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A
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Modernizing the Army's Rotary-Wing Aviation Fleet

Abbreviations Used in This Paper

AB3	Longbow Apache Block III
AH-64A	Apache (attack helicopter)
AH-64D	Longbow Apache (attack helicopter)
ARH	Armed Reconnaissance Helicopter
C3	Command, control, and communications
CAAS	Common Avionics Architecture System
CAB	Combat aviation brigade
CCA	Close combat attack
CH-47	Chinook (cargo helicopter)
FCR	Fire control radar
FCS	Future Combat Systems
JHL	Joint Heavy Lift rotorcraft
JMR	Joint Multi-Role rotorcraft
MTOGW	Maximum takeoff gross weight
OH-58C	Kiowa (observation helicopter)
OH-58D	Kiowa Warrior (armed observation helicopter)
RDT&E	Research, development, testing, and evaluation
SLEP	Service life extension program
TDA	Table of distribution and allowances
TOE	Table of organization and engineering
UH-1	Huey (utility helicopter)
UH-60	Blackhawk (utility helicopter)
UH-72A	Lakota (light utility helicopter)

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The Congress of the United States ■ Congressional Budget Office

Notes

All costs are presented in constant fiscal year 2007 dollars; all years are fiscal years.

Numbers in the text and tables may not add up to totals because of rounding.

The cover shows several helicopters in the Army's fleet. Clockwise from the top left: two UH-60 Blackhawks, UH-72A Lakota, AH-64 Apache, CH-47 Chinook, and OH-58D Kiowa Warrior. Source: www.army.mil.

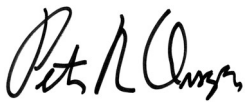
Preface

The United States Army's rotary-wing aviation fleet numbers about 3,500 aircraft, including utility, cargo, attack, and reconnaissance helicopters. Between now and 2030, the Army is planning to modernize the fleet to sustain and improve its capabilities, a task the Congressional Budget Office (CBO) estimates will have an average cost of about $3.3 billion per year, substantially more than the $2.2 billion per year average the Army spent on such programs over the past 20 years.

This CBO paper was prepared at the request of Congressman Curt Weldon, then-Chairman, and Congressman Neil Abercrombie, current Chairman and past Ranking Member of what is now the Air and Land Forces Subcommittee of the House Committee on Armed Services. The paper analyzes the costs and the capabilities of the Army's planned rotary-wing aviation fleet and offers four alternative approaches to modernizing the fleet. In keeping with CBO's mandate to provide objective, impartial analysis, this paper makes no recommendations.

Kevin Eveker of CBO's National Security Division prepared the paper under the supervision of J. Michael Gilmore and with assistance from David Arthur. David Newman of CBO's Budget Analysis Division prepared the cost estimates under the supervision of Sarah Jennings. John Gordon of the RAND Corporation and personnel in the Department of the Army provided comments. (The assistance of external participants implies no responsibility for the final product, which rests solely with CBO.) Raymond Hall, Arlene Holen, Sarah Jennings, Frances Lussier, and Donald B. Marron (formerly of CBO) reviewed drafts of the study.

Kate Kelly edited the manuscript, with assistance from John Skeen. Cynthia Cleveland produced drafts of the paper. Maureen Costantino designed the cover and, with assistance from Allan Keaton, prepared the report for publication. Lenny Skutnik produced the printed copies, Linda Schimmel coordinated the print distribution, and Simone Thomas prepared the electronic version for CBO's Web site (www.cbo.gov).



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November 2007

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Summary

Toward the end of the Cold War, the Army's helicopter, or rotary-wing, fleet consisted of nearly 9,000 aircraft. Over the past 20 years, however, the fleet has contracted to its current strength of about 3,500 aircraft. Despite the elimination of many older helicopters and the modernization or replacement of others, most of the helicopters in today's fleet already exceed or soon will reach ages greater than the Army considers practical. The Army has embarked on a modernization plan that, by 2030, would address the aging of the fleet and introduce new capabilities by replacing or significantly upgrading nearly every helicopter in the fleet.

By the estimate of the Congressional Budget Office (CBO), the effort would cost $3.3 billion per year, on average, from 2007 through 2030, significantly more than the $2.2 billion annual average the Army spent between 1986 and 2005. (If the Army had not canceled its Comanche attack/reconnaissance helicopter program in 2004, the cost of its modernization plan could have come to nearly $4 billion per year.) The proposed higher spending comes at the same time the Army expects to invest heavily in the new Future Combat Systems (FCS) family of equipment, and it is likely to present substantial budget challenges for Army planners.[1]

This CBO study examines the Army's plan to modernize its helicopter fleet and compares that plan with four alternatives that would either hold aviation spending to more nearly match historical averages or shift the emphasis toward procuring a fleet that is more consistent with plans for the FCS. CBO's analysis points to several general conclusions:

- Short of significantly cutting the aviation force structure or accepting further aging of the fleet, there is only a limited opportunity to reduce spending on the Army's helicopter modernization over the next 5 to 10 years.
- Under the Army's current plan, the years of highest spending occur after 2020. When combined with the simultaneous full-rate production of FCS equipment, that spending could be difficult to sustain if budgets are constrained.
- Alternatives that would reduce average spending on the Army's aviation force over the long term but still maintain current and near-term capabilities would come at the cost of sacrificing many of the expanded capabilities anticipated in the Army's long-term plans.

Modernizing the Army's Helicopter Fleet

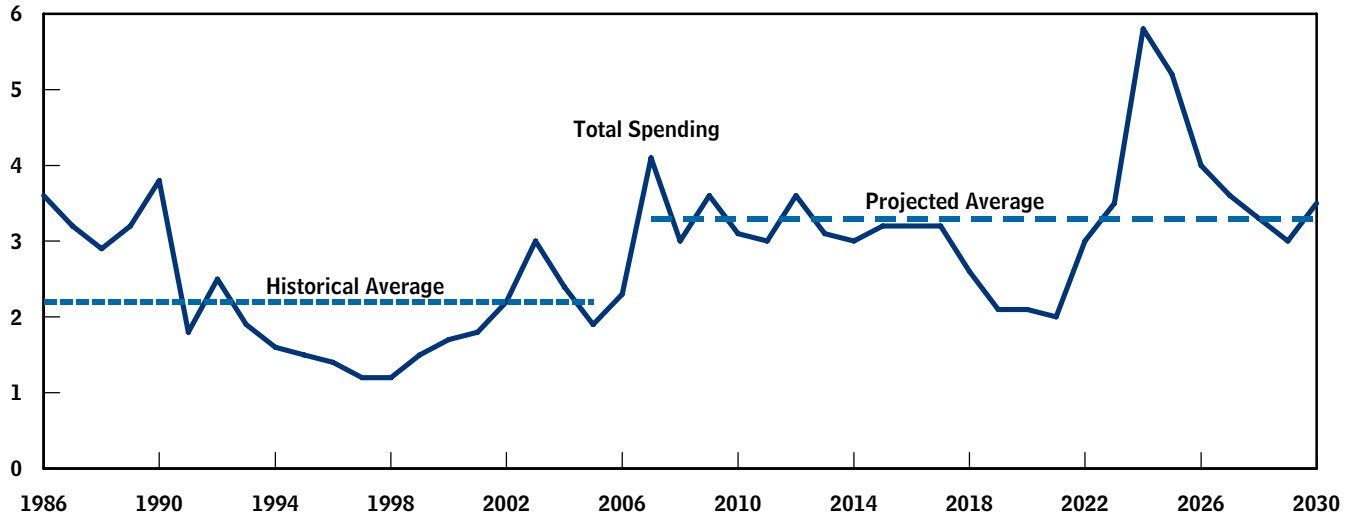
Today's Army helicopter fleet can be roughly divided into two general categories: transport and attack/reconnaissance. The Army's utility and cargo helicopters move troops, equipment, and supplies around the battlefield; its attack/reconnaissance helicopters gather information and engage the enemy. The current modernization plan calls for nearly the entire fleet of both types of helicopter to be upgraded or replaced: Over the next decade, the UH-1 Huey utility helicopter would be replaced by the new UH-72A Lakota light utility helicopter; the UH-60A/L Blackhawk utility helicopter would be upgraded to the improved M-model configuration; and CH-47D Chinook cargo helicopter, the Army's largest, would be upgraded to the improved F-model. Later on, the Army's plan calls for developing the Joint Heavy Lift

1. The Army has proposed a group of manned and unmanned aerial and ground vehicles, missile launchers, and communications links that would be developed and procured as a single program called the Future Combat Systems. See Congressional Budget Office, *The Army's Future Combat Systems Program and Alternatives* (August 2006).

Summary Figure 1.

The Army's Historical and Projected Spending on Helicopters

(Billions of 2007 dollars)



Source: Congressional Budget Office based in part on data from the Department of the Army.

rotorcraft (JHL)—a much larger transport aircraft—in cooperation with the Air Force.

Also over the next decade, the OH-58C/D Kiowa reconnaissance helicopters would be replaced with a mix of Lakotas and the new Armed Reconnaissance Helicopters (ARHs); upgrades of AH-64A Apache attack helicopters to the D-model Longbow configuration would be completed; and a further upgrade of Longbow Apaches to the Longbow Apache Block III (AB3) configuration would begin around 2011. By 2020, the Army plans to begin developing a new attack aircraft that currently is known as the Joint Multi-Role rotorcraft (JMR).

Annual spending to implement the Army's helicopter program would range from a low of about $2 billion (in 2021) to a high of almost $6 billion (in 2024) and average $3.3 billion per year through 2030 (see Summary Figure 1). By comparison, the Army spent $2.2 billion annually, on average, from 1986 to 2005.

Alternatives Examined by CBO

CBO considered four alternative approaches to modernizing the Army's rotary-wing aviation fleet. Although procurement quantities vary from one alternative to the next, each would maintain the total size of the Army's helicopter fleet through 2025 at or above current levels. Not all of the expanded capabilities anticipated in the Army's plan would be realized, however.

Alternative 1, with an average annual cost of $2.6 billion, would spread cuts across most of the Army's planned programs (see Summary Table 1). It would cut procurement quantities of the UH-72A, ARH, and JHL, and it would replace development of the JMR with a service life extension program (SLEP) for the Longbow Apache attack helicopter. With an average cost of $2.1 billion per year, Alternative 2 is the least expensive of the four. It would curtail improvements in transport capability, specifically by canceling plans for the JHL, and instead pursue a SLEP for the Chinook helicopter. The ability to transport FCS vehicles by rotorcraft would be lost under this alternative. With an average annual cost of $2.8 billion, Alternative 3 would focus cuts on the attack/reconnaissance helicopter programs. The AB3 and JMR programs would be eliminated, and no SLEP would be pursued for the Longbow Apache. Attack capabilities under this alternative would decline sharply as the Longbow Apache aircraft began retiring around 2025.

Alternative 4 differs from the others in that it does not focus on cost reduction. Instead, it would accelerate development of the JHL (to better match the planned schedule for fielding the Army's FCS brigades) at

Summary Table 1.

Modernization of the Helicopter Fleet Under the Army's Plan and Four Alternatives

(Billions of 2007 dollars)

Plan	Components	Quantity Procured	Annual Spending 2007–2030	RDT&E Cost[a]	Procurement Cost[b]
Army's Current Modernization Plan	Procure LUH, UH-60M, CH-47F, JHL, ARH, AB3, JMR	3,353	3.3	12	68
Alternative 1: Spread Reductions Across Programs	Cut procurement of LUH, JHL, ARH, AB3; replace JMR with Longbow Apache SLEP	2,839	2.6	9	54
Alternative 2: Forgo the Joint Heavy Lift Rotorcraft	Do not pursue JHL; substitute CH-47 SLEP for JHL	3,293	2.1	5	46
Alternative 3: Reduce Attack/Reconnaissance Modernization	Cancel AB3; do not pursue JMR or Longbow Apache SLEP; reduce ARH procurement	2,570	2.8	8	60
Alternative 4: Accelerate Joint Heavy Lift and Reduce Attack/Reconnaissance Modernization	Accelerate JHL; cancel AB3; subsititute Longbow Apache SLEP for JMR	3,111	3.3	10	69

Source: Congressional Budget Office based in part on data from the Department of the Army.

Notes: RDT&E = research, development, testing, and evaluation; LUH = Lakota light utility helicopter; UH-60M = improved Blackhawk utility helicopter; CH-47F = improved Chinook cargo helicopter; JHL = Joint Heavy Lift rotorcraft; ARH = Armed Reconnaissance Helicopter; AB3 = Longbow Apache Block III; JMR = Joint Multi-Role rotorcraft; SLEP = service life extension program.

a. RDT&E appropriations pay for scientific research, design, development, and testing of systems and the manufacturing technology necessary to produce them.

b. Procurement appropriations pay for aircraft manufacturing and for support and training equipment, technical data, and maintenance publications.

average spending that is similar to that of the Army's modernization plan. To offset some of the increase in spending on the JHL, Alternative 4 would eliminate the AB3 program and pursue a Longbow Apache SLEP in lieu of the JMR program.

Conclusions

Short of significantly cutting the aviation force structure or accepting further aging of the fleet, there is limited potential to reduce spending on the Army's helicopter modernization over the next 5 to 10 years. From 2007 through 2014, a span roughly concurrent with the Department of Defense's Future Years Defense Program, Alternatives 1, 3, and 4 would reduce costs by about 10 percent (see Summary Table 2). Alternative 2 would offer no near-term savings. The potential for realizing savings while maintaining forces is limited because the Army's plan pursues relatively low-cost approaches for its continuing and near-term efforts: Two helicopters are being upgraded (the UH-60 and CH-47) and the new helicopters are military derivatives of existing commercial designs. In the absence of unforeseen complications, those approaches tend to be less expensive than developing and building newly designed aircraft.

