APACHE

Introduction
The primary role of the Apache is to attack and destroy hostile armoured vehicles with maximum surprise and with maximum safety for its crew. This must be achieved under the most adverse weather conditions, day or night, even after suffering significant battle damage. Despite a demanding specification from the U.S. Army, the Apache surpassed all expectations.

Development
Its design began in response to the U.S. Army requirement for a new Advanced Attack Helicopter. A contract was awarded to Hughes in June 1973 to build two prototypes, the first of which flew on 30th September 1975. Following a competitive fly-off against the Bell Model 409, the Hughes prototype AH-64 was selected for further development.

Subsequent modifications in Phase 2 included extension of the main rotor mast upwards by 9.5in to prevent the blades making contact with the fuselage which was happening under certain manoeuvres! The tailplane was moved from the top of the fin to the base of the tailcone to improve handling qualities. Three more prototypes were built with modifications including a further extension to the main rotor mast, swept back tips to the main rotor blades, a 3in increase in the tail rotor diameter, and the introduction of the "Black Hole" exhaust coolers. Development continued with a full evaluation of all weapon systems and avionics. The introduction of computer-controlled variable incidence tailplane solved many unsatisfactory characteristics across the complete flight envelope.

Delivery of the first production Apaches to the Army took place in 1984 with the Army's projected total requirement in the region of 515 Apaches. Cost in 1984: $7.8 million each. The Apache production plant is at Mesa, Arizona where they aim to manufacture 12 machines per month.

Performance
Agility or aircraft response to control inputs is fast and precise. The Apache will produce 100 deg/sec rate of roll at between 120 kts and 140 kts and a high instantaneous turn rate, allowing it to be manoeuvred briskly around obstructions at low altitude. Sloppiness and slow response typical of most helicopter flight controls are absent, in fact, pilots tend to over control until they adjust to its crisp response. Despite this, pilots appear to adapt to the Apache's handling characteristics surprisingly quickly.

Tilting sharply forwards out of the hover and pulling 100% torque, the Apache reaches 100 kts in 250 yards, equivalent to 0 to 60 mph within 4.6 seconds. An impressive acceleration for a machine weighing 6.5 tons!

True airspeed in level flight with normal maximum continuous power (approx. 65% torque) is 146 kts. Aerodynamic drag rises sharply above this speed, with 100% torque giving approximately 160 kts in level flight. The maximum speed in a dive (Vne) is 197 kts.

Capable of hovering on both engines at 65% torque and 106% from a single engine, the Apache crew can be confident to survive a single engine failure, even in the hover.

Avionics
The Apache contains thirteen on-board computers with built-in self-test and automatic fault detection. Many of the "black boxes" are duplicated in different parts of the aircraft to reduce vulnerability to enemy fire. Much of the avionic equipment is located in bays either side of the forward fuselage, visible as large external fairings. This includes secure VHF, UHF, AM & FM radio, Doppler navigation, strapdown attitude and heading reference system, automatic stabilisaiton & command augmentation system (DASE), passive radar warning, IR & radar jammers, chaff/flare dispensers and the laser detector.

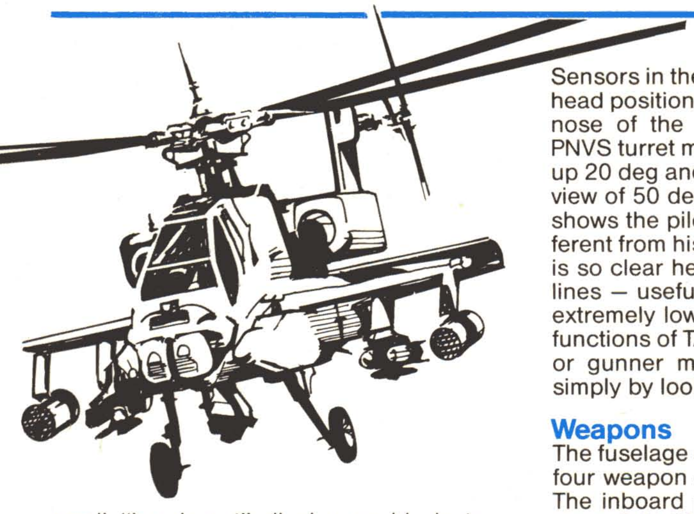
(a) Flight Control System
The flight control system is designed to simplify the task of flying under stressful conditions. Pilots find the Apache easy to fly, even without autostabilisation. At the heart of the system is the Digital Automatic Stabilisation Equipment (DASE) which takes information from sensors around the helicopter and shapes the pilot's control inputs to optimise the aircraft's response for tactical flying. Many of the unwanted control cross-coupling effects typical of many helicopters have been eliminated by automatic compensation and turns are automatically coordinated above 60 kts.

More specifically, DASE takes rate, velocity & heading information from the Heading & Attitude Reference System, collects normal air data from the PACER system on the rotor mast, matches this data with the pilot's control inputs & drives the rotor servos accordingly. In this manner, DASE may be described as a "command-augmentation" system shaping the helicopter's response to the pilot's intentions, giving us an "intelligent" system whereby the pilot simply "requests" his manoeuvre and the system handles both transient & steady states automatically to achieve the desired result.

