-scale engineering development began in June 1976, when Boeing Vertol was awarded a contract with a target price of \$71.3 million to design, fabricate, and demonstrate seven component systems in three prototype aircraft. As of October 31, 1977, engineering development was proceeding close to schedule. In 1976 the AVCO Corporation Lycoming Division (Lycoming) began a program to modernize the engines under a separate component improvement program.

In addition to the modernization program costs, the Army may spend about \$1.2 billion to buy new CH-47 aircraft to fill its projected authorized acquisition objective of 551 aircraft for 1985.

### COST

The Army's estimate of the CH-47 modernization program acquisition cost is \$1.6 billion. Development and procurement costs are as follows.

	<u>Decision coordinating paper fiscal year 1975 constant dollars</u>	<u>System status report of 9/30/77 fiscal year 1975 escalated dollars (note a)</u>
	(millions)	
Development	\$ 76.1	\$ 101.8
Modernization	<u>806.4</u>	<u>1,511.6</u>
Program acquisition cost	<u>\$882.5</u>	<u>\$1,613.4</u>
Average unit cost for 361 aircraft	<u>\$ 2.44</u>	<u>\$ 4.47</u>

a/As revised October 28, 1977.

Program costs have remained constant except for application of inflation indices and for an increase of \$3.4 million attributed to Boeing Vertol's decreased business base due to their losing the utility tactical transport aircraft system contract. Program officials stated that Boeing Vertol's

loss of the Navy's light airborne multipurpose system project will not increase the cost of the modernization program.

While the Army has designated the CH-47 modernization program a major acquisition because of the high dollar amount, it has not been required to submit selected acquisition reports to keep the Congress informed of program costs.

Development costs

Development costs are estimated to total \$102 million. Boeing Vertol was awarded an engineering development contract in June 1976 to design, fabricate, and demonstrate the seven systems in three prototype aircraft (see p. 1). The target cost of the contract is \$66 million plus \$5.3 million in target incentive fees. An additional \$3.6 million award fee is available to the contractor for design-to-cost and RAM achievements. Production engineering, Government-furnished equipment, Army management and testing costs, and contingency reserves comprise the remaining development costs.

Boeing Vertol began development efforts in 1975 with the engineering development of transmissions, hydraulics, and fiberglass rotor blades. The scheduled completion date for all development work is March 1980.

Modernization costs

The Army's estimate of \$1.5 billion in escalated dollars reflects the procurement cost to modernize 361 CH-47 aircraft. The following table shows the number of aircraft to be modernized by model, the design-to-unit-production cost, and the estimated design-to-flyaway costs. The difference between unit production and flyaway costs is primarily Government-furnished equipment, airframe preparation costs, and contractor profit.

<u>Model</u>	<u>Number to be modernized</u>	<u>Unit production costs (note a)</u>	<u>Flyaway costs (note a)</u>
(millions)			
A	104	\$1.7	\$2.8
B	74	\$1.4	\$2.4
C	183	\$1.0	\$1.6

a/Costs shown are in constant fiscal year 1975 dollars.

### Operating and support costs

The modernized aircraft are expected to reduce operating and support costs, which is one of the principal factors that justified the modernization program. However, reduced costs were estimated using reliability and maintainability goals that have yet to be demonstrated. The Army advised that this is normal for programs undergoing development. If reliability and maintainability goals are not achieved, the estimated reductions in operating and support costs will not be realized.

### Modernization efforts being funded by other programs

During our review, we found that changes were being made to the present CH-47 aircraft that related to the modernization program. We believe the costs of these changes should be recognized as associated costs to the CH-47 modernization program. The following costs were identified during our review.

	<u>Escalated dollars</u>
	(millions)
Contract to develop fiberglass blades	\$ 3.5
Related engine improvement program	<u>81.7</u>
Total	<u>\$85.2</u>

Boeing Vertol was awarded a \$3.5 million contract for trade-off analysis, engineering design, and tooling of fiberglass rotor blades.

Lycoming is improving the existing engines mounted on most C model aircraft in order to improve engine RAM characteristics. The \$81.7 million program began in 1976 and is to run concurrently with the modernization program.