Greater savings in the near term would probably require significant cuts in the Army's aviation force structure. Although halting or slowing the modernization programs would not necessarily require immediate force reductions,

Summary Table 2.

Average Annual Spending to Modernize the Army's Helicopter Fleet, 2007 to 2030 and Eight-Year Segments

(Billions of 2007 dollars)

Plan	Near Term (2007–2014)	Mid-Term (2015–2022)	Far Term (2023–2030)	2007–2030
Army's Current Modernization Plan	3.3	2.7	4.0	3.3
Alternative 1: Spread Reductions Across Programs	3.0	2.2	2.7	2.6
Alternative 2: Forgo the Joint Heavy Lift Rotorcraft	3.3	2.0	1.1	2.1
Alternative 3: Reduce Attack/Reconnaissance Modernization	3.0	2.1	3.4	2.8
Alternative 4: Accelerate Joint Heavy Lift and Reduce Attack/Reconnaissance Modernization	3.0	3.2	3.7	3.3

Source: Congressional Budget Office based in part on data from the Department of the Army.

a near-term need to retire older aircraft (the remaining C-model Kiowas and A-model Blackhawks, for example) would soon affect the size of the ground force that could be supported. The reductions would come as the Army's ground force structure is expected to increase in response to high demands for deployed ground units. The alternatives CBO examined did not include cuts to the fleet of transport helicopters used to support deployed forces. Cuts to the fleet of attack/reconnaissance helicopters were included in the alternatives under the assumption that some or all of their capabilities could be replaced by armed unmanned aircraft or by Air Force or Navy strike aircraft, for example.

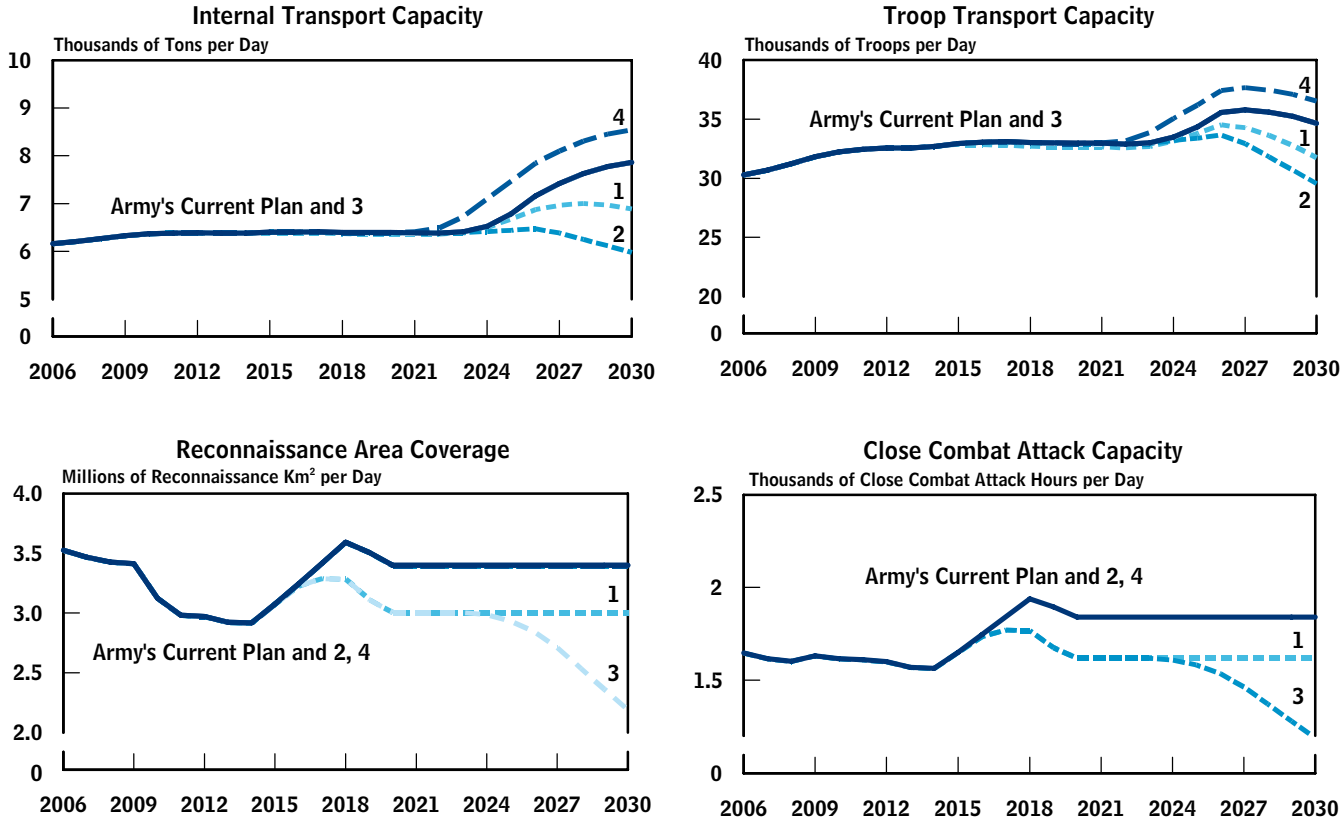
The analysis in this study also shows that, under the Army's plan, the years of highest spending would occur after 2020, primarily because of production of the JHL. CBO estimates that costs for the JHL will be higher than for past Army rotorcraft because a much larger airframe would be needed to provide the heavy payload capacity and long range the Army desires. The increase in spending on rotorcraft would be concurrent with the planned full-rate production of the FCS, potentially creating budgetary pressures for Army planners after 2020. The pressures would increase if the costs of those systems grew during their development, as has been the case with similar development programs. The Army thus could find it necessary to alter the timing or content of one or more programs to fit within available budgets after 2020. For example, postponing JHL production until after UH-60M upgrades are completed in 2025 could reduce the sharp increase in spending expected around 2023.

The converse, accelerating procurement of the JHL to better match the FCS schedule, would be particularly difficult. Spending on the JHL dominates the Army's plan (especially after 2025) to the extent that there is little available that could be shifted to the JHL within a constrained budget: Alternative 4, which was structured to stay within the amount of spending in the Army's plan, would produce only 32 additional JHL aircraft in the final 10 years of the analysis period. Attempts to begin JHL production in 2018 to 2020, where planned spending is at its lowest, would be limited by the long development time likely for such an advanced aircraft.

The alternatives to the Army's modernization plan that would reduce average spending over the long term, yet maintain current and near-term capabilities, would require the Army to forgo some of the expanded capabilities anticipated in the plan. Toward the end of the period, the JHL would provide considerably greater capability than current transport helicopters do. (The top panels of Summary Figure 2 illustrate the effects of marked

Summary Figure 2.

Comparison of Alternative Force Capabilities



Source: Congressional Budget Office based in part on data from the Department of the Army.

Notes: 1 = Alternative 1: Spread reductions across programs.

2 = Alternative 2: Forgo the Joint Heavy Lift rotorcraft.

3 = Alternative 3: Reduce attack/reconnaissance modernization.

4 = Alternative 4: Accelerate Joint Heavy Lift and reduce attack/reconnaissance modernization.

increases in fleetwide internal cargo transport capacity and troop transport capacity expected under the Army's plan. The capabilities shown in the figure are not additive; each panel assumes the entire fleet is dedicated to provide that particular capability.) The JHL also would be able to fly farther and carry much larger objects—specifically, FCS armored vehicles—than existing helicopters can. Although the JMR could offer significant improvements over the Longbow Apache, the attack and reconnaissance capabilities in Summary Figure 2 do not increase as much as the transport capabilities because, at most, only 12 JMR aircraft would be purchased by 2030.

Alternative 2, which includes the greatest cuts in funding for transport rotorcraft, would not increase transport capabilities but would maintain them as they are now. The cost is nearly $29 billion less (from 2007 to 2030) than the cost of the Army's plan, CBO estimates. Attack and reconnaissance capabilities would match those of the Army's plan. Average annual spending under Alternative 2 would be slightly below the 20-year historical average.

The broad cuts envisioned under Alternative 1 would offer smaller savings—CBO estimates about $17 billion through 2030. Transportation capabilities would be somewhat better than current capabilities. The capacity to attack ground targets would be similar to today's capacity, but the rate at which territory could be reconnoitered would be about 35 percent lower.

Alternative 3 would save about $12 billion through 2030. It would retain improvements in transportation capabilities expected in the Army's plans, but it would require substantial reductions in reconnaissance and attack capabilities, essentially retiring the Longbow Apache fleet without a replacement. That loss could be offset by greater reliance on fixed-wing-aircraft support from the Air Force and the Navy or on the unmanned aircraft (armed and unarmed) that are expected to be in greater use by all of the military services in the future. Improved reconnaissance and fire support inherent in the FCS itself could contribute as well.

This report describes the aircraft and force alternatives CBO examined and it outlines the analyses that underlie the performance comparisons among the alternatives. Chapter 1 describes the characteristics and costs of existing and planned Army rotorcraft. Chapter 2 describes the Army's planned fleet and the alternative fleets examined by CBO. Chapter 3 describes the metrics CBO used to compare the operational effectiveness of those fleets.

CHAPTER

1

Existing and Planned Helicopters in the Army's Fleet

The Army's helicopter fleet consists mainly of utility, cargo, and attack/reconnaissance helicopters. Utility and cargo helicopters are used primarily for transport. Their missions can range from inserting soldiers into battle to retrieving damaged equipment for repair in rear areas. (Box 1-1 presents a short summary of common Army helicopter missions.) Although there is not a hard distinction between utility helicopters (which have designations beginning with *UH-,* such as the UH-60 Blackhawk) and cargo helicopters (which have designations beginning with *CH-,* such as the CH-47 Chinook), utility helicopters tend to be smaller and more broadly distributed across the Army's force structure. Cargo helicopters tend to be larger, and their squadrons assigned to higher echelon units within the Army.[1] (Figure 1-1 illustrates the relative sizes of existing and conceptual Army rotorcraft, the appendix provides a description of the force structure for helicopter-equipped units, and the inside front cover lists the terms used in this report.)

Attack and reconnaissance helicopters are designed to attack enemy forces and to gather information about the disposition of forces on the battlefield. They primarily carry sensors and weapons instead of cargo, and because they are faster and more agile, they can operate over unfriendly territory for prolonged periods. (Pilots of utility and cargo helicopters that operate over hostile territory generally try to get in and get out with minimal exposure.) Attack and reconnaissance helicopter designations usually begin with an *AH-* or *OH-* prefix.

Until 2019, Army's modernization plan involves a combination of upgrades to some helicopters in the existing fleet and replacement of others with military versions of commercial helicopters. After 2020, the Army foresees two new types of rotary-wing aircraft—the Joint Multi-Role rotorcraft (JMR) and the Joint Heavy Lift rotorcraft (JHL)—which will be developed with other service branches to offer greater capabilities than are possible with today's technology. The upgrade and replacement plans are scheduled to ensure that the age of helicopters in the Army's fleet does not exceed their useful service lives. (Although Army planning documents indicate that a helicopter should be replaced after 20 years in service, fleet data show that attack/reconnaissance and cargo helicopters are regularly replaced after 27 years and utility helicopters are regularly replaced after 33 years. The alternatives examined by the Congressional Budget Office [CBO] adhere to those higher limits.)

Utility Helicopters

The Army's approximately 1,800 utility helicopters constitute slightly more than half of its total inventory of rotary-wing aircraft. More than 1,600 of that group are UH-60A and UH-60L Blackhawks; the rest are versions of the Vietnam-era UH-1 Huey. Near-term modernization plans for utility helicopters include upgrades to the UH-60s to improve performance and extend their service lives to well beyond 2030. The Hueys are currently being replaced with UH-72A Lakotas.

After 2038, the Army plans to replace the Lakotas and the upgraded Blackhawks with the JMR. (The JMR concept envisions attack/reconnaissance and utility versions based on a common design; the initial JMR variant is to

1. The ambiguity about what distinguishes utility helicopters from cargo helicopters is illustrated by another category, special operations helicopters (designated by the *MH-* prefix), which carry specialized systems for supporting special operations forces deep behind enemy lines. The MH- designation supersedes the UH- and CH- designations for the Army's MH-60 Blackhawks and MH-47 Chinooks. Inventory quantities quoted in this report include special operations helicopters, but they are not discussed in detail because they are operated outside the general force structure. (See the appendix.)

Box 1-1.

Helicopter Missions

Army doctrine, as outlined in its field manuals, specifies the nature of every mission performed by the Army's helicopter fleet.[1] Examples of common missions include the following:

Reconnaissance missions are for gathering information visually or electronically. Reconnaissance can focus on a route or area, for example, and it sometimes is performed in conjunction with ground-based surveillance. Reconnaissance aircraft can contribute to reconnaissance-in-force missions that engage the enemy to gain further information.

Security missions keep watch over surrounding areas and nearby enemy units. Although security missions can involve engagement with enemy reconnaissance elements, their primary task is gathering information.

Attack missions are designed to destroy enemy forces. They can occur deep in enemy territory or in conjunction with ground units in a close combat attack function. Helicopter attack missions most commonly occur at night and are most effective on the enemy's flanks and rear.

Air assault missions deliver infantry and artillery units to the battlefield to engage and destroy the enemy or to seize and hold key terrain.

Command, control, and communications, or C3, missions allow commanders to quickly see an area of operations and provide C3 for forces while on the move. They can also enhance battlefield communication through airborne transmissions or communications relay.

Air movement and sustainment missions are for transporting personnel, supplies, and equipment. They can involve dropping cargo from the air or unloading it after landing. Air movement and sustainment missions are distinct from air assault missions in that they do not directly insert units into combat.