A moving tailplane or stabilator is continuously controlled by the DASE, maintaining the Apache fuselage in a level flight attitude from 30 kts to its maximum speed of approximately 160 kts. The stabilator eliminates the pronounced nose-down or nose-up attitudes often seen on many helicopters thus reducing crew workload and allowing them to concentrate on accomplishing the anti-tank & ground-attack roles of the Apache.

(b) Target Aquisition and Designation Sight (TADS)
This is a cluster of sensors mounted in a stabilised housing in the helicopter's nose to give both pilot and gunner a choice of how to view the outside world. The weapon-aiming displays are viewed through an eye-piece by the gunner, plus a

ITS HISTORY, DESIGN, AND DEVELOPMENT



small "heads-out" display on his instrument panel. The TADS may be swivelled 120 deg right or left, 30 deg up, or 60 deg down. FLIR (Forward Looking Infra-Red) is used for night time vision, Daytime TV (DTV) in the near infra-red band can penetrate smoke and haze, and Direct View Optics (DVO) give a coloured display with a maximum magnification of ×126 – capable of visually zooming-in on a target up to 3 miles away! All three systems have a choice of field of view.

The TADS will automatically track a target after locking on to it. The gunner will use the DTV laser to determine target range, in practice offsetting the laser to avoid detection by the target. The target will finally be illuminated by the laser just prior to impact of the Hellfire missile. The target may also be illuminated by a remote source e.g. ground infantry. The Apache is then able to "fire-and-forget" each missle and return to cover. An alternative approach also available to the gunner is for the Apache to pop up from behind cover, take a video recording of the battlefield, and pop down again. After studying the video, the gunner may select a number of targets and enter their coordinates into the target computer. Hellfire missiles may then be launched from behind cover, popping up briefly to laser spot the target in the last few seconds of flight.

The gunner may select from a range of symbology on the displays according to the type of weapon to be used. For the Hellfire missiles, the TADS is rotated to place a dotted outline around the target. This outline becomes solid when the missile launch parameters are satisfied. For gun firing, a simple static sight is used but corrections for range and crosswind are automatically superimposed by the weapon control system.

(c) Pilot's Night Vision System (PNVS)

A remarkable system available to both pilot and gunner is the Integrated Helmet & Display Sighting System (IHADSS). The pilot looks through a helmet-mounted television "monocle" to view the outside world projected life-size into his right eye. Sensors in the pilot's helmet determine his head position and drive the cameras in the nose of the helicopter accordingly. The PNVS turret may swivel 90 deg left or right, up 20 deg and down 45 deg, with a field of view of 50 deg. Symbology on the display shows the pilot his direction of flight if different from his line of sight, and the picture is so clear he can even distinguish power lines – useful when flying aggressively at extremely low altitudes. By combining the functions of TADS and IHADSS, either pilot or gunner may aim his weapon system simply by looking at the target!

Weapons

The fuselage carries a stub wing fitted with four weapon attachment points or pylons. The inboard pylons are normally used to carry 8 Hellfire missiles, 4 per side. The outer pylons are fitted typically with 19-inch tube 2.75in. rocket pods, steerable by either crew member using their helmet-mounted sights.

(a) M230 Chain Gun

Mounted underneath the nose of the Apache is the 30mm M230 Chain Gun, controlled through a rotating turret. The complete assembly weighs 118lb. and has a rate of fire of 750 rounds/min. Capacity is 1200 rounds. The gun mounting is collapsible and forms part of the energy absorption process in the event of a crash. The gun may be aimed using either TADS or the helmet-mounted display.

(b) Hellfire Missiles

This 100lb supersonic missile has a range of over 3 miles and a variety of guidance systems. In the case of the Apache, the target is illuminated with a laser beam which is detected by the missile's homing head. The Apache is capable of carrying up to 16 Hellfires.

Typical mission configurations:

Anti-tank mission: 16 Hellfire missiles and 1200 rounds of ammo.
Ground support: 8 Hellfire missiles, 38 rockets, 1200 rounds of ammo.
Airmobile escort: 38 rockets and 1200 rounds of ammo.

Structure

The fuselage is a conventional semi-monocoque aluminium structure with fracture-tough materials, redundant load paths and oversized structural members to minimise effects of battle damage. The main rotor consists of four blades, each having five stainless steel spars lined with structural glass-fibre tubes, a laminated stainless steel skin and a composite trailing edge to give a multiple redundant structure. Tests have shown that the main rotors can survive a direct hit by a 23mm shell! Each blade is attached to the hub by elastomeric lead/lag dampers and offset flapping hinges.
The tail rotor arrangement is an unusual design with the blades mounted 55 deg apart. The uneven spacing gives optimum low noise levels.

Both crew are protected by armour plated seats. The energy-absorbing landing gear was designed for normal landings of up to 12 ft/sec. and heavy landings of up to 48 ft/sec.

