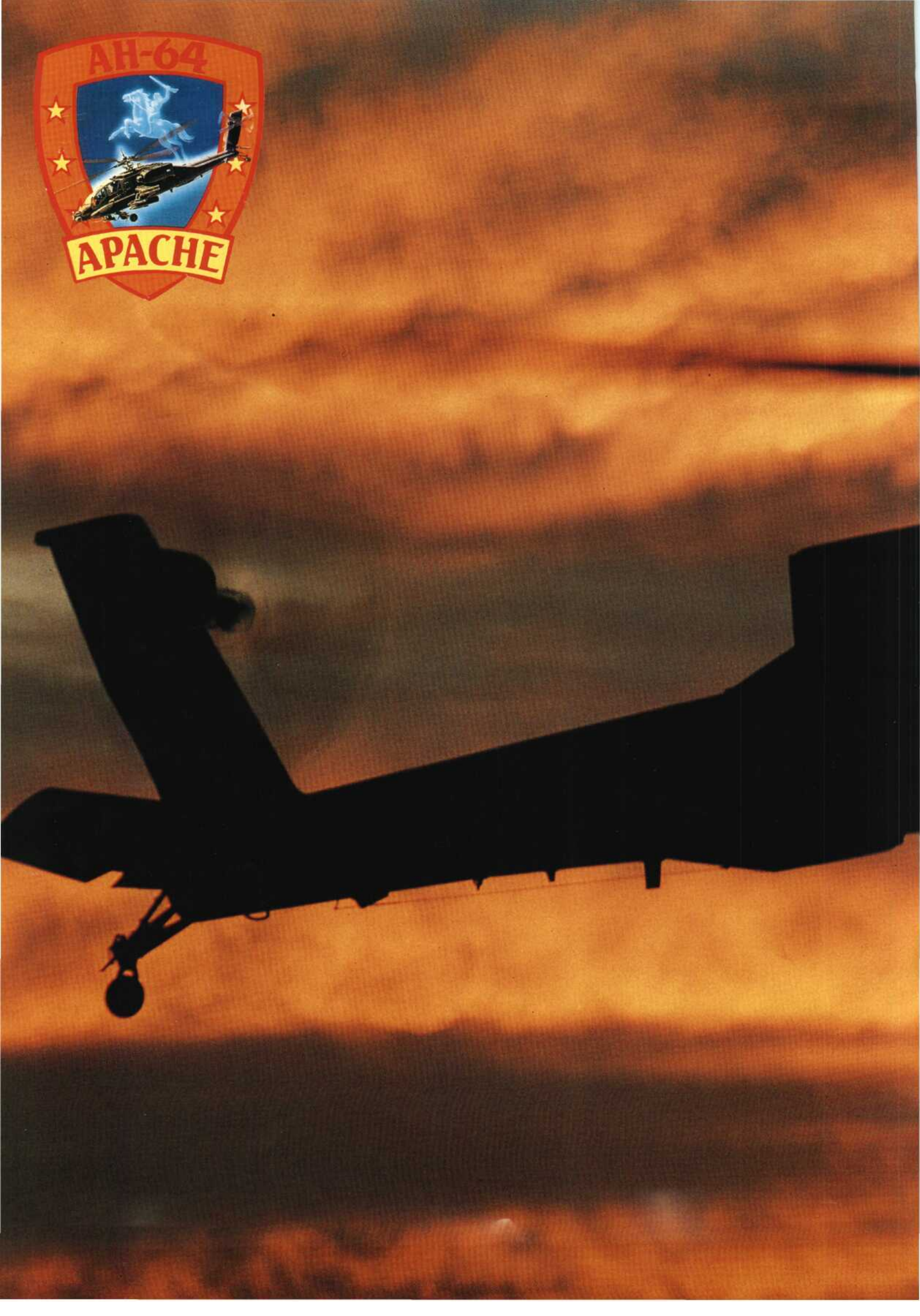

AH-64
APACHE

AH-64A/D Apache and AH-64D Longbow Apache

The Apache is the world's premier attack helicopter. Its long, and sometimes controversial, early history was crowned by a combat record in Operation Desert Storm which swept away any lingering doubts about the Apache's supremacy – doubts which none of its crews shared. Once a product of Hughes Helicopters and then McDonnell Douglas, the Apache is today the responsibility of the Boeing Corporation. To them now falls the responsibility of fielding the AH-64D Longbow Apache, an attack helicopter so advanced it will revolutionise the future battlefield.