### Purchase of new aircraft

While the modernization program does not include new medium lift helicopters to be procured by the Army, the Decision Coordinating Paper states that the Army should

procure new modernized CH-47s to fill its authorized acquisition objective and replace attrition losses. To meet the Army's authorized acquisition objective of 551 for 1985 and projected attrition rates, the Army will need to purchase about 190 aircraft estimated to cost about \$1.2 billion.

Funding

Shown below is the cumulative funding and the Army's estimate of funds required to complete the modernization program as of September 30, 1977.

	<u>Fiscal year 1975 escalated dollars</u>			
	<u>Prior funding through FY 1978</u>	<u>FY 1979 funding</u>	<u>Estimate to complete</u>	<u>Total (note a)</u>
	(millions)			
Development	\$71.6	\$19.5	\$ 10.7	\$ 101.8
Modernization	—	—	<u>1,511.6</u>	<u>1,511.6</u>
<b>Total</b>	<u>\$71.6</u>	<u>\$19.5</u>	<u>\$1,522.3</u>	<u>\$1,613.4</u>

a/As revised October 28, 1977.

SCHEDULE

Development work on components is on schedule except for the engines and hydraulics. We were advised that problems with those systems are not expected to affect the overall program schedule.

Program milestones, thresholds, and current estimates are provided in the following listing.

<u>Milestone</u>	<u>Approved program</u>	<u>Threshold</u>	<u>Current estimate if different from the approved program</u>
110 Hour Blade Whirl	Dec. 1977	June 1978	
Transmission Dynamic Strain	Mar. 1979	Sept. 1979	
50-Hour Transmission Survey Run	Apr. 1979	Oct. 1979	
First Flight	Sept. 1979	Mar. 1980	
Army Preliminary Evaluation	Dec. 1979	June 1980	
Developmental Testing/Operational Testing II Start	Jan. 1980		
Developmental Testing/Operational Testing II Complete	June 1980		
Army Systems Acquisition Review Council III	Aug. 1980		
Defense Systems Acquisition Review Council III	Sept. 1980		
Initial Production Contract Award	Sept. 1980		a/Oct. 1980
Developmental Testing/Operational Testing III Start	Oct. 1981		b/May 1982
Initial Production Delivery	May 1982		
Full-Scale Production Contract Award	Sept. 1982		
Developmental Testing/Operational Testing III Complete	Mar. 1983		b/June 1983
Initial Operational Capability	Aug. 1983		
First Full-Scale Production Delivery	Sept. 1983		

a/Changed to October 1980 because of the need for fiscal year 1981 procurement funds.

b/Developmental Testing/Operational Testing III has been changed to follow-on evaluation testing which will be done on modernized aircraft.

### Proposed modernization rate

The Army's proposed modernization program calls for modernizing three aircraft per month over a 12-year period from 1980 through 1991. Program officials state that the decision to set such a low modernization rate resulted primarily from a lack of funds available in the early 1980 time frame. Consideration is being given to other modernization rates, and the project manager stated that a formal assessment of various rates will be made prior to the modernization decision.

### Shortcomings associated with a low modernization rate

The Army and Boeing Vertol officials recognize that the proposed rate of three aircraft per month is not the most economical modernization rate. A higher rate would reduce the number of years required to modernize the CH-47 fleet and would reduce program costs. Also, this proposed rate requires CH-47 aircraft to be overhauled while modernization is ongoing. Increasing modernization rates could eliminate the need for overhaul of aircraft and reduce Army overhaul costs.

The low rate of modernization requires continuing overhaul of present CH-47 aircraft and will preclude the Army from modernizing A models first, followed by B and C models, respectively. Rather a mix of models will be modernized, leaving A, B, C and modernized aircraft in the field for the Army to maintain and manage.

### PERFORMANCE REQUIREMENTS OF THE MODERNIZED CH-47

Performance requirements for the modernized aircraft are the same as for the current CH-47C models and include the following

- a lift capability of 15,000 pounds at 4,000 feet altitude on a 95 degree Fahrenheit day,
- a 200 to 500 feet per minute vertical rate of climb, and
- sufficient fuel for a 30-nautical mile radius mission and a 30-minute reserve.

Current projections show that the modernized aircraft will achieve these requirements.

In addition to the above requirements, the required operational capability document emphasized the aircraft's need to use terrain flying techniques (less than 200 feet of altitude) during night or adverse weather conditions to avoid the enemy threat. The advanced flight control system will not enable the modernized aircraft to use terrain flying techniques with external loads during night or adverse weather conditions which require instrument assistance.