Engines

Two General Electric T700-GE-701 turboshafts producing 1,695 s.h.p. each, mounted on either side of the main transmission. The wide separation offers additional survivability, minimising the risk of both engines being lost due to a single hit, and full twin-engined redundancy. The main transmission will operate for up to one hour after the loss of all lubricating oil!
Fitted to the rear of each engine is a heat-exchanger known as a "Black-Hole". This is to reduce the temperature of the exhaust gases and minimise detection by infra-red homing missles.

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HELICOPTER AERODYNAMICS

The following description is intended only as an introduction to the subject. We recommend the following book for further reading:
"The Helicopter – history, piloting and how it flies" by John Fay, Published by David & Charles.

Lift, Weight, Thrust & Drag

Steady forward flight of any aircraft depends upon the balance of four forces – Lift, Weight, Thrust and Drag. In the case of the helicopter, Lift is generated by the rotor blades forcing air downwards as they rotate. In fact, each rotor blade is very similar to the wing of an aircraft with lift being generated by its aerofoil shape rotating at high speed. Variation of the lift is achieved by altering the angle at which the blade passes through the air, commonly known as the "angle of attack". If the pilot collectively tilts all of the rotor blades by the same amount, the resulting force will become greater than the weight of the helicopter and the aircraft will rise into the air. Finally, adjustment of the lift so that it equals the helicopter's weight will result in a steady hover. We have now balanced our first two forces – Lift and Weight. (Fig 1)
To begin forward motion, we must generate a forward force or Thrust. Unlike fixed-wing aircraft, helicopters do not use their engines as a direct source of forward thrust. The required force is generated by tilting the rotor blades thereby using a component of the vertical lift to pull the helicopter forwards. It is simple to imagine that the rotor blades would in fact act as a giant propeller if the helicopter were to tilt far enough forwards!
As the helicopter accelerates, an aerodynamic drag or wind resistance builds up to oppose the motion and eventually the helicopter's speed will stabilise so that the forward Thrust equals the aerodynamic Drag. We have now balanced our remaining two forces – Thrust and Drag. (Fig 1)
The helicopter however has an additional problem. The force required to turn the rotor blades generates an equal and opposite force (Newton's Third Law) tending to make the fuselage turn in the opposite direction to the rotor blades. This is overcome by introducing a tail rotor which pushes sideways and balances the unwanted reaction force.

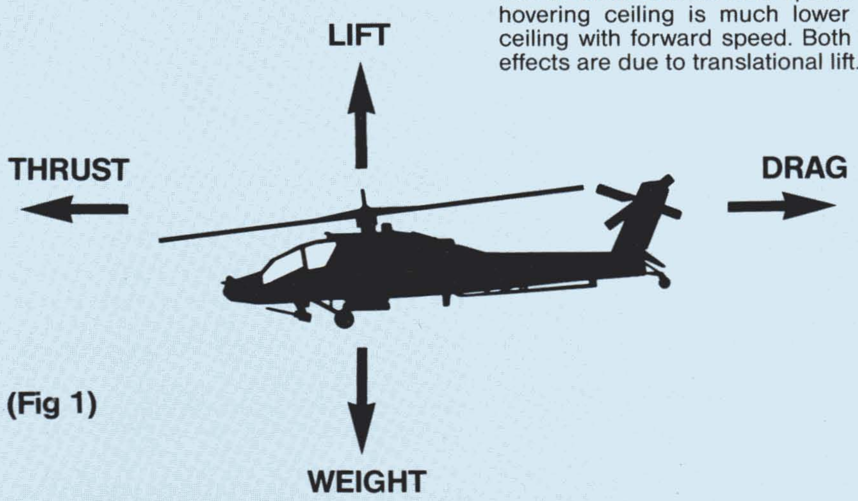
Pilot's Controls

The primary controls of a helicopter are similar to those found in a fixed-wing aircraft i.e. joystick and rudder pedals. The joystick or cyclic control column is used to tilt the fuselage of the helicopter up and down, and to roll the helicopter from side to side. Rudder pedals are used to turn or skew the helicopter by varying the pitch of the tail rotor blades. A third control, known as the Collective lever, is used to vary the pitch of the rotor blades "collectively" thereby giving a vertical lift control. Since forward thrust is derived from the main rotor blades, acceleration and speed control is achieved by a combination of cyclic and collective controls.

Unlike fixed-wing aircraft, operation of any one control usually results in the need to counteract unwanted responses with the other controls. In the case of the Apache however, much of this "cross-coupling" has been eliminated by automatic computer-controlled systems.
Since the engines are only providing power to rotate the rotor blades, it is typical in modern gas turbine helicopters to set and leave the throttle control at its maximum position. As the effort or "torque" required to drive the rotor blades varies due to blade pitch changes or aerodynamic effects, the power required from the engines varies accordingly. In order to keep the rotor blades turning at a constant speed, the power output from the engines is adjusted automatically by an "autothrottle" which operates in parallel with the pilot's control. This considerably simplifies the task of flying the helicopter. Variations in power output from the engines can be seen as fluctuations in the engine rpm display on the instrument panel.