AH-64 Apache and Longbow Apache

Above: A total of 821 (excluding prototypes) AH-64As was delivered to the US Army, between January 1984 and April 1996. The first operational unit reached IOC in July 1986. Since then the Apache has led the field in terms of battlefield helicopter technology and tactics. As the massive Soviet threat which the Apache was designed to defeat declined, the AH-64A and its crews have had to adapt to new 'security' roles - in a world far less politically and militarily 'certain' than the Cold War era.

Above right: The AH-64D Longbow Apache transforms the combat capability of the basic AH-64A and ushers in a new era of the 'omnipotent' battlefield helicopter. The AH-64D substantially improves upon theAH-64A's already staggering reputation as a tank killer, while adding effective anti-air and SEAD capability to the same airframe.

Opposite page, right: The best defence for any combat helicopter is agility and this was a watchword throughout the Apache's early developmental days at Hughes Helicopters. Despite its size, the AH-64 boasts a reputation for manoeuvrability that was once unequalled.

At 02:37:50, in the early darkness of 17 January 1991, First Lieutenant Tom Drew thumbed the radio switch in the pilot's seat of his AH-64A and initiated Operation Desert Storm with the laconic words "party in 10." Today it is a fact well-known, but still worth repeating, that the first shots of the war against Iraq were fired not by US Air Force F-117s, 'Secret Squirrel' B-52s or Tomahawk-toting US Navy vessels, but by AH-64A Apaches of the 101st Airborne Division, US Army. On that first night, eight Apaches operating as Task Force Normandy headed north from Al Jouf in Saudi Arabia, over the border and through the Iraqi front line, to destroy two key air-defence radar sites inside Iraq. First with Hellfires, and then with rocket and gun fire, the two teams of Apaches obliterated the Iraqi positions in a mission that would prove to be the template for all subsequent AH-64 operations in Desert Storm — supremely effective and deadly accurate.

There is no denying that the Task Force Normandy operation, planned and executed by Lieutenant Colonel Dick Cody and the men of the 1st Battalion, 101st Aviation Regiment, 101st Airborne Division, was the long-awaited vindication of the AH-64 as a weapon, in its first true combat test. The Apache and its crews had come in for more than their fair share of criticism since the first AH-64s were fielded in 1986. Teething troubles - some serious, some not — led to damaging speculation and Congressional scrutiny that proved, to the Apache community, that mud sticks. Furthermore, the personnel of the 15 Apache battalions deployed to the Gulf, along with their friends and families at home, had to suffer the assault of a prime-time American current affairs programme which damned the aircraft and forecast doom for those about to go to war in it. None of their prophecies came true. As recorded below, the AH-64 had an exceptional operational debut and notched up many firsts for US Army aviation, and for the combat helicopter as a whole. In Operation Desert Storm the Apache finally proved its claim to be the best attack helicopter in the world, a claim which no-one could begin to dispute, except perhaps those involved with the AH-64D Longbow programme.

This is not to say that the Apache is invincible, and one need look no further than the success of TF Normandy to discern some of the weaknesses that still hinder the AH-64A. While the Apaches performed with finesse their task of killing their first night targets, it is an unpalatable fact (for some) that they could never had found those targets without the help of USAF AFSOC Pave Low III MH-53Js which led the Apache teams to the right place with their GPS and TFR systems. The Apache's own navigational fit was simply not up to the job. As an aircraft of the 1970s the Apache is an analog, not a digital, warrior. The mission-planning effort required for any Apache mission today, let alone one as important as TF Normandy, is immense, because every eventuality must be foreseen, sketched out and planned on paper before the aircraft are in the air. Apaches fight as a team and if the cohesion of that team is lost, so is the mission. More than most, Apache crews know the truth of von Clausewitz's maxim that 'no plan survives contact with the enemy'. This places immense strain on the crews, who have to call on the skill and experience gained from hundreds of hours of training. Communication of new ideas or new intelligence is difficult, if not impossible, after launch, so Apache crews have to fly and fight in one of the most stressful combat environments imaginable, hoping that all the answers have been worked out before the shooting starts.