Combat search and rescue missions provide assistance to downed aircrews, usually behind enemy lines.

Casualty evacuation missions rescue wounded personnel from the battlefield and transport them to treatment facilities.

1. See Department of the Army, *Army Aviation Operations,* Field Manual 1-100 (February 1997), which describes mission types in greater detail.

be an attack aircraft. The JMR is discussed with attack/reconnaissance helicopters later in this chapter.)

UH-60 Blackhawk and Upgrades

The single-rotor, twin-turbine-engine UH-60 Blackhawk is the Army's second-largest helicopter. (Table 1-1 on page 4 lists the main characteristics of helicopters in the Army's current fleet.) The Army has two Blackhawk versions, the UH-60A and UH-60L, the newer L-model has more powerful engines and a strengthened transmission that gives it improved performance in a variety of operating conditions. The UH-60L's MTOGW (maximum takeoff gross weight) is 22,000 pounds; for the UH-60A it is 20,250 pounds.[2] Cargo can be carried inside the aircraft or on external cargo hooks. The Blackhawk's crew consists of a pilot, a copilot, and a crew chief/gunner. The helicopter can accommodate 14 additional passengers, and it has space for four litters to transport casualties.

The Army is developing a new Blackhawk, the UH-60M, with a more powerful engine, enhanced rotor system, and digital avionics based on the Common Avionics Architecture System (CAAS, a flexible software architecture the Army is using for avionics upgrades throughout its

2. MTOGW is the weight of the helicopter along with all equipment, stores, fuel, munitions, cargo, crew, and passengers.

Figure 1-1.

Current and Proposed Army Rotorcraft

OH-58D
Kiowa
Warrior

AH-64A
Apache Attack
Helicopter

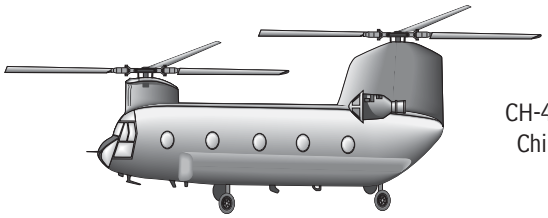
Armed Reconnaissance
Helicopter

AH-64D
Longbow Apache

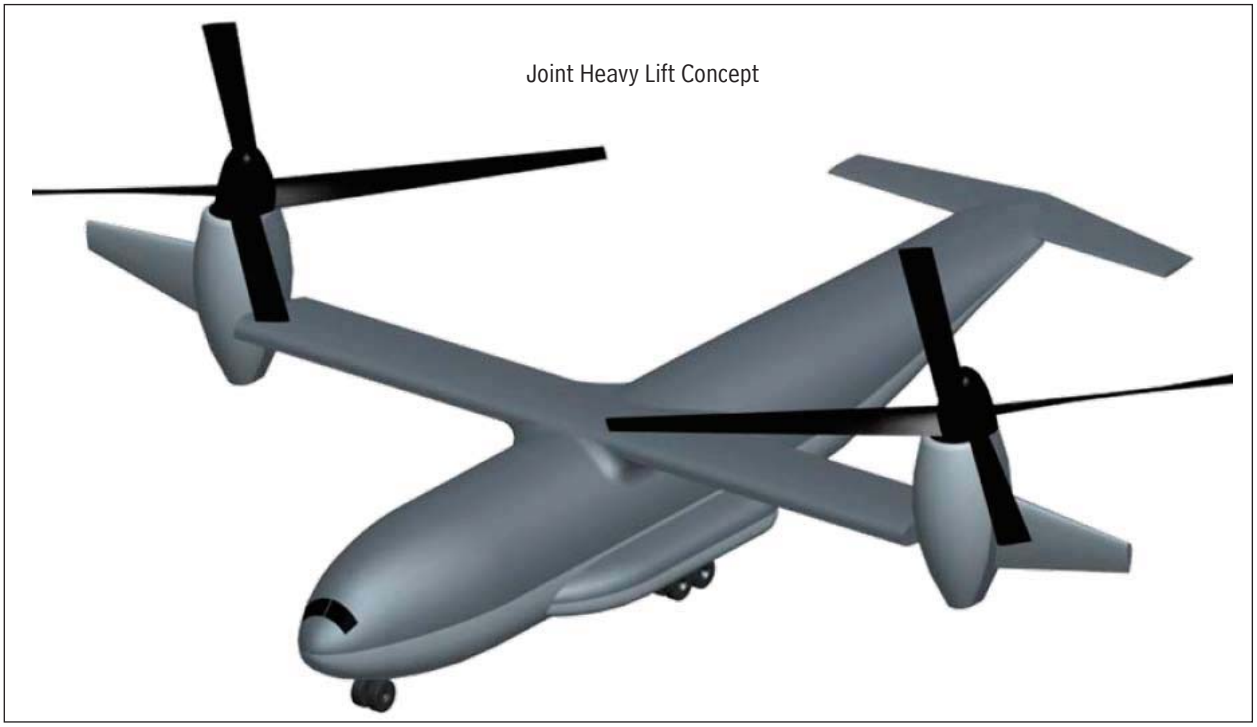
UH-1
Huey

LUH
Lakota Light Utility
Helicopter

UH-60A/L/M
Blackhawk



CH-47D/F
Chinook



Source: Congressional Budget Office and the Department of the Army.

Table 1-1.

Characteristics of Army Helicopters

Aircraft	Fuselage Length[a]	Fuselage Height[a]	Rotor Diameter[a]	Engines	MTOGW (Pounds)	Capacity Crew	Capacity Troops	Capacity Litters	Capacity Rockets[b]	Capacity Missiles[c]
UH-60A	50.0	17.5	53.7	2	20,250	3	14	4	n.a.	n.a.
UH-60L	50.0	17.5	53.7	2	22,000	3	14	4	n.a.	n.a.
UH-72A	33.4	11.3	36.1	2	7,903	2	8	2	n.a.	n.a.
CH-47D/F	51.0	18.7	60.0	2	50,000	4	33	24	n.a.	n.a.
OH-58C	32.6	12.0	35.3	1	3,200	2	2	n.a.	n.a.	n.a.
OH-58D	33.8	12.9	35.0	1	5,200	2	n.a.	n.a.	14	4
ARH	34.7	10.9	35.0	1	5,250	2	n.a.	n.a.	14	4
AH-64A/D	49.1	12.5	49.0	2	17,400	2	n.a.	n.a.	76	16

Source: Congressional Budget Office based on data from the Department of the Army.

Notes: MTOGW = maximum takeoff gross weight; n.a. = not applicable; UH-60A, UH-60L = Blackhawk utility helicopters; UH-72A = Lakota light utility helicopter; CH-47D/F = Chinook cargo helicopter; OH-58C = Kiowa observation helicopter; OH-58D = Kiowa Warrior helicopter; ARH = Armed Reconnaissance Helicopter; AH-64A/D = Apache/Longbow Apache attack helicopter.

a. Measurements are in feet.

b. 2.75-inch diameter Folding-Fin Aerial Rockets fired from seven-tube launchers (OH-58D and ARH) and nineteen-tube launchers (AH-64).

c. Laser-guided Hellfire (OH-58D, ARH, AH-64A/D) or radar-guided Longbow Hellfire (AH-64D only).

helicopter fleet). New equipment aboard the UH-60M will provide more protection against infrared-guided missiles and other threats. The new configuration also will include integrated vehicle management systems, which increase an aircraft's reliability and make it simpler to maintain. The MTOGW of the M-model Blackhawk will be the same as that of the UH-60L, but its external hauling capacity will be 9,000 pounds, 1,000 pounds more than the L-models. The UH-60M also will be able to carry heavier payloads over longer distances.

The Army's modernization plan calls for procurement of 1,227 UH-60M Blackhawk helicopters, all of them newly built (rather than rebuilt A- or L-model Blackhawks). Development of the UH-60M began in 2000 and is planned for completion in 2010. The Army projects the total cost for research, development, testing, and evaluation (RDT&E) at about $820 million (see Table 1-2). Procurement of the UH-60M began with the purchase of five aircraft in 2005 (with some advance funding from 2004). Final procurement is scheduled for 2025. The total cost of procurement is projected at just under $19 billion, with a unit cost of about $15.5 million. By comparison, the unit cost for the UH-60A was about $9.4 million; the unit cost for the UH-60L was about $9.5 million.

UH-72A Lakota

The UH-72A single-rotor, twin-turbine-engine light utility helicopter is a version of the Eurocopter EC-145 built to military standards and designed to transport troops, supplies, and equipment. The UH-72A entered into service in 2007. It is much smaller than the Blackhawk (its MTOGW is 7,900 pounds), and it is not intended to operate in battle zones. In addition to its crew of a pilot and copilot, the UH-72A can carry eight passengers.

The Army initiated the light utility helicopter program in 2004 to replace the UH-1 Huey general support helicopter and the OH-53C Kiowa observation helicopter, both of which are being retired. The total RDT&E cost for the light utility helicopter was $3.3 million. The Army began procuring the aircraft in 2006 (with some advance funding from 2005) with an initial purchase of 16 Lakotas. It anticipates a total fleet of 322, the last of which will be procured in 2016. The total procurement cost is projected at just over $1.7 billion; the average cost per aircraft is about $5.4 million.

Cargo Helicopters

The Army's only cargo helicopter is the CH-47 Chinook, early versions of which were first introduced in 1962. Currently, there are more than 400 in Army service. The

Table 1-2.

Cost Estimates for Past and Planned Army Helicopter Programs

(Millions of 2007 dollars)

Aircraft	Quantity	Total Program Cost		Total Cost	Unit Cost	Total Cost 2007–2030
		RDT&E[a]	Procurement[b]			
UH-60A Blackhawk	980	1,698	9,191	10,889	9.4	0
UH-60L Blackhawk	634	0	6,039	6,039	9.5	0
UH-60M Blackhawk	1,227	820	18,990	19,810	15.5	18,838
UH-72A Light Utility Helicopter	322	3	1,735	1,739	5.4	1,643
CH-47D Chinook	474	293	5,047	5,340	10.6	0
CH-47F Chinook	510	197	12,312	12,509	24.1	9,845
OH-58D Kiowa Warrior	346	459	3,786	4,245	10.9	0
Armed Reconnaissance Helicopter	512	749	4,565	5,313	8.9	5,139
AH-64A Apache	811	3,009	16,194	19,203	20.0	0
AH-64D Longbow Apache	666	2,011	12,005	14,016	18.0	2,985
Fire Control Radar	227	1,070	997	2,068	4.4	0
Aircraft Portion	666	941	11,008	11,949	16.5	2,985
Longbow Apache Block III	634	1,081	6,378	7,459	10.1	7,293
Joint Multi-Role[c]	*2,400*	*3,700*	*57,000*	*61,000*	*24.0*	*4,400*
Joint Heavy Lift[c]	*284*	*7,000*	*47,000*	*54,000*	*166.0*	*30,000*

Source: Congressional Budget Office based on data from the Department of the Army.

Notes: Estimates in italic type are based on CBO's analysis of analogous systems and on work published by RAND (see Jon Grossman and others, *Vertical Envelopment and the Future Transport Rotorcraft: Operational Considerations for the Objective Force* [Santa Monica, Calif.: RAND Arroyo Center, 2003]). Estimates in roman type are based on the Army's acquisition data.

RDT&E = research, development, testing, and evaluation.

a. RDT&E appropriations pay for scientific research, design, development, and testing of systems and the manufacturing technology necessary to produce them.

b. Procurement appropriations pay for aircraft manufacturing and for support and training equipment, technical data, and maintenance publications.

c. Quantities are notional: The Joint Multi-Role quantity would replace, one-for-one, all Longbow Apache Block III, Armed Reconnaissance Helicopters, and UH-60M helicopters. The Joint Heavy Lift quantity could equip 15 aviation battalions (one for each planned Future Combat Systems brigade) including training and spare aircraft. Data reflect Army purchases only. Under current plans, most of the aircraft would be purchased after 2030. Purchases for the other programs in this table would be completed by 2030.

current CH-47D entered service in 1984. Over the long term, the Army hopes to develop the JHL aircraft for carrying much heavier loads longer distances and at higher speeds than is possible with the CH-47.

CH-47 Chinook and Upgrades

The tandem-rotor, twin-turbine-engine CH-47 Chinook is used to transport cargo, troops, and weapons. With a 50,000 pound MTOGW, the CH-47D is the largest of the Army's helicopters. Its flight crew includes a pilot, copilot, flight engineer, and crew chief, and it can carry up to 33 passengers or 24 medevac litters. The CH-47D carries cargo internally or externally on cargo hooks (with a maximum external load of 26,000 pounds).

The Army is upgrading all of its Chinooks from the CH-47D to the CH-47F configuration, with a more powerful engine and an improved transmission. The F-model began to enter service in 2007. The MTOGW for the CH-47F is the same as for the CH-47D, but the engine upgrade allows the CH-47F to transport the same payload over longer distances. Additional upgrades include a new cockpit with a digital avionics suite based on the CAAS, structural improvements, improvements to increase reliability and maintainability, improvements for

survivability, and airframe modifications to reduce the time needed to disassemble and reassemble the helicopters before and after deployment on Air Force C-5 or C-17 aircraft.

Current plans call for procurement of 510 CH-47F aircraft—119 of them new and 391 remanufactured CH-47Ds. Development of the CH-47F began in 1995 and was completed in 2007. The Army projects a total cost for RDT&E at just under $200 million. The first 14 of the F-model Chinooks were purchased in 2003, and the final purchases are scheduled for 2018. The Army projects that total procurement will cost slightly more than $12.3 billion. The unit cost for the CH-47F is close to $24.1 million; the CH-47D's unit cost was about $10.6 million.