Translational Lift

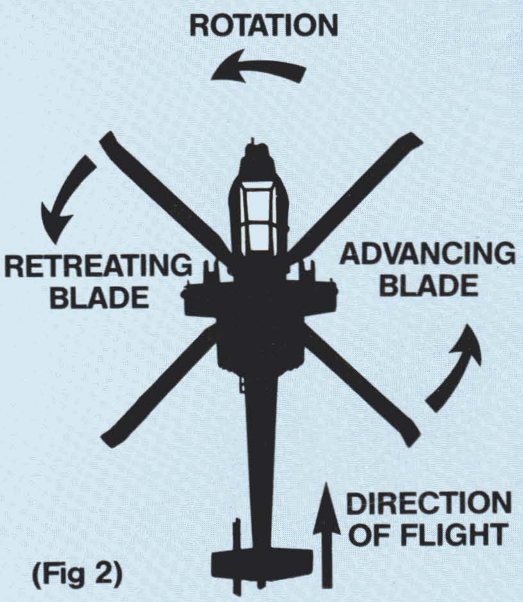
The amount of lift generated by the rotor blades increases with helicopter speed. This is called "translational lift" and results in the pilot requiring less collective pitch as his speed increases. However, as the helicopter continues to accelerate, the extra lift generated is offset by the build up of large aerodynamic drag forces which in turn must be overcome with higher collective settings in order to maintain forward thrust. This variation in "operating efficiency" can be visualised as a curve with its peak at approximately 60 kts.
A helicopter requires much more power for a vertical climb than it does for the same rate of climb with forward speed. Also, its hovering ceiling is much lower than its ceiling with forward speed. Both of these effects are due to translational lift.



(Fig 1)

Limiting Speed

It is interesting to note what determines the limiting speed of a modern helicopter. Two factors contribute to a helicopter's top speed, both of which are associated with the aerodynamics of the main rotor blades. Firstly, the speed of the airflow over a rotor blade increases from its root to its tip simply because the tip speed is considerably faster than at the root. During each rotation, a blade will be advancing then retreating relative to the fuselage of the helicopter (Fig 2). As the helicopter flies forwards, part of the inner section of the retreating blade will be rotating in a rearwards direction at a speed which is lower than the forward speed of the helicopter. The airflow at this part of the blade will be passing backwards over the aerofoil and consequently unable to generate any lift. As the helicopter's speed increases, this loss of lift will spread out towards the tip of the retreating blade, which by now is the only part producing any lift. To achieve high forward speed, we have already seen that the pilot must increase the angle of attack of each rotor blade in order to generate the necessary forward thrust. The limiting speed of the helicopter is reached when the angle of attack becomes so great that the tip of the blade stalls, resulting in total loss of lift and severe vibration.
Secondly, as the speed of the helicopter increases, the speed of the advancing rotor blade will approach the speed of sound and begin to suffer aerodynamic compressability effects.



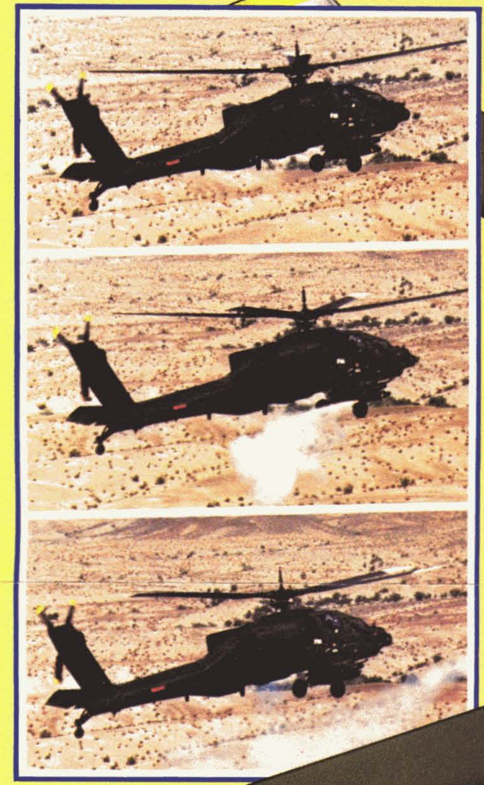
(Fig 2)