#### CONCLUSIONS AND RECOMMENDATION

Estimated program costs have remained constant except for the application of inflation indices and a \$3.4 million increase attributed to the Boeing Vertol's reduced business base. However, reported costs do not include the \$85.2 million to improve the engines and develop the fiberglass rotor blades. In addition, the \$1.2 billion required to purchase the 190 additional aircraft needed to meet projected Army requirements are excluded from program cost estimates.

The proposed modernization rate of three aircraft per month is not the most economical rate and will result in a lengthy (12-year) modernization period. Use of this rate requires overhaul of existing CH-47 aircraft to continue. This will result in the Army modernizing a mix of A, B, and C models rather than completing A models first followed by B and C models, respectively. It will also result in all models of the CH-47 remaining in use for several years.

Program milestones have been established and generally remained unchanged. Performance requirements are basically the same as the demonstrated performance of the CH-47C aircraft. The modernized CH-47 is required, but will not be able to carry external cargo using approved terrain flying techniques (less than 200 feet altitude) during night or adverse weather conditions that require use of instrument assistance.

We recommend that the Secretary of Defense evaluate the proposed modernization rate of three aircraft per month.

## CHAPTER 5

### SYSTEMS BEING MODERNIZED

#### AND RELIABILITY, AVAILABILITY,

#### AND MAINTAINABILITY REQUIREMENTS

The modernization program is designed to reduce operating and support costs by providing significant RAM improvements to seven systems. (See p. 1.) Further RAM improvements are expected from a separate engine modernization program. RAM improvements are scheduled to be tested before the Army decides to modernize. However, the current program does not require the Army to demonstrate that interim reliability goals have been achieved prior to that decision.

#### DESCRIPTION AND STATUS OF SYSTEMS BEING MODERNIZED

The seven systems being modernized were selected to improve RAM performance, incorporate technological advancements, and improve the safety or survivability of the aircraft. The Army's objective is to improve each system's reliability while decreasing overall aircraft maintenance by 24 percent. Current C models require about 23 man-hours of maintenance for every hour flown. Improvements to transmissions and to the hydraulic system represent the principal increases in the program's RAM objectives. The other five systems represent a relatively small portion of the proposed RAM improvements but significantly increase the safety and survivability of the aircraft. While the engines are not included in the modernization program, they are undergoing a concurrent program to improve RAM characteristics. Transmissions, hydraulics, engines, and other systems are discussed below.

#### Transmissions

RAM goals for transmissions call for substantial improvement over current C models. These improvements are needed because transmissions in the C models are not designed for the shaft horsepower generated by current engines. Specific improvements will include

--integral lubrication,

--hardened metals,



- redundant oil system,
- self-lubricating bearings, and
- improved debris detection.

Transmission designs have been finalized for the five transmissions mounted in each aircraft and some component hardware has been fabricated. Component assembly and testing is scheduled to begin in 1978. Transmission development is critical to the overall program schedule because completion of qualification testing is not scheduled until 2 months prior to the first flight. This allows little time to correct problems that may develop. The Army advised that pre-flight release is scheduled 11 months prior to the first flight.

### Hydraulics

Modernization of the hydraulic system consists of modularizing the system and reducing the number of potential leak points from 1,040 to 219. The present system has been characterized by leaks and, generally, poor maintainability. Final testing of the hydraulic system cannot be accomplished until all the modernized components are installed on the aircraft, 4 months prior to roll out. Once again, the schedule allows little time to correct problems that may develop. The Army advised testing will be accomplished on an integrated test rig 12 months prior to first flight.

### Engines

Existing engines are undergoing a component improvement program to improve their mean-time-between-depot actions from 329 hours to 1,150 hours. While this engine effort is not formally included in the modernization program, its objectives of improved RAM characteristics are similar. The improved engine is to be installed on existing C models beginning in 1980, as well as on the modernized aircraft.

The engine testing program virtually stopped during 1977 because test engines experienced burning of fuel nozzles. Lycoming plans to correct the problem and testing resumed in December 1977. While the engine program has slipped 6 to 8 months, program officials do not believe the slippage will adversely affect program schedule.