This will soon change. At present, the US Army is in the early stages of fielding the AH-64D Longbow Apache, a combat helicopter for the digital battlefield of the 21st century. These are not mere buzz-words. The US Army is probably further ahead than any other branch of the US armed forces in planning to make maximum use of new technology in weapons, sensors, intelligence gathering and C (command, control, communications) on the future battlefield. Army aviation and McDonnell Douglas have designed the Longbow to fight and win the intelligence war, which again is not an empty phrase but one which describes a combat situation where the AH-64D crew will be all-seeing, all-knowing and all-powerful. That, at least, is the plan. Before examining the Apache of the future we should discuss the Apache*of the present, and why it is the benchmark against which all others are measured.

Although the lineage of the attack helicopter in United States service can be traced to Southeast Asia, the roots of the Apache lie firmly in Europe. The Bell AH-1G Huey-Cobra had a highly successful combat career in Vietnam after its introduction in August 1967. The Hughes BGM-71 TOW (Tube-launched, Optically-tracked, Wire-guided) missile ultimately gave the sleek 'Snake[1] unprecedented hitting power against armoured targets, coupled with secure stand-off ranges (though initial results of airborne TOW firings in Vietnam were poor). In Europe, where the 'real' war would be fought, the arrival of the AH-1 paved the way for the second generation of US attack helicopters that would be firmly dedicated to killing Soviet tanks in Germany. However, the AH-1 was originally only a stop-gap — developed in haste to cover delays in the Army's 'big plan' for armed helicopters.

Prehistory of the AH-64

After the successful debut of the armed UH-1, the US Army initiated the Advanced Aerial Fire Support System programme to develop a new combat helicopter for gunship, escort and fire support tasks. The result was a 1966 contract with Lockheed to develop 10 prototypes of the immense AH-56A Cheyenne. The Cheyenne was one of countless aircraft which appear as a footnote to the story of others but deserve an entire account of their own. It was conceived not as a manoeuvrable armed helicopter for nap-of-the-earth (NoE) flying, but as a large weapons platform for Vietnam-era gun and missile attacks. The Cheyenne had a General Electric T64 turboshaft driving a four-bladed main rotor, coupled with a conventional tail rotor and a decidedly unconventional pusher propeller at the end of the tailboom. The first AH-56A made its maiden flight on 21 September 1967, chalked up a startling maximum speed of 220 kt (407 km/h, 253 mph), and in January 1968 the US Department of Defense signed a contract for an initial batch of 375. The Air Force took issue with the Army for acquiring this 'close-support aircraft'. The first prototype crashed on 12 March 1969 (killing the pilot), technical delays and hitches abounded and, finally, the advent of the shoulder-launched SAM, in the shape of the SAM-7 'Grail' (9K32 Strella-2), sealed the fate of the Cheyenne. To survive from then, any new helicopter would have to

Above: Lockheed's AH-56 Cheyenne was an over-complex design that was ultimately defeated by the small infantry SAMs that emerged in the late 1960s. As a result the Cheyenne became just a museum exhibit.

Right: In 1972 Lockheed became one of the five bidders for the Army's Advanced Attack Helicopter (AAH) competition with its proposed CL-1700. Owing much to the Cheyenne, the CL-1700 was one of the more unwieldy AAH designs.

Right: Boeing's AAH entrant featured a novel side-by-side, yet staggered, cockpit arrangement offering "four eyes forward to find and fight," as the brochure put it. Ironically, Boeing is now at the helm of the AH-64 Apache.

Right and below right: When the winners of the AAH initial evaluation were announced it was not surprising that Bell was selected as one of the two finalists. The wooden mock-up that Bell first produced was completely camouflaged; even the blades were painted. In contrast, the two prototypes wore an overall drab green scheme. Bell's YAH-63 design drew on all the company's experience with the AH-1 HueyCobra. It was beaten into the air by its Hughes rival, by a single day, in September 1975. The YAH-63 had an unhappy development and one of the two flying prototypes was lost in a crash. The other prototype, like the Cheyenne before it, survives today as an exhibit in the US Army Aviation Museum, at Ft Rucker, Alabama.

operate at less than tree-top height and be supremely agile. What was needed was a gunboat and not an ironclad, and so the US Army retired to generate another specification.