Ground Cushion

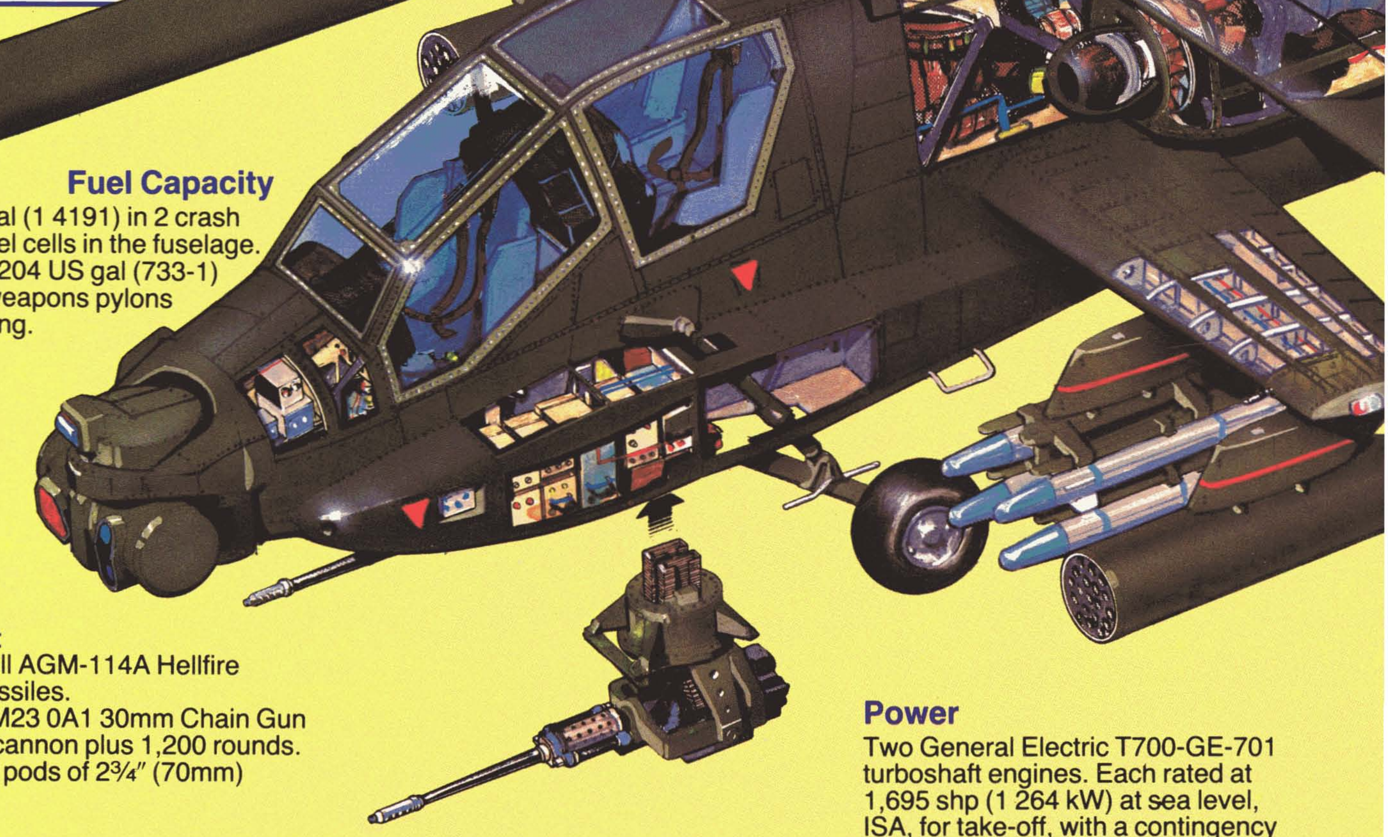
When hovering close to the ground, the downwash from the rotor blades tends to build up a cushion of air commonly called "ground cushion". This has the effect of increasing the effective lift, particularly useful with heavier take-off weight or at altitude where the air is less dense. It is possible to fly forwards whilst maintaining the ground cushion in order to build up some translational lift. The effectiveness of ground cushion decreases however with forward speed.

It took 11 years to develop the first Advanced Attack Helicopter (AAH) for the U.S. Army, (the first prototype flew on 30th September 1975) and the Hughes AH-64A Apache has surpassed all expectations.
The very appearance of this monstrous machine is calculated to instill fear into the hearts of the enemy. Its performance is equally terrifying.

The Apache is first and foremost a formidable fighting machine. It can fly low over the ground at great speed yet with enough stealth to surprise the enemy with a massive bombardment. Its Hellfire anti-tank missiles are guided by laser beams for extraordinary accuracy. It can operate by day or night and in adverse weather conditions, and is designed to protect the 2-man crew from the most arduous battle conditions. Some really special and unique features include a 'Black Hole' which is an IR suppression system in the exhaust to protect against IR-homing missiles. A truly futuristic touch is the Integrated Helmet and Display Sight System (IHADSS) which, amongst other things, permits both pilots to point weapons simply by looking at the target. The delivery of the first Apaches to the U.S. Army in 1984 has given them fighting machines described as possibly "more revolutionary than the Germans' use of tanks and dive bombers in the Blitzkrieg warfare of World War II".



AH-64A APAC



SPECIFICATION

Accommodation
Co-pilot/gunner and pilot in tandem, in armour protected seats.

Fuel Capacity
375 US gal (1 4191) in 2 crash resistant fuel cells in the fuselage. 4 external 204 US gal (733-1) tanks on weapons pylons for ferry flying.

Armament
16 Rockwell AGM-114A Hellfire antitank missiles.
1 Hughes M23 0A1 30mm Chain Gun automatic cannon plus 1,200 rounds.
4 19-round pods of 2¾″ (70mm) rockets.

Power
Two General Electric T700-GE-701 turboshaft engines. Each rated at 1,695 shp (1 264 kW) at sea level, ISA, for take-off, with a contingency rating of 1,723 shp (1 286 kW).