Joint Heavy Lift Rotorcraft

The Army hopes to develop a much larger rotorcraft to support aerial maneuver tactics for units in the Future Combat Systems (FCS).[3] The JHL would replace the Chinook, which CBO estimates would begin retiring around 2030. Initial JHL goals call for an aircraft that can transport up to 29 tons—the currently anticipated weight of a vehicle in the FCS—to a radius of about 500 nautical miles at speeds greater than 250 knots. (For comparison, preliminary designs for the CH-53K heavy-lift helicopter that the Marine Corps plans to put in service around 2016 show the ability to carry cargo of about 14 tons at speeds of slightly more than 100 knots to a radius of 100 nautical miles.[4])

Because such a large increase in performance over that of current systems is likely to carry high development and procurement costs, the Army's aviation plan calls for collaborating with the Air Force on the JHL program. The assumption is that the Air Force will pursue an aircraft with similar capabilities to replace its fleet of C-130 theater transport aircraft. The Army is currently evaluating the technical feasibility of the JHL concept.

A 2003 RAND study analyzed the costs and capabilities of alternative concepts for a JHL.[5] On the basis of information in that study, CBO estimates that the development costs for the JHL will be about $14 billion over a period of 17 years. Procurement costs will depend on the number of aircraft purchased and on the production rate. (The Army and Air Force have not yet established inventory objectives for the JHL.) To produce 500 aircraft at a rate of 32 per year, for example, CBO estimates the unit cost would average about $170 million and total procurement would come to $85 billion.

Those costs can be compared with costs for current Department of Defense rotorcraft, such as the Marine Corps's CH-53K heavy-lift helicopter and the V-22 Osprey tilt-rotor, although both have far less capability than is envisioned for the JHL. According to projection of the Naval Air Systems Command, it will cost $4 billion to develop and about $12 billion to put a fleet of 152 CH-53K aircraft into service, at a unit cost of about $77 million. Current estimates indicate that development will cost about $12 billion; procurement will cost about $41 billion; and the 456 V-22s for the Marine Corps, Navy, and Air Force will have a unit cost of $90 million.

Attack/Reconnaissance Helicopters

The Army currently operates over 1,200 attack/reconnaissance helicopters; about 700 AH-64 Apache attack helicopters and over 500 OH-58C Kiowa and OH-58D Kiowa Warrior observation helicopters. In the near term, the Army plans to complete conversion of its Apaches from the original A-model to the upgraded D-model, the Longbow Apache. Current plans call for that upgrade to be followed by the so-called Longbow Apache Block III (AB3) configuration. Also in the near term, the Army plans to replace the OH-58D with the new Armed Reconnaissance Helicopter (ARH). The unarmed OH-58C helicopters are being replaced by UH-72A Lakotas. In the long term, the Army hopes to replace its entire

3. The FCS is proposed as a single program that would include manned and unmanned aerial and ground vehicles, missile launchers, and communications links. See Congressional Budget Office, *The Army's Future Combat Systems Program and Alternatives* (August 2006).

4. The JHL initially was planned as a joint program of the Army and the Marine Corps. However, the two service branches' dissimilar requirements did not allow for the cost-effective design of a single aircraft. In particular, an aircraft that would satisfy the Army's performance goals would probably be far too large for operation aboard amphibious ships. Although it is currently developing the CH-53K, the Marine Corps is expected to remain interested in the JHL and could join the program in the future.

5. See Jon Grossman and others, *Vertical Envelopment and the Future Transport Rotorcraft: Operational Considerations for the Objective Force* (Santa Monica, Calif.: RAND Arroyo Center, 2003), available from www.rand.org/ard.

attack/reconnaissance fleet with an attack version of the JMR.

OH-58C Kiowa and OH-58D Kiowa Warrior

The OH-58C Kiowa is a single-rotor, single-turbine-engine light observation helicopter. With a 3,200-pound MTOGW, the OH-58C is the smallest of the Army's helicopters. It can carry three people other than the pilot (a copilot or observer and up to two other passengers) or small amounts of cargo (up to 950 pounds). More than 200 Kiowas are currently assigned to National Guard Aviation Service and Support Battalions.

The OH-58D is similar to the OH-58C, but its engine is more powerful and it has a redesigned rotor system. It also has a slightly larger MTOGW of 5,200 pounds. The additional capacity is needed to accommodate its reconnaissance sensors and up to four Hellfire air-to-surface missiles, four Stinger air-to-air missiles, two seven-round 2.75-inch rocket pods, or two 0.50-caliber machine guns mounted on pylons on either side of its fuselage. The OH-58D has a mast-mounted sight (over the main rotor) that carries a television sensor, a thermal imaging sensor, a laser rangefinder–designator, and an optical bore sight.

AH-64 Apache Attack Helicopter and Upgrades

The Army has two models of the single-rotor, twin-turbine-engine Apache attack helicopter: the AH-64A and the AH-64D Longbow. Each carries a crew consisting of a pilot and a copilot/gunner.

The older AH-64A is armed with a 30-millimeter chain gun, and it can carry up to 16 laser-guided Hellfire missiles and 76 2.75-inch rockets (in pods of 19 rockets each), in various combinations. (Four Hellfire missiles can be interchanged with one rocket pod.) The AH-64A is equipped with a target acquisition and designation sight that consists of a direct-view optical telescope, a day television sensor, a night vision sensor, and a forward-looking infrared sensor. Most of the 700 AH-64A aircraft purchased by the Army have been upgraded to the D-model configuration. Eventually, about 115 will be retired as A-models. The remainder will be upgraded to the D-model configuration.

The most significant improvements in the D-model are its ability to employ radar-guided Longbow Hellfire missiles and its ability to carry the mast-mounted Longbow fire control radar (FCR), which allows the helicopter to detect and attack targets when rain, fog, or smoke would compromise the A-model's sensors and laser designator. Other modifications include enhancements to the cockpit, navigation systems, and communications systems that allow a single FCR-equipped Longbow Apache to control Longbow Hellfire missiles carried by AH-64D aircraft that are not equipped with the radar sensor. The Army plans to procure 666 AH-64D helicopters. (The planned AH-64D inventory is 634 aircraft, but 32 additional helicopters will be procured to replace war losses.) The Army plans to install FCR kits on 227 of its Longbow Apaches.

Development of the AH-64D aircraft upgrades began in 1988 and was completed in 2005 at a total RDT&E cost of about $941 million. Procurement began in 1996 (with some advance funding from 1995) with the initial purchase of 24 aircraft. The Army plans to procure the last of its Longbow Apaches in 2010. According to the Army's projections, the total procurement cost for the portion of the program to upgrade the aircraft is just over $11 billion; the average cost is about $16.5 million. With the cost of the FCR kits included, the unit cost for the D-model upgrade is about $18 million. By comparison, the unit cost for the AH-64A was about $20 million.

Although upgrades to the Longbow configuration are not complete, the Army is pursuing plans to upgrade the D-model Apache to the AB3 configuration, which will enter service in 2011. The AB3 will incorporate some systems and associated capabilities that were planned for the Comanche helicopter, which was canceled in 2004. New communications and processing systems will allow that Apache to better interact with Army ground units, such as Stryker brigades and FCS-equipped brigades. The AB3 also will include an improved transmission and an extended-range FCR to complement the Joint Air Ground Missile, a longer range replacement for the Longbow Hellfire missile.

In all, the Army plans to purchase 634 AB3 helicopters. Development began in 2005 and is to be completed in 2016. The total RDT&E cost is projected at a little less than $1.1 billion. The initial purchase of eight AB3 aircraft is scheduled for 2010 (with some advance funding from 2009); the last one is expected to be procured in 2024. Total procurement costs are projected to be about $6.4 billion, and the unit cost is estimated at $10 million.

Armed Reconnaissance Helicopter

The ARH program was initiated in 2004 to replace the retiring OH-58D Kiowa Warrior aircraft. The ARH is a single-rotor, single-turbine-engine helicopter designed for reconnaissance and light attack. At 5,250 pounds, its MTOGW is close to that of the OH-58D. The Kiowas were built with the Bell 406 commercial fuselage; the ARH is expected to have the Bell 407 fuselage.

The ARH crew will consist of a pilot and a copilot/gunner. The helicopter can carry up to four Hellfire air-to-surface missiles, one or two 7-round 2.75-inch rocket pods or 0.50-caliber or 7.62-millimeter machine guns. In lieu of the mast-mounted sensor on the OH-58D, the ARH will have a nose turret with a color television sensor, a forward-looking infrared sensor, a laser rangefinder, and a laser designator and spot tracker. The digital cockpit of the ARH is based on the CAAS.

The Army's latest published plan for the ARH projects total RDT&E costs of $749 million through completion in 2009. Procurement is scheduled to begin with 16 aircraft in 2008 and to end in 2017. Total procurement costs for 512 aircraft were projected by the Army at just over $5.3 billion, with a unit cost of $8.9 million. By comparison, the unit cost for the OH-58D was $10.9 million.

Joint Multi-Role Rotorcraft

Starting in 2023, the Army's aviation modernization plan calls for the JMR to be developed jointly with the Marine Corps. The JMR will replace the fleet of Longbow AB3 attack helicopters as they are retired beginning around 2030. Subsequently, a utility version of the JMR will replace the Blackhawk as it begins to be retired around 2038, CBO estimates. Under the current concept, the various versions of the JMR will have all of the capabilities of the Blackhawk, Apache, and ARH, with some new capabilities based on improvements in technology that may be achieved in the coming decade.

CBO based its estimate of the cost, in the absence of definitive plans for the JMR, on the costs for the aircraft it would replace: the Apache, Longbow Apache, and AB3; and the Blackhawk. CBO used historical costs for those programs as a starting point to arrive at an estimate for RDT&E of $3.7 billion from 2019 to 2026. For 2,400 JMRs—enough for a one-for-one replacement of the Army's Apaches and Blackhawks—and a full production rate of about 200 JMRs per year, CBO estimates a unit cost for the JMR at $24 million and a total procurement cost of about $57 billion. For purposes of comparison, CBO estimates that the total cost of developing and purchasing the AH-64A, AH-64D, AB3, and ARH (beginning in 1973 and ending in 2024) will come to $46 billion and that the figure for the UH-60A, UH-60L, and UH-60M helicopters will be $37 billion (from 1968 to 2025).

There is significant uncertainty about the capabilities, technology, and costs associated with the JMR. As is the case for other programs that are either mostly conceptual or in the early stages of development, there is a greater risk of cost and schedule overruns than would attend more definite designs based on proven technologies. Although the cost estimates for the JMR consider risk to some extent, CBO expects that its estimates will change, perhaps significantly, as the JMR is more clearly defined.

CHAPTER

2

Approaches to Modernizing the Fleet

The Congressional Budget Office has analyzed the Army's plan for modernizing the helicopter fleet and compared it with four alternatives: Three would have lower average costs from 2007 to 2030; the cost of the fourth would be closer to that for the Army's plan but it would shift the emphasis in the fleet from attack/reconnaissance aircraft to heavy-lift aircraft. Alternative 1 takes a broad cost-cutting approach that would trim nearly all planned programs. Alternative 2 would eliminate the program to develop the Joint Heavy Lift rotorcraft. Alternative 3 would deemphasize procurement of attack/reconnaissance helicopters by eliminating the Joint Multi-Role helicopter from the Army's plan and curtailing expenditures on Apache upgrades. Alternative 4 would accelerate the procurement of the JHL to better align its schedule with that for the Future Combat Systems and would offset those increased costs with cuts in attack helicopter programs. (Table 2-1 compares costs and quantities under the Army's plan and the four alternatives. Figures 2-1 and 2-2 on pages 11 and 12, respectively, illustrate the comparison of inventories and spending for the Army's plan and the alternatives.)

The Army's Plan

The Army's plan for modernizing its helicopter fleet calls for average annual spending of $3.3 billion between 2007 and 2030, CBO estimates—an amount that is significantly greater than the $2.2 billion annual average the Army spent between 1986 and 2005. The Army's plan includes aircraft currently in development or entering the fleet (the UH-60M Blackhawk utility helicopter, the UH-72A Lakota light utility helicopter, the CH-47F Chinook cargo helicopter, the Armed Reconnaissance Helicopter, the AH-64D Longbow Apache attack helicopter, and the Longbow Apache Block III upgraded helicopter) and the conceptual JHL and JMR. CBO estimates that development of the JHL and JMR would begin around 2014 and 2022, respectively, given the expected lifespans of 27 to 33 years in service for the current fleet.

In all, the Army's plan calls for 3,353 aircraft to be purchased or significantly upgraded. The total cost for research, development, testing, and evaluation would be just over $12 billion, and the procurement cost through 2030 would be about $68 billion, CBO estimates. Those estimates are based on the Army's projections of production quantities and costs for the near-term programs and CBO's assumptions about likely characteristics and procurement schedules for the conceptual JHL and JMR. For the JHL, CBO assumed that the Army would share the cost of RDT&E equally with the Air Force and that each service would purchase 120 JHLs through 2030. CBO assumed the Army would fund the entire development effort for the JMR but that it would have purchased only 12 aircraft by 2030. (The Marine Corps's participation later in the program could result in lower unit costs after 2030 because of higher annual production rates.)

Under the Army's plan, spending on cargo and heavy-lift helicopters (the CH-47 Chinook and the JHL) would take the largest share of funding—about 50 percent. The remaining spending would be split about equally between utility and attack/reconnaissance helicopters. By aircraft type, total spending on the JHL would account for the largest share (37 percent), followed by the upgraded Blackhawk (24 percent), and then the upgraded Chinook (12 percent). Annual spending would peak at nearly $6 billion in 2024. By comparison, the Army has not spent more than $4 billion on helicopters in any year since 1985, when the fleet was more than twice the size it is now. The lowest annual spending in the Army's plan is $2.0 billion for 2021, which is just before the JHL enters production and the JMR enters development.