The space left by the cancellation of what might have been up to 1,000 Cheyennes still needed to be filled. With a eye on the Central European front, the US Army's next requirement coalesced around an aircraft that would better the AH-1 in terms of range, performance and firepower which still being manoeuvrable enough to fly NoE missions through, around and under forests, hills and power lines. The AH-1/TOW combination was still the best available and held the line in Europe for a decade, but it obviously could be improved.

Birth of the AAH

In August 1972 the official Request for Proposals (RFF) for the Advanced Attack Helicopter (AAH) was announced. It specified an aircraft that would cruise at 145 kt (269 km/h, 167 mph) with a full load of eight TOW missiles (or a minimum expendable ordnance load of 1,000 lb/ 454 kg) for a mission duration of 1.9 hours. Performance demands were set, surprisingly, in (Middle Eastern) terms of 4,000 ft (1220 m) altitude at an ambient temperature of 95° F (35°C). By way of comparison, conditions for 'NATO hot day' operations were defined as 2,000 ft (610 m) at 7()°F (21"C). Maximum speed was to be 175 kt (323 km/h, 201 mph) and maximum vertical rate of climb 500 ft/min (152 m/min). The new helicopter would have to have operational £ limits of+3.5 and -1.5 and be structurally resistant to hits from 12.7-min armour-piercing incendiary rounds. In addition, the rotorhead (and the entire aircraft) had to remain flyable after a hit from a 23-mm high-explosive incendiary shell, the then-standard Warsaw Pact AAA calibre. A sign of the prescience of these requirements is that they would not be seen as unreasonable, or inadequate, today. The SAM threat to the aircraft was perhaps even a higher priority and the AAH would have to prove that its IR signature, and thus its vulnerability to shoulder-launched infantry SAMs, could be reduced to an acceptably low level. Such passive countermeasures would be backed up by chaff/flare dispensers. Crew survivability was placed at a premium - far too many crews had been lost in Vietnam in fragile helicopters. The AAH crew must be able to survive a crash at 30 mph (48 km/h) — a vertical impact of 42 ft/s (12.8 m/s) - with a forward speed of 15 kt.

Of course the key to survivability on the battlefield would be to allow the AAH to kill its targets outside the air defence envelope that could be expected around an advancing armoured column. The alarming Israeli experience of the 1 973 Yom Kippur war showed that this might no longer be possible when faced with Soviet weapons such as the ZSU 23-4 Shilka radar-directed mobile AAA system or SA-8 'Gecko[1] and SA-9 'Gaskm' mobile SAMs. The TOW missile was becoming progressively less able to outreach these defences and its method of employment left the launch aircraft exposed for an unacceptable length of time.

Bell's rival and the YAH-64

While this issue was emerging as a serious challenge to the AAH concept, the US Army was faced with five competing submissions for the new helicopter - from Bell, Bocing-Vertol (teamed with Grumman Aerospace), Hughes, Lockheed and Sikorsky. Bell Helicopter Textron, not surprisingly, saw itself as the front-runner. It had amassed the most relevant experience of any of the competitors and its resultant YAH-63 (Bell Model 409) had the appearance of a thoroughbred. Boeing-Vertol, whose YUH-61A design was about to go head-to-head with Sikorsky for the US Army's UTTAS transport helicopter fly-off, offered a large AAH design, reminiscent of the Cheyenne, with some unusual features. It had a reversed tricycle undercarriage, podded engines, four-bladed rotor and large forward fuselage. The crew sat in tandem, but in

separate off-set cockpits. Lockheed, determined not to be left behind after the success, and failure, of the Cheyenne, developed the Cheyenne-lookalike CL-1700, powered by a Lycoming PLT-27 engine. Sikorsky (which would ultimately win the UTTAS competition in December 1976 with the UH-60 Blackhawk) came up with a development of the S-67 Blackhawk — however, like Boeing-Vertol, the ongoing UTTAS competition made it an unlikely candidate for AAH victory.