Dimensions

Main rotor diameter: 48′ (14,63m)
Tail rotor diameter: 9′ 2″ (2, 79m).
Fuselage length: 49′ 1½″ (14,97m).
Height overall: 16′ 9½″ (3,84m)
Main rotor disc area: 1,809½ sq. ft. (168.11^2).

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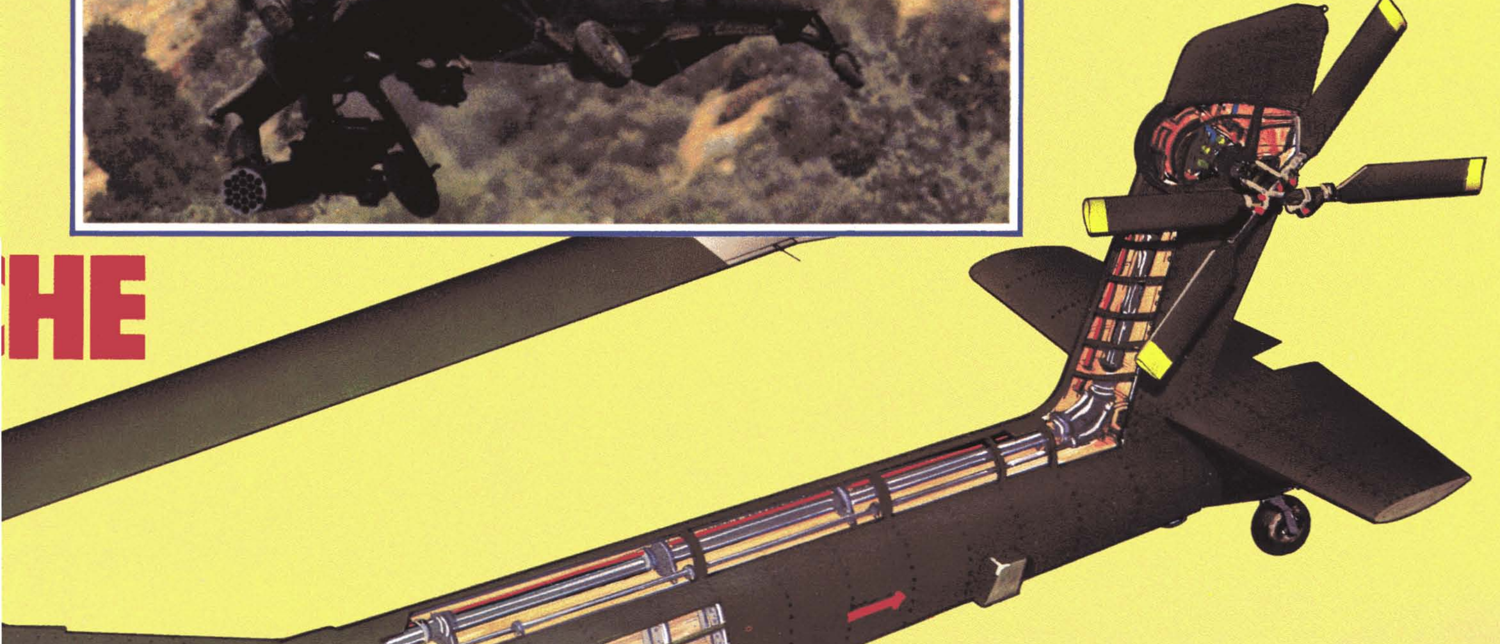

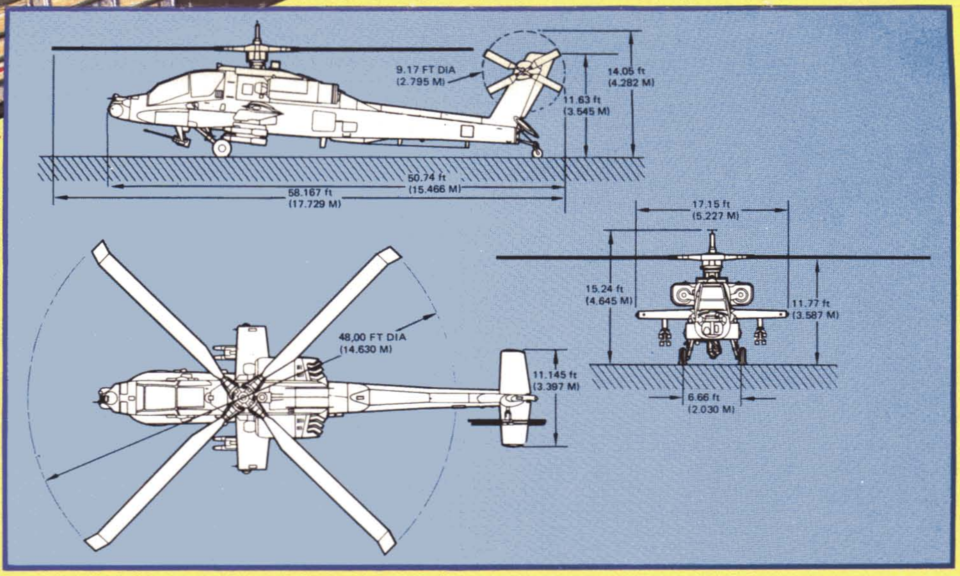

Tomahawk by D.K. Marshall

Demonstrated performance

Based on actual flight test data, the AH-64A exceeds the Army's stated requirements by a factor of 3. Given primary mission requirements, vertical rate of takeoff has been demonstrated at 1450 FPM. A superior performance which gives the Apache substantial horsepower reserves and optimum tactical flexibility.