Table 2-1.

Program Costs and Quantities for Modernizing the Army's Helicopter Fleet Under the Current Modernization Plan and Four Alternatives, 2007 to 2030

(Costs in millions of 2007 dollars)

	Army Plan			Alternative 1			Alternative 2			Alternative 3			Alternative 4		
	RDT&E	Proc	Qty	RDT&E	Proc	Qty	RDT&E	Proc	Qty	RDT&E	Proc	Qty	RDT&E	Proc	Qty
UH-60M	238	18,600	1,205	238	18,600	1,205	238	18,600	1,205	238	18,600	1,205	238	18,600	1,205
UH-72A	0	1,643	306	0	1,375	259	0	1,643	306	0	1,643	306	0	1,643	306
CH-47F	1	9,844	426	1	9,844	426	1	9,844	426	1	9,844	426	1	9,844	426
CH-47 SLEP	0	0	0	0	0	0	113	1,148	60	0	0	0	0	0	0
ARH	575	4,565	512	575	3,616	375	575	4,565	512	575	3,616	375	575	4,565	512
AH-64D	0	2,985	138	0	2,985	138	0	2,985	138	0	2,985	138	0	2,985	138
Apache SLEP	0	0	0	861	3,794	372	0	0	0	0	0	0	861	3,794	372
AB3	915	6,378	634	122	0	0	915	6,378	634	122	0	0	122	0	0
JMR	*3,650*	*700*	*12*	*0*	*0*	*0*	*3,650*	*700*	*12*	*0*	*0*	*0*	*0*	*0*	*0*
JHL	*7,000*	*22,850*	*120*	*7,000*	*13,550*	*64*	*0*	*0*	*0*	*7,000*	*22,850*	*120*	*8,200*	*27,900*	*152*
Total	**12,378**	**67,565**	**3,353**	**8,796**	**53,764**	**2,839**	**5,492**	**45,863**	**3,293**	**7,935**	**59,538**	**2,570**	**9,996**	**69,331**	**3,111**
Memorandum:															
Average Annual Spending		3,331			2,607			2,140			2,811			3,305	

Source: Congressional Budget Office based in part on data from the Department of the Army and RAND (see Jon Grossman and others, *Vertical Envelopement and the Future Transport Rotorcraft: Operational Considerations for the Objective Force* [Santa Monica, Calif.: RAND Arroyo Center, 2003]).

Notes: Quantities and costs prior to 2007 are not included (UH-60M, UH-72A, CH-47F, and AH-64D).

Estimates in italic type are based on CBO's analysis of analogous systems and work by RAND. Estimates in roman type are based on the Army's acquisition data. Shaded values differ from those in the Army's current plan.

RDT&E = research, development, testing, and evaluation; Proc = procurement cost; Qty = quantity; UH-60M = improved Blackhawk utility helicopter; UH-72A = Lakota light utility helicopter; CH-47F = improved Chinook cargo helicopter; CH-47 SLEP = Chinook helicopter service life extension program; ARH = Armed Reconnaissance Helicopter; AH-64D = Longbow Apache; Apache SLEP = Longbow Apache service life extension program; AB3 = Longbow Apache Block III; JMR = Joint Multi-Role rotorcraft; JHL = Joint Heavy Lift rotorcraft.

Alternative 1 = spread reductions across programs; Alternative 2 = forgo the JHL; Alternative 3 = reduce attack/reconnaissance modernization; Alternative 4 = accelerate JHL and reduce attack/reconnaissance modernization.

With the fairly rapid production of the UH-72A Lakota, the number of utility helicopters in the Army's fleet initially would rise above the current inventory but then drop as older Blackhawks are retired.

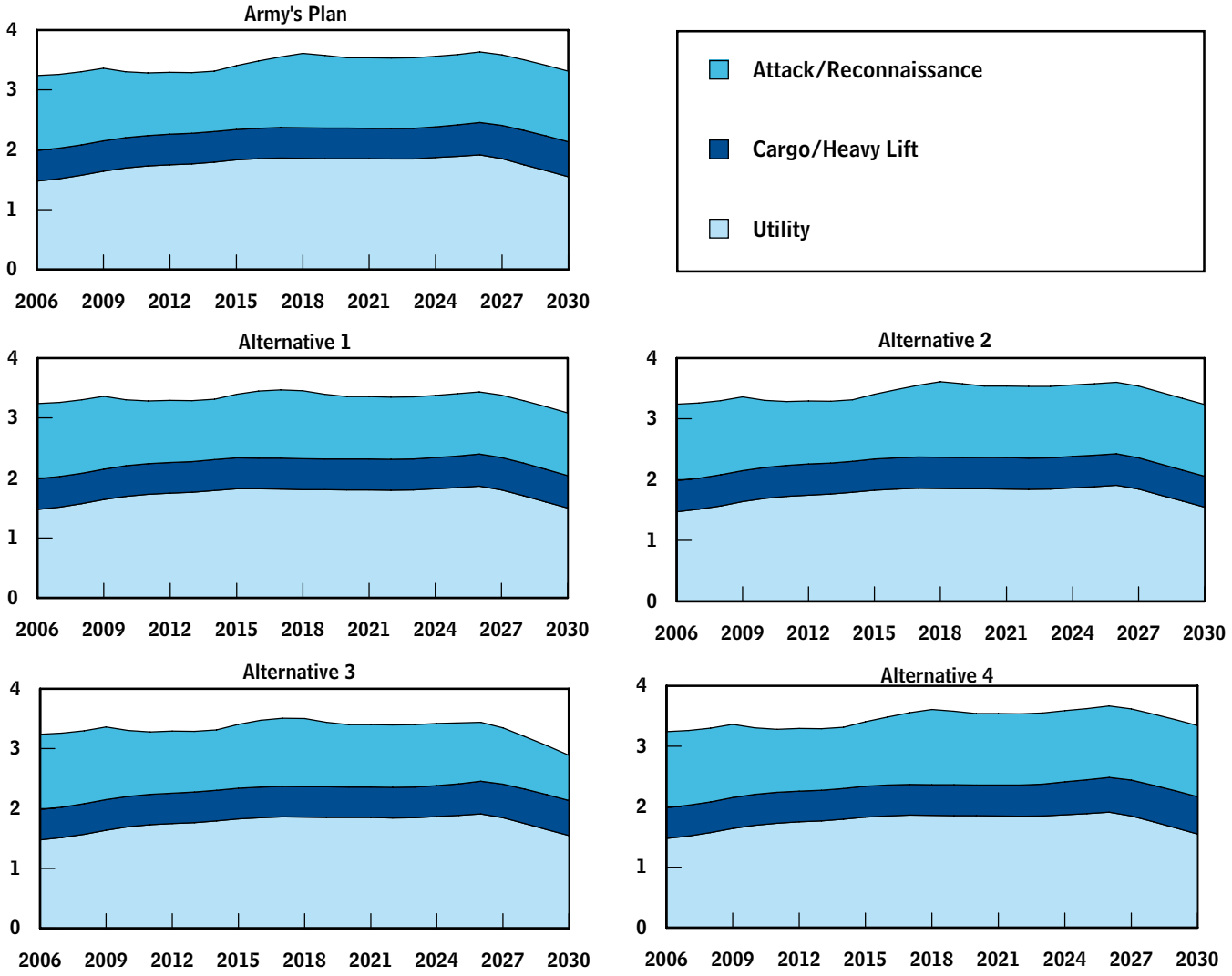
Spending on utility helicopters—for UH-72A production and Blackhawk upgrades to the M-model configuration—would remain relatively stable until 2025, but then decline rapidly. (Spending on utility helicopters would be expected to rise again around 2038 with the onset of Blackhawk retirements and the production of the utility version of the JMR.)

The Army's spending on attack/reconnaissance helicopters would remain relatively stable, although funding would be somewhat higher over the short term as the Army plans to pursue the ARH, AH-64D, and AB3 simultaneously. In the Army's plan, the number of attack/reconnaissance helicopters initially would drop, as the OH-58C/D observation helicopter fleet was retired (from

Figure 2-1.

The Army's Helicopter Inventory Under the Current Modernization Plan and Four Alternatives

(Thousands of helicopters)



Source: Congressional Budget Office based in part on data from the Department of the Army.

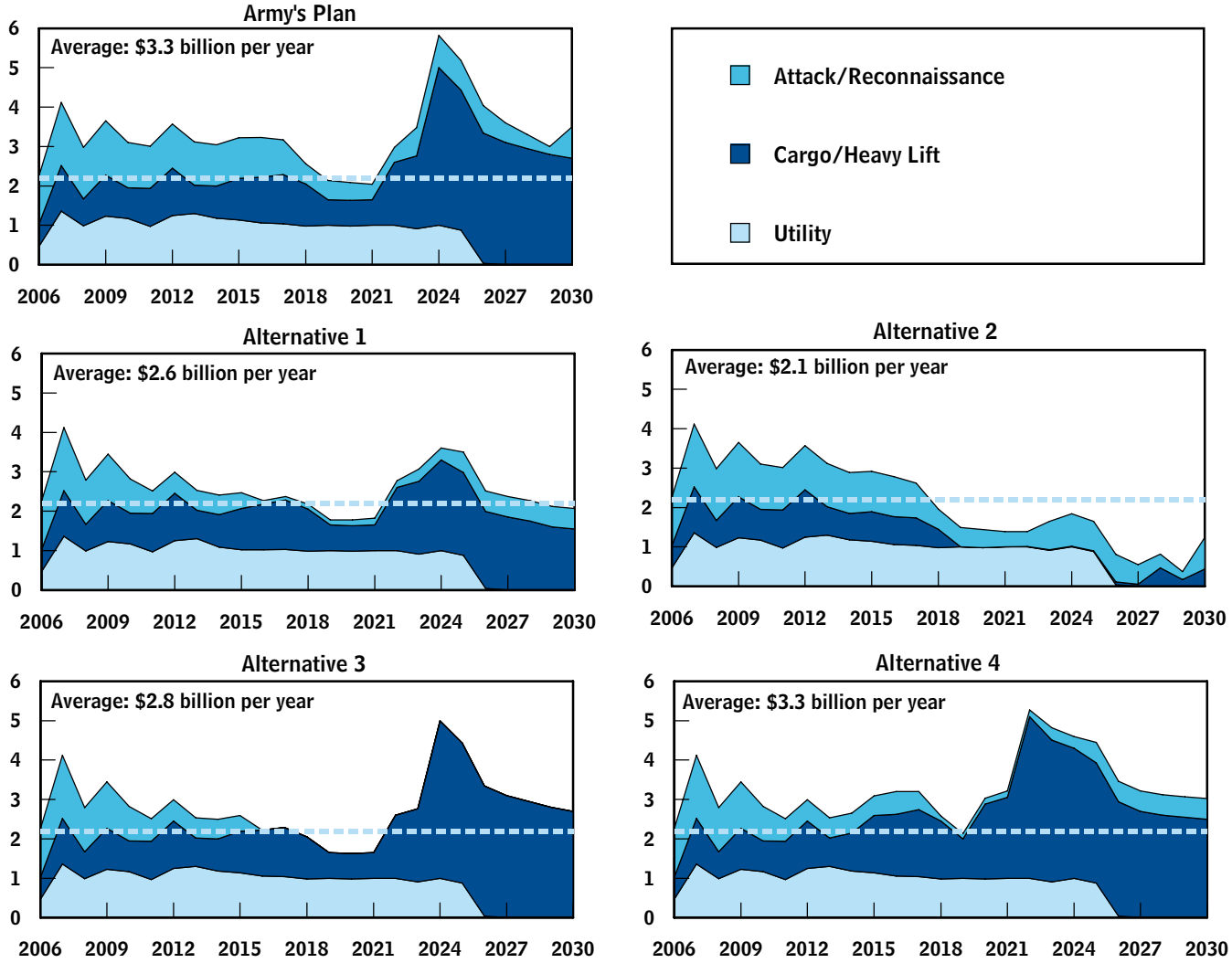
Notes: Utility helicopters are the UH-60 Blackhawks and the UH-72A Lakota. Cargo and heavy-lift helicopters are the CH-47 Chinooks and the Joint Heavy Lift rotorcraft. Attack/reconnaissance helicopters are the AH-64 Apaches, the Joint Multi-Role rotorcraft, the OH-58C Kiowa and OH-58D Kiowa Warrior, and the Armed Reconnaissance Helicopter.

Alternative 1 = spread reductions across programs; Alternative 2 = forgo the JHL; Alternative 3 = reduce attack/reconnaissance modernization; Alternative 4 = accelerate JHL and reduce attack/reconnaissance modernization.

Figure 2-2.

The Army's Spending for Helicopters Under the Current Modernization Plan and Four Alternatives

(Billions of 2007 dollars)



Source: Congressional Budget Office based in part on data from the Department of the Army and RAND (see Jon Grossman and others, *Vertical Envelopement and the Future Transport Rotorcraft: Operational Considerations for the Objective Force* [Santa Monica, Calif.: RAND Arroyo Center, 2003]).

.Notes: Utility helicopters are the UH-60 Blackhawks and the UH-72A Lakota. Cargo and heavy-lift helicopters are the CH-47 Chinooks and the Joint Heavy Lift rotorcraft. Attack/reconnaissance helicopters are the AH-64 Apaches, the Joint Multi-Role rotorcraft, the OH-58C Kiowa and OH-58D Kiowa Warrior, and the Armed Reconnaissance Helicopter.