The final competitor was Hughes Helicopters, of Culver City, California. Hughes Helicopters was founded on 14 February 1934 by the great Howard R. Hughes Jr, as the aviation division of his Hughes Tool Company. Hughes had supplied the much-loved and respected OH-6A Cayuse, the 'Loach', to Army aviation units in Vietnam, where the type had proved to be a very tough and reliable performer, even though substantial numbers were lost in combat. For the AAH competition Hughes looked first to its OH-6 experience and took that type's small size and damage-tolerant structure as its guiding principles. An OH-6-inspired design soon proved to be far too small to meet the Army's AAH requirements and so Hughes's designers proffered the angular and awkward-looking Model 77 which, to the US Army, became the YAH -64.

Defining the future battlefield

As planning tor the AAH competition advanced so, too, did US Army doctrine for the attack helicopter, as a concept and a weapon. The philosophy during the 1960s and 1970s had been one of'whoever brings the most to the party wins' - victory in battle would be decided by the size of the force one side could apply to the battlefield. By the 1970s advancing technology — and clear Soviet numerical superiority — transformed this credo to 'win at night'. The interim Army aviation solution, the AH-l/NVG combination, was not proving successful in Europe. The Cobra had only maps rather than Doppler navigation, limited comms, limited reach and limited combat effectiveness. The emergence of the doctrine of 'active defence', where units would move laterally along the battlefield to reinforce each other, defined the AAH as an aircraft that must be able to conduct regimental operations at night. The objective was for an attack helicopter regiment to be capable of destroying an armoured corps. As a result, the AAH fell into line with other Army battlefield systems destined for service in the 1980s (and then under development), such as the XM1 which became the Abrams MBT and the MICV which became the M2 Bradley IFV. The AAH became a platform for electro-optical sensors that would allow it to locate, identify and target the enemy in darkness when their combat performance was rightly seen as degraded, and then engage them from concealed positions. As the AAH competition progressed so did the development of this system, the heart of the Apache, which emerged under the unrevealing acronym of TADS/PNVS.

On 22 June 1973 the US Department of Defense announced that the Bell YAH-63 and Hughes YAH-64 had been chosen as the AAH competitors. This launched Phase 1 of the competition whereby both firms would build and fly two prototypes, plus a Ground Test Vehicle (GTV) for a competitive fly-off in mid-1976. Following the Phase 2 evaluation and selection, it was anticipated that an initial order for 472 aircraft would be awarded in late 1978/early 1979. Hughes confidently predicted that its aircraft would have a flyaway cost of not more than $1.6 million, in 1972 dollars. Bell's YAH-63A drew heavily on its AH-1G experience and was essentially a scaled-up HueyCobra which retained Bell's trademark twin-bladed, 'teetering' rotor. Like the YAH-64 it was powered by a pair of 1,500-shp (1'17-kW) General Electric YT700 turboshafts — an engine choice virtually dictated to the two manufacturers for commonality with the UTTAS (Utility Tactical Transport Aircraft System) helicopter. The YAH-64 followed the same configuration, though without the same

Hughes Helicopters responded to the AAH competitor! with a design based on its egg-shaped OH-6. The 'Loach', a nickname derived from its LOH (Light Observation Helicopter) designation, was a Vietnam stalwart much respected by its crews. OH-6s were used as FACs and light gunships, and their losses were heavy - one wry saying at the time had it that 'the target is marked by the burning Loach'. However, Hughes's designers respected its structural integrity enough to use it as their starting point. All OH-6 developments soon turned out to be too small to make an effective AAH, so Hughes's engineers ultimately produced the Model 77. The mock-up (above) differed from the prototypes (top) in several respects, but is clearly the ancestor of the Apache. Note the original TOW missile pods on the mock-up.

AH-64 Apache and Longbow Apache

Above: AV-02 (73-22248) was the first YAH-64 to fly. The first to be built (AV-01/73-22247) served its whole life as the GTV (Ground Test Vehicle). AV-02 is seen here soon after its first flight with the original T-tail configuration and mid-set rotor. Several tailplane configurations were tested, including reversing the 'arrowhead' tailplane and adding end-plate fins.

Top right: AV-03 (73-22249) is seen here with a revised tail configuration, featuring the low-set stabilator adopted for production AH-64s. For a period AV-05 flew with no horizontal stabiliser.

Above right: AV-02 flew with a (red) instrumentation boom on its earliest flights. It also carried a dummy gun under its nose, to maintain the YAH-64's centre of gravity.