Performance

Maximum speed: (at 6316 kg/13,925 lb) 197kts
Max cruise speed: 158 kts.
Range: (internal fuel) 611 km (380 miles) and (ferry) 1804 km (1,121 miles).
Max. vertical rate of climb: 1450 ft. per minute.
Service ceiling: 20,000 ft. (6 100m).
Max. range internal fuel: 372 naut. miles (689 km).
Endurance: 1hr 50 min to 2hr 30min according to weapon load and mission profile.
Max. endurance on internal fuel: 3hr 34 min.

Weights

Empty: 11,015 lb (4 996 kg).
Structural design gross weight: 14,660 lb (6 650 kg).
Primary mission gross weight: 14,694 lb (6 665 kg).
Max. take-off weight: 17,650 lb (8006 kg).

Photographs supplied courtesy of McDonnell Douglas

AIR-TO-AIR COMBAT TECHNIQUES

To date, the "dogfight" scenario has rarely occured between helicopters but experts believe that there is a real possibility of air-to-air combat in future conflict, particularly with the most modern combat machines being equipped for the purpose.
Various techniques have been perfected by U.S. pilots, a few of which are described here for you to try.

High Yo Yo (Fig 1)

The objective of all manoeuvres is to position oneself on the tail of the threat aircraft and to maintain this advantage until weapon release. The "High Yo Yo" begins with the enemy aircraft making a sudden tight turn in an attempt to break off the pursuit. By pulling up into a climb followed by a steep roll, turn and dive, the attacking helicopter prevents an overshoot and pulls out again onto the tail of the enemy aircraft.

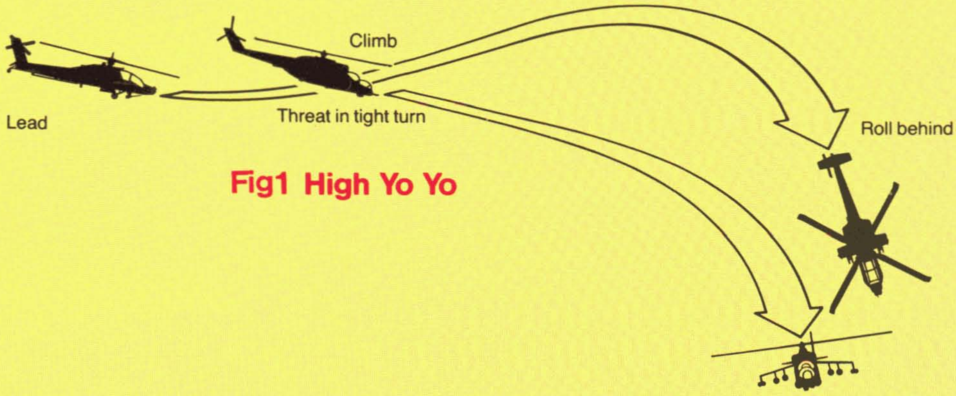

Fig1 High Yo Yo

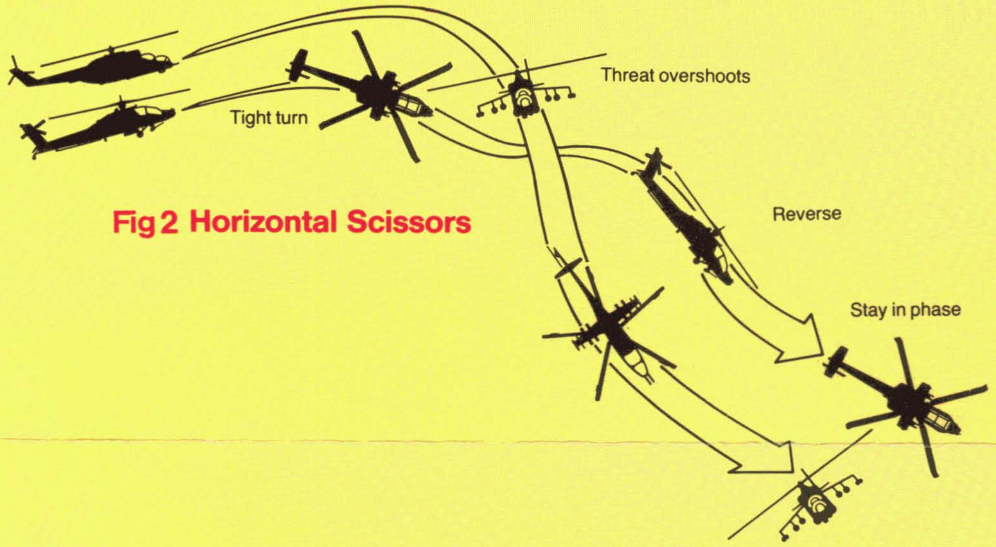

Fig 2 Horizontal Scissors

Horizontal Scissors (Fig 2)

This is a defensive manoeuvre intended to throw off a pursuing aircraft and subsequently come out onto his tail. Begin with a steep roll angle as if to enter a tight turn. As the enemy aircraft responds with his turn, quickly reverse the procedure to force the pursuer to overshoot. By rolling once again into a tight turn towards the enemy, the manoeuvre is completed.