Alternative 1 = spread reductions across programs; Alternative 2 = forgo the JHL; Alternative 3 = reduce attack/reconnaissance modernization; Alternative 4 = accelerate JHL and reduce attack/reconnaissance modernization.

The dashed line in each graph shows average spending of $2.2 billion per year from 1986 to 2005.

2009 to 2014) but then rise to a new peak in 2018, as procurement of the ARH fleet was completed. The total would fall again between 2018 and 2021, as the remaining AH-64A Apache helicopters were retired.

Spending on cargo and heavy-lift helicopters (CH-47F, JHL) in the Army's plan would proceed at a relatively modest pace in the near term, with procurement of the CH-47F, and then expand to be more than half of each year's projected total after procurement of the JHL began in 2022. Shortly thereafter, the number of cargo and heavy-lift helicopters would exceed the current fleet but level off as the CH-47F aircraft began to enter retirement in 2029.

Alternative 1: Spread Reductions Across Programs

Alternative 1 illustrates the effects of across-the-board cuts in spending on helicopters. Under Alternative 1, the AB3 program would be terminated and the JMR program would not be pursued; instead, an Apache service life extension program beginning in 2016 would keep the Longbow in service past its projected retirement beginning after 2023. (It also would be necessary to include a Blackhawk SLEP in any alternative that excludes the JMR, although such a program need not enter development before 2030.) Additionally, Alternative 1 would reduce the planned procurement quantities of the UH-72A, ARH, and JHL. Despite the reductions, Alternative 1 would preserve transportation support capabilities for Army combat units by retaining the Blackhawk and Chinook upgrade programs. In all, 2,839 aircraft would be purchased or significantly upgraded under Alternative 1. Although the capabilities of the Army's helicopter fleet would not be reduced relative to today's fleet, the capabilities also would not match the improvements anticipated by the Army's current plans.

The largest amount of spending in Alternative 1 would be for cargo and heavy-lift helicopters (49 percent). Utility helicopters would come next (32 percent), and attack/reconnaissance helicopters would follow (19 percent). By type of aircraft, the JHL program would consume 33 percent of the total cost for Alternative 1; next would be the program to upgrade the UH-60M Blackhawk model, at 30 percent; and finally, the program to upgrade the Chinook to the CH-47F, at 16 percent.

Under Alternative 1, the Army's helicopter inventory would remain below 3,500, ending with fewer than 3,100 aircraft in 2030. CBO estimates the total cost for RDT&E at nearly $9 billion and the procurement cost through 2030 at nearly $54 billion. From 2007 to 2030, Alternative 1 would cost an average of $2.6 billion annually. In eight-year blocks, that spending would work out to $3.0 billion annually for 2007 to 2014, $2.2 billion annually for 2015 to 2022, and $2.7 billion annually for 2023 to 2030 (see Figure 2-2).

As with CBO's projection of the Army's plan, spending for cargo and heavy-lift helicopters would remain fairly constant through procurement of the CH-47F and development of the JHL. It would then grow to constitute the bulk of annual spending when JHL production began in 2022. Overall spending would be lower, however, because only 64 JHLs would be purchased by 2030, about half the number estimated in the Army's plan. Thus, by 2030, only three FCS brigades would have maneuver support by the JHL instead of the roughly six brigades anticipated under the Army's plan.[1] The smaller number of JHL aircraft would still be sufficient to offset initial Chinook retirements beginning in 2029.

Under Alternative 1, the Army would procure 47 fewer UH-72A Lakotas (for a total of 275). As a consequence of that reduction, a smaller quantity of those aircraft would be available to National Guard units in the United States to perform light utility missions.

Under Alternative 1, spending on attack/reconnaissance helicopters also would be less, and their inventory would be about 12 percent lower than the number projected by the Army's current plan. Alternative 1 would reduce the procurement of the ARH from 512 to 375 aircraft. The number of Apaches would not be reduced, but some new equipment and upgrades in the Army's plans for the Apache would be omitted. In particular, the AB3 program would be terminated; its upgraded transmission, increased-range fire control radar, and ability to control FCS unmanned aerial vehicles would be forgone. Instead of the JMR, with as-yet-undefined capabilities, a service

1. Consistent with current Army aviation force structure, CBO assumes that a combat aviation brigade (CAB) assigned to an FCS division would include 54 JHL aircraft, an average of 18 JHLs per FCS brigade. With those aircraft, a CAB could move battalion's worth of vehicles (about 100) in two trips. The appendix has an overview of the Army's aviation force structure.

life extension program for the Longbow Apache would be pursued. CBO estimates RDT&E costs for the Apache SLEP at about $860 million and a unit cost of about $10 million. Under Alternative 1, with the termination of the AB3 and the elimination of the JMR, no attack or reconnaissance helicopters would be purchased from 2015 to 2022. In 2016, development of the AH-64D SLEP would begin; procurement of the SLEP aircraft would begin around 2023.

Alternative 2: Forgo the Joint Heavy Lift Rotorcraft

Cost reductions in Alternative 2 would come from eliminating funding for the JHL rotorcraft, the most expensive (as projected by CBO) rotary-wing aircraft in the Army's plan. The largest long-term effect would be the loss of the ability to transport FCS vehicles. In place of the JHL, the Army would extend the service life of the CH-47F Chinook. In all, 3,293 aircraft would be purchased or significantly upgraded under this alternative.

Spending on utility helicopters would account for the largest share under Alternative 2 (40 percent), attack/reconnaissance helicopters would come next (38 percent), and cargo helicopters would constitute the smallest share (22 percent). By type of aircraft, the largest share of spending would be for the UH-60M Blackhawk (37 percent), followed by the CH-47F Chinook (19 percent), and the AB3 (14 percent).

The costs for RDT&E under Alternative 2 would be about $5 billion, and its total procurement costs would be more than $46 billion, CBO estimates. The Army's costs would average $2.1 billion annually for this alternative (average annual spending has been $2.2 billion over the past 20 years). Higher-than-average spending would occur from 2007 to 2014 ($3.3 billion annually); but spending thereafter, at $2.0 billion annually for 2015 to 2022 and $1.1 billion annually for 2023 to 2030, would be lower than the past average.

The JHL would not be developed under Alternative 2. To replace the cargo-carrying capacity lost with the retirement of the F-model Chinooks around 2029, a Chinook SLEP would begin in 2026. By CBO's estimates, the cost of RDT&E would be $120 million, and the unit cost would be about $15 million. A Chinook SLEP would preserve the overall cargo capacity of the fleet, but it would not offer the JHL's ability to carry heavier payloads, such as FCS vehicles.

Alternative 2 would match the Army's plan for spending and inventory for utility helicopters and for attack/reconnaissance helicopters. Because the JHL program would not be pursued, however, funding for cargo and heavy-lift helicopters in Alternative 2 would be below that in the Army's plan. Until 2018, funding would be provided to procure Chinooks. The number of cargo helicopters would remain roughly constant through 2030, as the CH-47D Chinooks would be replaced by CH-47Fs, which in turn would be replaced by CH-47 SLEP aircraft.

Alternative 3: Reduce Attack/Reconnaissance Modernization

Alternative 3 would reduce annual spending to more nearly match the previous 20-year average (1986 to 2005) by reducing purchases of the ARH and phasing out the heavy attack helicopter fleet as those aircraft reach the end of their service lives. Upgrades of A-model Apaches to the Longbow configuration would be completed, but the subsequent AB3 program would be canceled and the service life of the Longbow Apache would not be extended. The JMR program would not be pursued to replace the Apache. As a result, the inventory of attack/reconnaissance helicopters would start to decline when the first Longbow Apaches were retired in 2024. Alternative 3 also would reduce by nearly 30 percent—from 512 to 375 aircraft—the planned procurement of the ARH. As will be illustrated in Chapter 3, the reductions would result in a sharp decrease in helicopter-delivered weapons capacity relative to that of today's force and the Army's plans for the future. Alternative 3 would not reduce the utility, cargo, or heavy-lift helicopter programs.

Spending for cargo and heavy-lift helicopters would account for the largest share (59 percent) under Alternative 3. Utility helicopters would come next (30 percent), and attack/reconnaissance helicopters would take up the smallest share (11 percent). By type of aircraft, the JHL would account for the largest share of spending (44 percent), followed by the UH-60M Blackhawk (28 percent) and the CH-47F Chinook (15 percent).

Alternative 3 calls for the purchase or upgrade of 2,570 helicopters, with total RDT&E costs of somewhat less

than $8 billion and total procurement costs of almost $60 billion. By CBO's projections, average annual spending between 2007 and 2030 would be about $2.8 billion, about 27 percent more than the Army's average annual spending over the past two decades. In eight-year blocks, spending would come to $3.0 billion annually for 2007 to 2014, $2.1 billion annually for 2015 to 2022, and $3.4 billion annually for 2023 to 2030. The peak in annual spending (nearly $5 billion) would occur in 2024.

Alternative 4: Accelerate Joint Heavy Lift and Reduce Attack/Reconnaissance Modernization

Alternative 4 would accelerate development and procurement of the JHL rotorcraft to better match its placement into service with the introduction of the Army's Future Combat Systems while limiting total spending through 2030 to the amounts anticipated by the Army's plan. Under the Army's plan, the JHL would enter into service nine years after the first FCS brigades did so, and by 2030 the Army would have enough aircraft to support about six FCS brigades. Under Alternative 4, the JHL rotorcraft would enter into service two years earlier, and by 2030, enough JHLs would be purchased to support about eight FCS brigades. The accelerated development and procurement schedule under this alternative would introduce some additional risk to the JHL program.

To accelerate the JHL program without exceeding the spending envisioned by the Army's plan, the AB3 program would be replaced by a SLEP for the Longbow Apache fleet, and the Army would not pursue the JMR program. Spending for the Lakota, the M-model Blackhawk, the CH-47F Chinook, the ARH, and the Longbow Apache would be as currently planned by the Army. Under Alternative 4, through 2030 the Army would purchase or upgrade 3,111 aircraft.

According to CBO's estimates, total RDT&E costs for Alternative 4 would be about $10 billion; total procurement costs would be about $69 billion. Average annual funding for Alternative 4 for 2007 to 2030 would be about $3.3 billion. In eight-year blocks, spending would come to $3.0 billion annually for 2007 to 2014, $3.2 billion annually for 2015 to 2022, and $3.7 billion annually for 2023 to 2030. Peak annual spending (above $5 billion) would occur in 2022.

Cargo and heavy-lift helicopters would constitute the largest share of spending (58 percent), utility helicopters would come next (26 percent), and attack/reconnaissance helicopters would account for the smallest portion (16 percent) under Alternative 4. By program, the JHL would account for the largest share of spending (46 percent), followed by the UH-60M Blackhawk (24 percent) and the CH-47F Chinook (12 percent). Alternative 4 would spend more on cargo and heavy-lift helicopters than called for in the Army's plan, beginning with the current CH-47F Chinook procurement and expanding to over 70 percent of the annual cost after the start of the JHL program. The inventory of cargo and heavy-lift helicopters would rise above the current number after JHL production began and then increase more slowly as the CH-47F Chinooks began to be retired.

CHAPTER

3

Capability Metrics for the Army's Helicopter Fleet

The Congressional Budget Office developed performance metrics to compare the capabilities provided by the Army's plan and the four alternatives. Three of the options (Alternatives 1, 2, and 3) can be expected to offer less capability than the Army's current plan because they rely more on upgrades to older systems than on new designs. An alternative with less capability than envisioned in the Army's plan might still offer improvements over the current helicopter force, however. Alternative 4 might be expected to reduce attack and reconnaissance capabilities in exchange for improved cargo-carrying capabilities.

CBO considered seven quantitative metrics for its comparison of fleet capabilities. Four measure different aspects of transportation capabilities; the remaining three measure attack and reconnaissance capabilities. The sections that follow include discussions of quantitative measures and qualitative differences among the alternatives.

Transportation Metrics

Two aspects of an aircraft force are important to measuring its transportation capability: the throughput capacity of cargo or troops that can be maintained and the maximum range and payload capacities of individual aircraft in the force. The former provides a general measure of the rate at which cargo can be moved. The latter defines limits on the single-mission ranges and on the maximum weight of vehicles that can be delivered by air. Both aspects can be important for comparing alternative forces. For example, a force with many smaller helicopters might have the same throughput capacity over a given range as a force with a few large helicopters, but the larger helicopters might make it possible to deliver heavier equipment or to carry cargo over longer distances.

Throughput Capacity

Transportation flow rates depend on aircraft characteristics, aircraft support capabilities, and the distance to be traveled, as described in Equation (1):

$$ThroughputCapacity = NumAC \times \frac{Payload \times OperatingHoursPerDay}{GroundTimePerCycle + 2 \times MissionRadius/Speed} \quad (1)$$

To compare the throughput capacity of the Army's plan and the alternative fleets, CBO calculated throughput capacity in the context of a mission typical of those described in the Army's planning scenarios. Specifically, the representative mission assumed a radius of about 120 nautical miles (225 kilometers), and rotorcraft were assumed operate at an altitude of 4,000 feet and at an ambient temperature of 86 ºF (30 ºC)—a so-called high, hot environment.[1] The average speed was assumed to be 120 knots for helicopters and 240 knots for the Joint Heavy Lift rotorcraft. (Box 3-1 is a glossary of abbreviations used in the equations; the parameters are quantified for each type of rotorcraft in Table 3-1 on page 19.)

CBO examined three types of throughput capacity: throughput with internal cargo, throughput with cargo slung from hooks under the aircraft (also called external carriage), and troop throughput. For the three metrics, the number of JHLs purchased is the primary factor that differentiates the Army's plan from the various alternatives. Consequently, significant differences among the alternatives do not arise until after 2021 when the first JHLs enter the force (see Figure 3-1 on page 20).