Below: This photograph of dummy Hell fires fitted to AV-03 provides a clear view of the actuated trailing-edge flap originally fitted to the YAH-64's stub wings.

sleekness of form, sharing Bell's stepped tandem cockpit, widely-spaced podded engines, stub wings, narrow tailboom and nose-mounted sensors. It differed through its tailwheel undercarriage arrangement (versus a tricycle one), four-bladed main rotor and unfaired gun installation set well back under the fuselage. The YAH-63's cannon was located above and in front of the sensor turret. In the Bell design the pilot sat in the front seat (the direct opposite of the AH-IG), but not so in the YAH-64. Hughes positioned its pilot aft on the principle that by sitting just 2 ft (60 cm) forward of the rotorshaft he would be more attuned to shifts in pitch and angle of rotation - a useful aid to ultra-low-level flight.

The definitive YAH-64 mock-up did not appear until late in 1973, and Hughes soon refined some elements of it still further. Chief amontr these was the addition of a revolutionary new gun, the single-barrelled XM230A 30-mm Chain Gun" cannon designed by Hughes Aircraft Corporation. It is worth pointing out at this stage that the YAH-64's manufacturer - Hughes Helicopters — was by then a division of the Summa Corporation, while Hughes Aircraft Corp. (which had not built an aircraft for 20 years) was a separate entity, although both owed their existence to Howard Hughes. The YAH-63 was fitted with the three-barrelled General Electric XM188 30-mm cannon, which also was originally specified by Hughes. Ongoing research at Hughes convinced its AAH designers that the Chain Gun" concept offered sizeable advantages over previous aircraft guns, chiefly light weight and resistance to stoppages, and Hughes rushed its development in parallel with that of the YAH-64. Another change made to the mock-up by July 1975 was the revised canopy, which had previously been curved and less heavily framed. The revised canopy used flat-plate transparencies to reduce the problem of glint (curved transparencies will reflect light in a number of planes and for an increased length of time compared to a smaller flat surface). Framing of the canopy was also made more pronounced, dividing the cockpit glass into seven distinct sections.

The YAH-64 consortium

The Hughes AAH entry was widely perceived as a conservative one, avoiding the complicated design features and advanced material techniques that dogged the Cheyenne. Its lightweight aluminium, conventional skin-and-stringer airframe design, rugged straight-forward power train and simple rotor system were tailored to meet the Army's design-to-cost requirements. A team of 12 major sub-contractors was formed to provide expertise in areas where Hughes was lacking and to cut costs. All were allowed the freedom to develop the solution to problems in their particular area of expertise, while meeting Hughes' basic criteria. These firms included Bendix Corporation's Electric Fluid Power Division, responsible for design/fabrication of drive shafts, couplings, electrical power systems. Bertea Corporation: hydraulic systems. Garrett Corporation: design/fabrication of IR suppressors, integrated air systems. Hi-Shear Corporation: crew canopy/escape system. Litton Precision Gear Division: main transmission, engine nose gear boxes. Menasco Manufacturing Inc: landing gear. Solar Division, International Harvester Corporation: APU. Sperry Flight Systems Division: auto-stabilisation system. Teledyne Ryan Aeronautical Division: fabrication of airframe structure. Teledyne Systems: design assistance for fire control computer. Tool Research and Engineering Corporation, Advapced .Structures Division: main/tail rotor. Precision Products Division, Western Gear: intermediate/tail rotor gear boxes. Of all the above probably the most significant contribution was made by Teledyne Ryan, which not only supplied major sections of the airframe but later facilitated the demanding initial production schedule that had a major effect on the early days of the Apache.

By June 1976 Hughes had begun ground tests with AV-01 (Air Vehicle), the prototype. This aircraft would be tasked with all the preliminary power tests, but AV-02 would be