Side-Flare Quick Stop (Fig 3)

This close-range defensive manoeuvre begins with a rapid deceleration brought about by brisk use of the rudder pedals to skew the helicopter. This gives an impression to the pursuing aircraft that you are entering a turn, when in fact you are slowing down rapidly. As he overshoots, the manoeuvre continues with a rapid acceleration (nose down, pull up on the collective) and a tight turn to bring yourself out onto the opponent's tail.
Defence against the side-flare is to perform a zoom climb followed by a torque turn, giving yourself a height advantage to begin a diving attack.

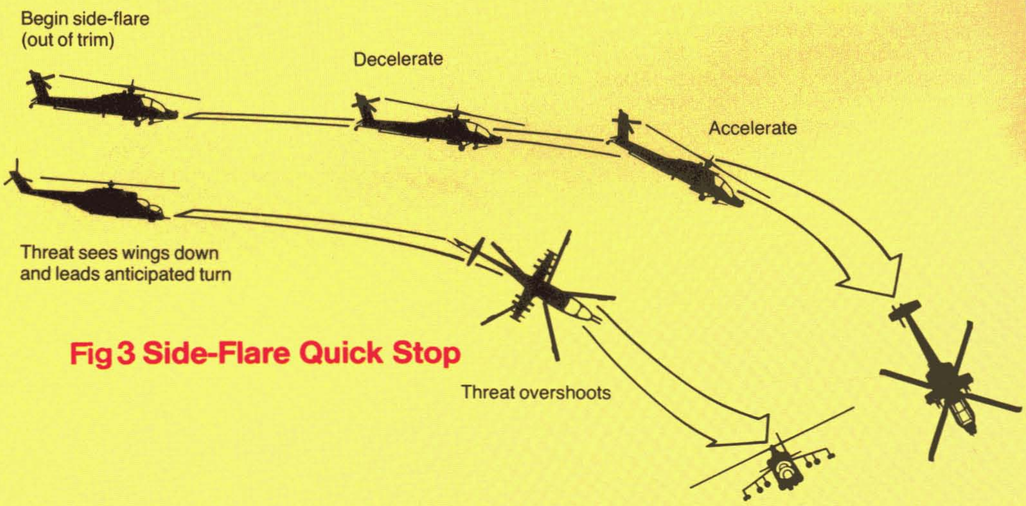

Fig 3 Side-Flare Quick Stop

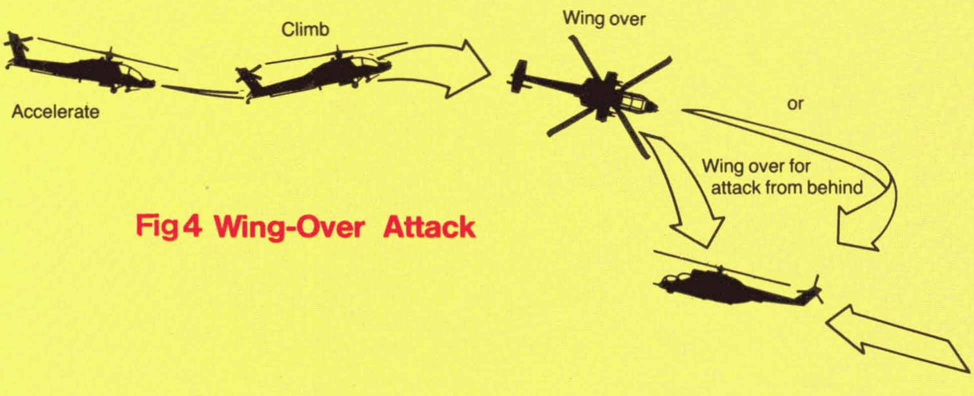

Fig 4 Wing-Over Attack

Wing-Over Attack (Fig 4)

This offensive manoeuvre is used in a head-on approach situation and begins by accelerating towards the target, followed by a rapid climb to gain a height advantage. The attack continues with a steep turn or "wing-over", finally closing in for the kill. Defence against this manoeuvre begins with a climbing turn towards the attacking aircraft after he has committed himself to the closing attack. The outcome is usually a series of spiralling manoeuvres by both aircraft as each attempts to get onto the other's tail.
The unique agility of the helicopter offers enormous scope for very aggresive and spectacular combat manoeuvres. Practice makes perfect!