1. The most difficult atmospheric conditions for flight performance are those that occur when air has the lowest density. High altitude, high temperature, and high humidity all reduce the density of air, making it more difficult for a helicopter rotor blade or an aircraft wing to generate lift.

Box 3-1.

Parameters in Capability Metric Equations

CCAMissionDuration	Hours per close combat attack mission (CCA time plus travel time)
CCATimePerMission	Hours per mission dedicated to close combat attack
GroundTimePerCycle	Amount of mission time spent on the ground (refueling, loading, unloading)
HellfireLoadout	Number of Hellfire missiles a helicopter can carry on an attack mission
MissionRadius	One-way distance for mission; round-trip distance is twice the mission radius
NumAC	Number of deployable aircraft in the fleet
OperatingHoursPerDay	Segment of a 24 hour-period in which an aircraft can operate
Payload	Maximum weight of cargo or number of troops that can be carried
Speed	The helicopter's average velocity during the mission
SwathWidth	Distance that can be observed from the helicopter during reconnaissance

Through 2020 the Army's plan and the alternatives have nearly identical force structures. In particular, the Blackhawk utility helicopter and the Chinook cargo helicopter fleets that provide the bulk of transport capability—about 97 percent in CBO's estimation—are identical. Consequently, the small reduction in the number of Lakotas under Alternative 2 is not significant relative to the aggregate capabilities of the Blackhawks and Chinooks.

Differences in the transportation metrics arise when the JHL enters the fleet and older helicopters are retired. Because the JHL would carry a large internal payload, beginning around 2023, deliveries of the JHL will cause a sharp increase in internal transport capability. Under the Army's plan, by 2030 the throughput capacity for internal cargo carriage would increase about 25 percent relative to the pre-JHL capacity. Alternative 1, which slows purchases of the JHL, would see a peak increase of about 10 percent by 2027, but that increase would start to be lost thereafter because the JHL procurement rate would not keep up with Blackhawk retirements. Alternative 4 would result in about a 35 percent increase in internal carriage throughput capacity by 2030. Blackhawk retirements would result in decreased internal carriage capacity under Alternative 2, which does not include the JHL.

External carriage capacity is essentially the same for the Army plan and the alternatives because current JHL concepts do not envision external cargo carriage. Alternative 2 shows a small increase in external carriage throughput capacity at the very end of CBO's assessment period because the CH-47 service life extension program pursued under that alternative maintains the fleet of CH-47F helicopters, and their external carriage capability, in lieu of retiring Chinooks and purchasing JHLs without external carriage. If the JHL design were to include external carriage (as does the V-22 tiltrotor) the relative capabilities of the alternatives would be similar to the internal carriage capabilities. The increase might be less pronounced, however, because the JHL throughput capacity would be reduced by the lower speeds that must be flown when carrying a slung load.

Table 3-1.

Parameters Used to Calculate Capability Metrics for Utility and Cargo Helicopters

Parameter	Light Utility Helicopter	Blackhawk	Chinook	Joint Heavy Lift
Internal Payload (Tons)	0.6	1.68	10.1	29
External Payload (Tons)	n.a.	4/4.5 [a]	13	n.a.
Troop Capacity	8	14	33	80
Mission Radius (Kilometers)	225	225	225	225
Speed (Knots)	120	120	120	240
Average Operating Time per Day (Hours)	2.4	2.4	2.4	2.4
Average Ground Time per Cycle (Hours)	0.5	0.5	0.5	1.75

Sources: Congressional Budget Office based in part on data from the Department of the Army and John C.F. Tillson and others, *Review of the Army Process for Determining Force Structure Requirements,* IDA Paper P-3189 (Alexandria, Va.: Institute for Defense Analyses, May 1996).

Notes: n.a. = not applicable.

a. The UH-60M Blackhawk has an external cargo capacity of 9,000 pounds; the external capacity of the UH60A and the UH-60L is 8,000 pounds.

Troop throughput capacity also varies, although changes from one alternative to the next are less pronounced. (For this calculation, each helicopter is assumed to carry its maximum passenger load.) From 2020 to 2030, the new JHL would increase troop-carrying capacity by about 8 percent for the Army's plan and by about 15 percent for Alternative 4. The increases would probably not be realized in practice, however, because the JHL is more likely to be used to haul cargo.

Range and Payload Capability

The throughput capacity results described above illustrate the aggregate differences between the transportation capabilities of the Army's modernization plans and the four alternatives examined by CBO. The significantly larger payload and longer range offered by the JHL results in further capability differences between plans that include the JHL and those that do not. As described before, the JHL could move heavy cargo (notably armored vehicles), which today's helicopters cannot lift. It also would allow the Army to move lighter equipment and troops over much greater distances than is possible today.

The ability to move heavier objects opens the tactical flexibility to move heavier units by air around the battlefield. Today, that so-called "vertical envelopment" is limited to light units by the maximum payloads of the UH-60 (about 9,000 pounds external for the M-model) and the CH-47 (about 26,000 pounds external). The planned JHL would be able to move units equipped with armored FCS vehicles. The new capability, however, come at the cost of large investments in the JHL and in FCS vehicles that are being designed to be lighter than today's armored vehicles.

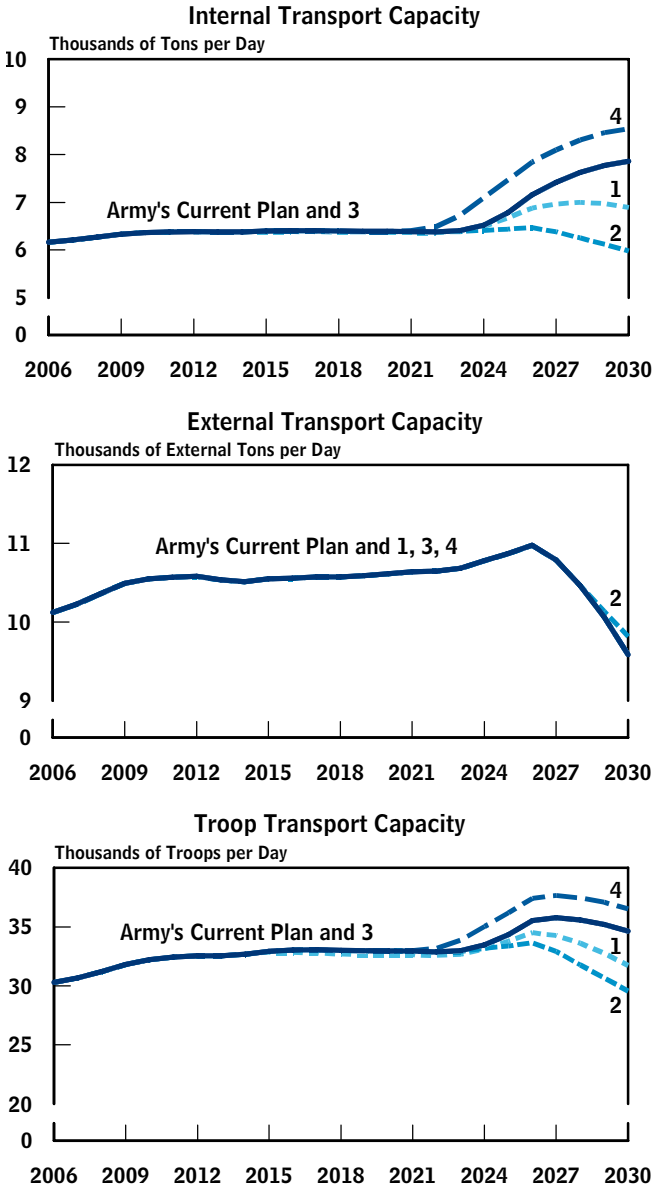
In addition to carrying heavier units, the JHL would be able to carry light units over much greater distances than currently is the case. The UH-60 and CH-47 cannot carry significant payloads much farther than the 120 nautical miles that is considered in the calculations above. In contrast, because the JHL design objective is to carry 29 tons to a radius of 500 nautical miles, it would offer greater reach for vertical maneuvers.

Attack/Reconnaissance Metrics

CBO developed three metrics for attack/reconnaissance capability: reconnaissance area coverage, attack by Hellfire missiles, and close combat attack (CCA). The aircraft considered are the Kiowa and Kiowa Warrior observation helicopters, the Armed Reconnaissance Helicopter, the Apache AH-64 attack helicopter, and the Joint Multi-Role rotorcraft. The number of ARHs purchased is the primary factor for differentiating the Army's plan from the various alternatives for the metrics. (The applicable specifications and various parameters for the helicopters are listed in Table 3-2 on page 21. Figure 3-2 on page 22 illustrates the results of computing the attack/reconnaissance capability metrics for the Army's plan and the four alternatives.)

Figure 3-1.

Transportation Capabilities



Source: Congressional Budget Office based in part on data from the Department of the Army.

Notes: 1 = Alternative 1: Spread reductions across programs.

2 = Alternative 2: Forgo the Joint Heavy Lift rotorcraft.

3 = Alternative 3: Reduce attack/reconnaissance modernization.

4 = Alternative 4: Accelerate Joint Heavy Lift and reduce attack/reconnaissance modernization.

Reconnaissance Area Coverage

Reconnaissance area coverage, the area that can be observed in one day by the Army's attack/reconnaissance helicopter fleet, is calculated by Equation (2):

$$AreaCovered = NumAC \times \frac{2 \times MissionRadius \times SwathWidth \times OperatingHoursPerDay}{GroundTimePerCycle + 2 \times MissionRadius / Speed} \quad (2)$$

Until about 2014, the Army's plan and the alternatives would provide comparable reconnaissance capability, with the Apache fleet providing over 75 percent of the reconnaissance area coverage capability in 2014; the remainder would come from the OH-58 and ARH fleets. After 2014, reconnaissance area coverage would increase under the Army's current plan and under Alternatives 2 and 4 because the capability offered by the new ARH would more than offset OH-58 retirements; the capability would peak in 2019 as deliveries of the ARH are completed but decline again with the retirement of the remaining Apache AH-64A models. Reconnaissance area coverage under Alternatives 1 and 3 would increase less than the Army's plan after 2014 because 137 fewer ARHs would be purchased. It would then decline when the A-model Apaches retired from 2018 to 2020.

Beginning in 2025, CBO's Alternative 3 calls for the retirement of the Longbow Apache helicopters. Because no replacement is scheduled, there would be a further decline in reconnaissance area coverage. Alternative 1, by contrast, would extend the Longbow's service life, and prevent that decline. The loss of reconnaissance capabilities under Alternative 3 could be offset somewhat by other systems expected in the field by the 2020s. All of the military services plan to add substantial fleets of unmanned aircraft in the coming decade. In particular, FCS plans include a family of unmanned aircraft that would give ground units their own reconnaissance capability. Additionally, the Department of Defense plans call for further improvements in communications and interoperability between the services that it hopes will make Air Force, Navy, and Marine Corps reconnaissance data more readily available to Army units.

Table 3-2.

Parameters Used to Calculate Capability Metrics for Attack/Reconnaissance Helicopters

	Kiowa		Armed Reconnaissance		Joint
	OH-58C	OH-58D	Helicopter	Apache	Multi-Role
Reconnaissance Swath Width (Kilometers)	10	10	10	10	10
Hellfire Missile Capacity	0	4	4	16	16
CCA Time per Mission (Hours)	n.a.	2.5	2.75	2.25	2.25
CCA Mission Duration (Hours)	n.a.	2.75	3.0	2.5	2.5
Mission Radius (Kilometers)	150	120	150	150	150
Speed (Knots)	90	100	100	100	100
Average Operating Time per Day (Hours)	2.4	2.4	2.4	2.4	2.4
Average Ground Time per Cycle (Hours)	0.5	0.5	0.5	0.5	0.5

Sources: Congressional Budget Office based in part on data from the Department of the Army and John C.F. Tillson and others, *Review of the Army Process for Determining Force Structure Requirements,* IDA Paper P-3189 (Alexandria, Va.: Institute for Defense Analyses, May 1996).

Notes: OH-58C = Kiowa observation helicopter; OH-58D = Kiowa Warrior helicopter; CCA = close combat attack; n.a. = not applicable.

The preceding calculations are based on the assumption that all the rotorcraft in the alternatives would have a similar sensor swath width. Although the Longbow Apache Block III is expected to have an improved radar system to support a new missile, it is not clear that the improvements also would result in greater reconnaissance capability. Radar detections often must be followed up with visual inspection, so the infrared and optical sensors would be the limiting capability. If the AB3 radar improves reconnaissance coverage rates, performance would improve for the Army's plan and for Alternative 2. Radar improvements also could be incorporated in the Apache SLEP postulated in Alternative 4, although they would probably increase costs.