## Other systems

The remaining systems being modernized (rotor blades, an advanced flight control system, electrical system, auxiliary power unit, and cargo suspension system) are progressing satisfactorily according to program officials. Fiberglass blades represent the most significant technological improvement of these five systems. The Army plans to install fiberglass blades on C model aircraft prior to the modernization in order to achieve cost savings and increased survivability. The whirl testing of fiberglass blades, a program milestone, is scheduled for March 1978. According to program officials, the other system improvements represent technology proven in other helicopter systems. The current schedule for these items provides little time to correct problems which may develop.

The airframe, while not being modernized, will be inspected for proper alignment and for fatigue cracking of critical points. No tests have been done nor are any planned to determine the fatigue life of the airframe. All models will receive a new forward pylon assembly (forward rotor mount) and structural reinforcement. Army and contractor officials advised that they believe the airframe will last another 20 years.

## RAM OBJECTIVES AND TESTING

The Army has established RAM objectives which must be realized to achieve lower operating and support costs. Testing is designed to measure RAM improvements and to validate expected RAM growth.

## RAM goals and requirements

While the Army used RAM goals reflecting a 24-percent maintenance reduction in developing operating and support costs for the modernized aircraft, it established significantly lower minimum acceptable RAM values on which it may base its decision to initiate modernization. RAM goals and minimum acceptable values presented in the table on the following page reflect interim goals (values expected and required) prior to the modernization decision point and values to be demonstrated at maturity (100,000 flight hours).

	<u>Goal</u>	<u>Minimum acceptable values</u>
<u>Maintainability (maintenance man-hours per flight hour)</u>		
Interim goals	19.0	-
Mature goals	17.66	19.0
<u>Reliability (mean time between failure-hours)</u>		
System operational (note a)		
Interim goals	.96	.76
Mature goals	1.4	1.1
Hardware system (note b)		
Interim goals	2.06	1.52
Mature goals	3.0	2.2
Mission (note c)		
Interim goals	34.0	27.2
Mature goals	49.5	39.5

a/A system operational failure is one which results in the inability of any component to satisfactorily perform its function within specifications and requires unscheduled maintenance for correction.

b/A hardware system failure is defined as a fault in any equipment that results in the inability of the item to perform its required function and requires unscheduled removal of the item.

c/A mission failure occurs when the aircraft cannot complete an assigned mission.

As shown, the minimum acceptable reliability values required to be demonstrated prior to the modernization decision are much lower than the interim reliability goals. Also, the required minimum acceptable value for maintenance man-hours is 76 percent of the mature maintainability goal.

The interim minimum acceptable reliability values required to be demonstrated prior to its decision to modernize are also lower than values demonstrated by existing C model aircraft. Measured system operational and hardware system reliability values for C models are 0.96 hours and 2.6 hours, respectively. Minimum acceptable system operational and hardware system reliability values are 0.76 hours and 1.52 hours.

The Army pointed out values for the CH-47C are higher because it is a mature system and that additional RAM data will be collected on the CH-47C prior to testing the modernized aircraft.

#### Scheduled testing to determine RAM values

The Army has scheduled 400 hours of development and operational tests before it decides to modernize the aircraft. The Army's decision to modernize will be based on RAM data collected during these tests. Program officials stated that the decision to modernize will not be made unless minimum acceptable RAM values are fully demonstrated. However, they are not required to demonstrate the interim RAM goals prior to this decision. The Army advised that it is required to demonstrate that minimum acceptable values have been achieved at a 90-percent confidence level.

Mature RAM values represent anticipated values after 100,000 flight hours have been accumulated. Interim RAM values are projected over a growth curve to arrive at mature values. Therefore, interim values and projected RAM growth must be achieved to realize lower operating and support costs. The projected RAM growth curve will not be verified until after modernization has been initiated. Current plans call for 700 hours of RAM growth verification testing with scheduled completion to be about 7 months after modernization begins.

#### CONCLUSIONS AND RECOMMENDATION

The minimum acceptable reliability values which the modernized aircraft must demonstrate prior to the modernization decision are substantially lower than the interim reliability goals and the reliability values demonstrated by C model aircraft. Also, the projected RAM growth will not be validated prior to the modernization decision. We question the Army's plan which allows initiation of modernization without demonstrating that interim reliability goals have been achieved. Attainment of these goals is essential to reducing operating and support costs which justified the selection of this program.

We recommend that the Secretary of Defense withhold approval to initiate modernization unless interim reliability goals have been achieved.