Hellfire Missile Delivery Capacity

The number of Hellfire missiles that can be delivered by the attack/reconnaissance helicopter fleet can be computed by Equation (3):

$$HellfireDeliveryCapacity = NumAC \times \frac{HellfireLoadout \times OperatingHoursPerDay}{GroundTimePerCycle + MissionDuration} \quad (3)$$

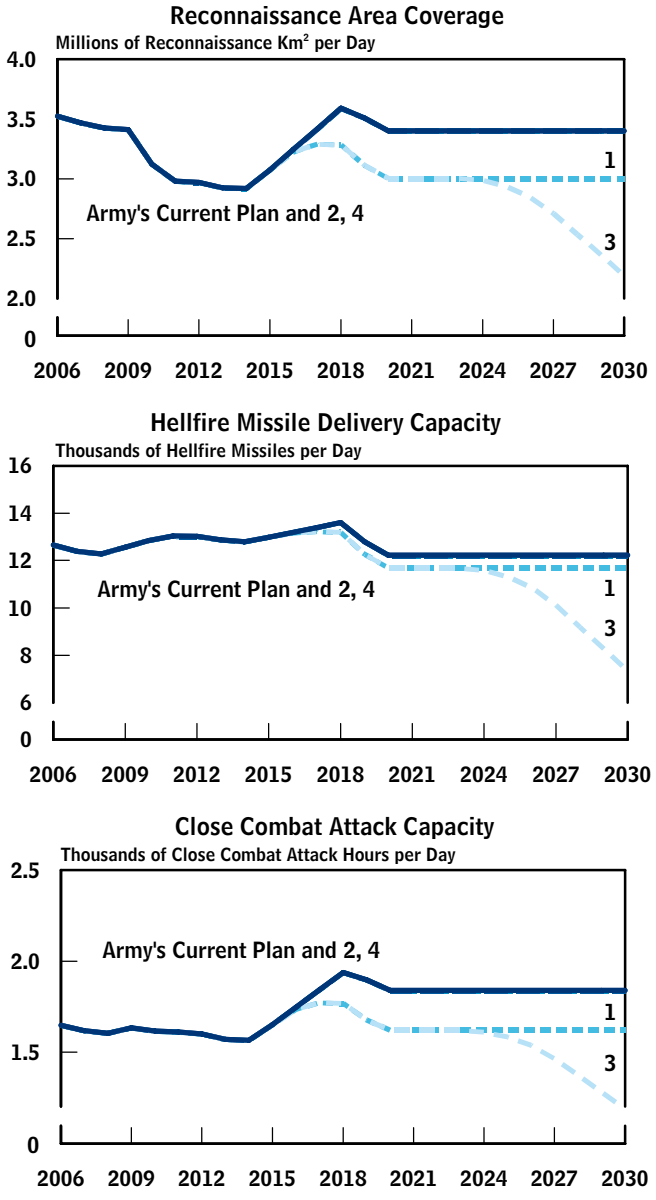
The equation describes the theoretical capacity of the fleet to deliver Hellfire missiles, not the rate at which missiles would be expended in an actual conflict; in most circumstances, the scarcity of targets results in a much smaller number of missiles fired. The primary discriminator among the helicopter types is loadout (the number of missiles the helicopter can carry).

Under the Army's plan and all alternatives, until 2014, more than 85 percent of the capacity to deliver Hellfire missiles will be resident in the AH-64 fleet. The smaller attack/reconnaissance helicopters—the OH-58D Kiowa Warrior fleet in the near term and the ARH fleet after 2015—will provide the remaining capacity. The missile delivery capacity will increase when the Kiowa Warriors are retired and replaced by a larger number of ARHs but then decline as the last A-model Apache helicopters are retired. Because fewer ARHs would be purchased under Alternatives 1 and 3, those alternatives would provide a lower delivery capacity than the Army's plan or Alternatives 2 and 4.

The delivery capacity declines more in Alternative 3 after the retirement of the Longbow Apaches; they would not be replaced under that alternative. That loss in capability could be offset by improved fire support weapons expected as part of the FCS and by greater use of precision weapons delivered by fixed-wing tactical aircraft in close coordination with ground controllers. Additionally, the use of armed unmanned aircraft—Army or Air Force unmanned aerial vehicles firing Hellfire missiles, for example—is expected to increase significantly in the coming years.

Figure 3-2.

Attack/Reconnaissance Capabilities



Source: Congressional Budget Office based in part on data from the Department of the Army.

Notes: 1 = Alternative 1: Spread reductions across programs.

2 = Alternative 2: Forgo the Joint Heavy Lift rotorcraft.

3 = Alternative 3: Reduce attack/reconnaissance modernization.

4 = Alternative 4: Accelerate Joint Heavy Lift and reduce attack/reconnaissance modernization.

Close Combat Attack

CCA time measures the ability to maintain aircraft on station to provide fire support rapidly to units on the ground. The number of hours per day the Army's attack helicopter fleet could maintain on station is computed by Equation (4):

$$CCATime = NumAC \times \frac{CCATimePerMission \times OperatingHoursPerDay}{GroundTimePerCycle + CCAMissionDuration} \quad (4)$$

As with the Hellfire deliveries, Equation (4) computes a theoretical maximum for comparing relative availabilities among the alternatives. Actual availabilities would be lower. For this metric, there are relatively small differences between helicopter types. For the Army's plan and all four alternatives, until 2014, the AH-64 fleet will provide about two-thirds of the CCA. The remainder will be provided by the OH-58 fleet until 2014 and by the ARH fleet after that. CCA hours will rise when the OH-58s are retired and replaced by a larger number of ARHs, but then decline as the remaining A-model Apache helicopters are retired. For Alternatives 1 and 3, CCA hours are fewer than they are for Alternatives 2 and 4 or for the Army's plan because Alternatives 1 and 3 call for a smaller ARH fleet. Under Alternative 3 CCA hours decline again after 2024 as the Apache Longbows are retired but not replaced.

As with Hellfire missile delivery capacity, the loss of CCA capability under Alternative 3 could be offset by improved ground-based fire support systems or by more reliance on manned and unmanned fixed-wing aircraft. The FCS is expected to include several precision fire support systems that could fill this role, for example. Additionally, Air Force bombers have demonstrated the ability to support ground forces with precision-guided 500-pound bombs. Bombers can provide substantial CCA time because their large payloads and long endurance allow them to remain on station for extended periods.

Appendix: The Army's Helicopter Force Structure

The more than 3,500 aircraft in the Army's current helicopter force are assigned to various deployable and nondeployable units (see Table A-1).[1] Deployable units—also called table of organization and equipment (TOE) units—equipped with Army helicopters include combat aviation brigades (CABs), theater aviation commands, a special operations aviation regiment, and air cavalry squadrons. Nondeployable units—called table of distribution and allowances (TDA) units—equipped with Army helicopters consist of training and test units and a unit that is dedicated for use in the military district of Washington, D.C.

Combat Aviation Brigades

Most Army helicopters equip the 19 CABs that are assigned to 10 active Army divisions and 8 National Guard divisions (see Table A-2 on page 25). Each CAB is assembled from five types of aviation battalions or squadrons: general support aviation battalions (equipped with the UH-60 Blackhawk utility helicopter and the CH-47 Chinook cargo helicopter), assault battalions (equipped with the UH-60 Blackhawk), light attack/reconnaissance squadrons (equipped with the OH-58D Kiowa Warrior), heavy attack/reconnaissance battalions (equipped with the AH-64 Apache attack helicopter), and aviation service and support battalions (equipped with the OH-58C Kiowa).

The aviation battalions or squadrons for all CABs consist of a general support aviation battalion, an assault battalion, and two additional aviation battalions or squadrons of the remaining three types.

General Support Aviation Battalions

General support aviation battalions have three helicopter-equipped companies. The first has a dozen Chinook cargo helicopters that transport troops, supplies, and equipment. The second has the same number of Blackhawk utility helicopters that are configured to evacuate casualties. The third has eight Blackhawks configured to provide command, control, and communications (C3) flights and limited air transportation. General support aviation battalions can perform air assault, air movement, combat search and rescue, medical evacuation, and C3 missions as well as aerial recovery of disabled aircraft.[2]

Assault Battalions

Assault battalions consist of three companies, each equipped with 10 Blackhawk helicopters for performing air assault and air movement operations. Those battalions also evacuate casualties, conduct combat search and rescue, and provide rear area reconnaissance or surveillance.

Attack/Reconnaissance Squadrons

Attack/reconnaissance squadrons have three companies, each equipped with 10 OH-58D Kiowa Warriors that can attack armored, mechanized, and other massed forces and perform aerial reconnaissance and screening. Battalions of this type perform reconnaissance within an area of operations; conduct surveillance of enemy forces; and provide reconnaissance, surveillance, and security for lines of communications. They also conduct aerial surveys for nuclear, biological, and chemical weapons; they conduct target acquisition missions in support of artillery, attack helicopters, naval guns, or tactical air strikes; and they provide aerial security in support of air assault.

1. For more information regarding the Army's force structure see Congressional Budget Office, *Options for Restructuring the Army* (May 2005).

2. Examples in this section are extracted from the Army's narratives describing TOE units and the equipment assigned to them.

Table A-1.

Army Helicopter Force Structure

	Utility	Heavy Lift	Attack/ Reconnaissance	Total
Combat Aviation Brigade	950	228	920	2,098
Other Table of Organization and Equipment	500	148	107	755
Table of Distribution and Allowances	355	59	262	676
Total	**1,805**	**435**	**1,289**	**3,529**

Source: Congressional Budget Office based on data from the Department of the Army.

Attack/Reconnaissance Battalions

Attack/reconnaissance battalions have three companies, each with eight AH-64 helicopters that are used to destroy enemy armored, mechanized, and other massed forces. (Several National Guard battalions of this type are not fully equipped; their companies have five or six, rather than eight, helicopters.) Battalions of this type perform air attack missions, provide aerial escorts, and support air assault missions and missions to suppress enemy air defenses. They provide reconnaissance, security, and joint air attacks with tactical air and field artillery forces.

Aviation Service and Support Battalions

Aviation service and support battalions have three companies, each equipped with eight OH-58C Kiowa observation helicopters. (The Kiowas are slated for replacement with UH-72A Lakota light utility helicopters.) The battalions are assigned only to CABs of National Guard infantry divisions, for which they perform C3, air movement, reconnaissance and observation (including support for counternarcotic operations, drug interdiction, and local law enforcement), medical evacuation, and combat search and rescue. They also can support civil aviation in the event of a chemical, biological, radiologic, or nuclear incident or an explosion or when states require aviation functions of the National Guard.

Theater Aviation Command

Theater aviation units are used to augment division CABs as necessary. A theater aviation command typically consists of a headquarters company, a theater airfield operations group, and two theater aviation brigades (one assault and one general support).

Theater Aviation Brigade (Assault)

The theater aviation brigade (assault) consists of a headquarters company, an aviation support battalion, a general support aviation battalion, and three assault battalions. As described above, the general support aviation battalion is equipped with Blackhawks and Chinooks; the assault battalion is equipped with Blackhawks.

Theater Aviation Brigade (General Support)

The theater aviation brigade (general support) consists of a headquarters company, an aviation support battalion, a fixed-wing theater aviation battalion, and three general support aviation battalions equipped with Blackhawks and Chinooks, as described.

Special Operations Aviation Regiment

The special operations aviation regiment supports the special operations forces. It consists of a headquarters company and four aviation battalions that are equipped with 72 Blackhawks and 61 Chinooks. It also has 46 MH-6 Little Bird light utility/attack helicopters that are specific to the special operations aviation regiment. The UH-60 Blackhawk and CH-47 Chinook helicopters, designated MH-60 and MH-47, respectively, are different from the regular Blackhawk and Chinook models. They have larger fuel tanks and mission-specific enhanced avionics for communication, navigation, and self-protection; they carry six-barrel mini-guns and are configured for Stinger air-to-air missiles; they are equipped with rescue hoists.

Table A-2.

Army Divisions with Associated Combat Aviation Brigades

Division	Combat Aviation Brigade	Active or National Guard	General Support Aviation Battalion	Assault Battalion (UH-60)	Attack/ Recon Battalion (AH-64)	Attack/ Recon Squadron (OH-58D)	Aviation Service and Support Battalion (OH-58C)
1st Infantry	1I	Active	1	1	1	1	0
1st Armored	12th	Active	1	1	2	0	0
1st Cavalry	1C	Active	1	1	2	0	0
2nd Infantry	2I	Active	1	1	2	0	0
3rd Infantry	3I	Active	1	1	2	0	0
4th Infantry	4I	Active	1	1	2	0	0
10th Mountain	10	Active	1	1	0	2	0
25th Infantry	25th	Active	1	1	0	2	0
82nd Airborne	82nd	Active	1	1	1	1	0
101st Airborne	101	Active	1	1	1	1	0
101st Airborne	159	Active	1	1	1	1	0
28th Infantry	28I	Guard	1	1	2	0	0
29th Infantry	29I	Guard	1	1	2	0	0
34th Infantry	34I	Guard	1	1	1 [a]	0	1
35th Infantry	20th	Guard	1	1	1 [a]	0	1
36th Infantry	36I	Guard	1	1	1 [a]	0	1
38th Infantry	38I	Guard	1	1	1	0	1
40th Infantry	40I	Guard	1	1	1 [a]	0	1
42nd Infantry	42I	Guard	1	1	1 [a]	0	1

Source: Congressional Budget Office based on data from the Department of the Army.

Notes: UH-60 = Blackhawk utility helicopter; Recon = reconnaissance; AH-64 = Apache attack helicopter; OH-58D = Kiowa Warrior helicopter; OH-58C = Kiowa observation helicopter.

a. Battalions equipped with 16 of 24 required aircraft.

Air Cavalry Squadrons

Three independent air cavalry squadrons support the Army's armored cavalry regiments. Two are equipped with 30 OH-58D Kiowa Warriors and 10 UH-60 Blackhawks. The third squadron has 24 AH-64s and 10 UH-60s. The squadrons perform the same kinds of missions as those described above for assault battalions and for attack/reconnaissance battalions and squadrons.

Table of Distribution and Allowances Aircraft

There are several nondeployable units, which are used almost exclusively for testing and training, equipped with 106 AH-64s, 146 OH-58s, 59 CH-47s, 254 UH-60s, and 185 flight-training helicopters (TH-67s). Included is a TDA battalion for the military district of Washington, D.C., which has 16 Blackhawks that support the Department of Defense, the headquarters of the Department of the Army, and other federal agencies in and around the nation's capital.