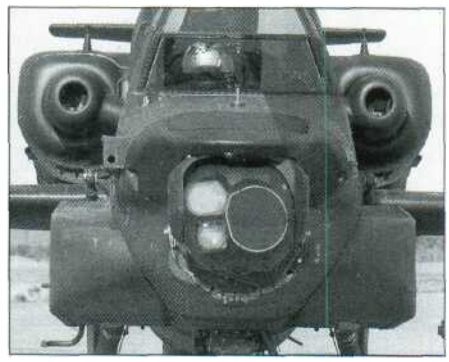
the first to fly. In fact AV-01 never flew and served as Hughes's *de facto* Ground Test Vehicle. In contrast, Bell had already run a dedicated YAH-63 GTV in April of that year and its apparent lead in the programme forced Hughes to hurriedly accelerate its work. The first YAH-64 succeeded in beating the YAH-63 into the air by a single day, on 30 September 1975. Pilots for the YAH-64's 38-minute maiden flight (delayed for several hours after the port starter unit failed) were Robert G. Ferry and Raleigh E. Fletcher. It was then Bell's turn to suffer delays as the YAH-63 experienced gearbox problems induced by its high-speed transmission. Gene L. Colvin and Ronald G. Erhart's maiden flight in the YAH-63 had ended after only 2M minutes, when the aircraft began to experience main rotor vibration. Two more flights were made on that day, totalling 10 minutes, but vibration problems persisted on later flights. Hughes launched AV-03 on its maiden flight on 22 November 1975 (by which time AV-02 had logged 35 flying hours), while Dell's second aircraft followed on 21 December. Pilots for the maiden flight of Hughes's AV-03 were Morne Larson and Jim Thompson. Hughes conducted all ground and air tests at Palomar Airport, Carlsbad, California. The flight test programme entailed 342.6 hours between September 1975 and 31 May 1976 before the AAH competitor was handed over to the Army's integrated flight evaluation programme at Edwards AFB. A further 125.5 hours of flying ensued in Army hands, from 1 6 June, plus 384.4 hours of associated ground tests. The Army's senior Apache test pilot, Colonel Robert L. Stuart, later became the first astronaut to spacewalk (from the Space Shuttle) without using a tether.

Bell's transition to service testing did not go smoothly. On 4 June 1976, while being flown by an Army pilot in the front seat and a Bell pilot in the rear -just prior to its scheduled handover on 16 June — the number two prototype YAH-63 crashed. The accident was traced to a tail rotor drive shaft failure during high-load, sideways flight. Both crew survived but the aircraft was destroyed, and so Bell desperately scrambled to make its GTV airworthy for the US Army.

Sensor systems and Hellfire

The Army test programme was not concerned merely with the AAH aircraft but also with the TADS/PNVS (Target Acquisition and Designation Sight/Pilot's Night-Vision Sensor) suite which was being developed for it. As in the AAH competition, there were two firms vying for this contract - Martin-Marietta and Northrop, which both submitted their proposals on 27 November 1976. Both systems were broadly similar, combining a FLIR and electro-optical sensors in a rotating ball turret mounted on the aircraft's nose. The Martin-Marietta system provided a permanent FLIR for the pilot above the nose faring, but Northrop's design was retractable. TADS/PNVS evaluation would be an important part of the Phase 2 evaluation of the AAH winner.

Before revealing which of the two designs would be the winner, the Army announced a major change in the AAH specification, one which must have caused dismay to all concerned at the time but which set the seal on the Apache's future as the most lethal helicopter on the battlefield. In 1972 the requirement had been for an aircraft armed with eight basic TOW missiles that had a maximum range of 3000 in (9,843 ft), in day or night. By 1973 this had been modified to include the extended-range XRTOW with its 3750-m (12,303-ft) range. By 1975 the shortcomings of TOW were acknowledged and a replacement weapon was introduced for AAH. This was the Rockwell Hellfire (HELicopter-Launched, FIRE-and-forget), a laser-guided anti-tank missile which promised effective engagement ranges in excess of 6 km (3.7 miles). The unproved, and then unbuilt, Hellfire had a development history that stretched back to the early 1960s, but the risks inherent in its adoption were wisely seen to be less serious than allowing the AAH programme to proceed with inadequate weaponry. On 6 January 1976 the Army System Acquisition Review Board approved the adoption of Hellfire, and this decision was recommended to the Defence Systems Acquisition Review Council on 26 February. Hughes Aircraft Corporation and Rockwell International were both awarded contracts for Hellfire engineering development, with a single contract to be awarded as a result. The decision to integrate Hellfire added five months to the AAH RDT&E schedule, and $49.6 million. It was expected to add, in 1976 terms, $6,000 to the price of each AAH (a figure which later turned out to be impossibly low) but would provide a quantum leap in penetration capability compared to the TOW and Shilleleagh missiles then in service. On 8 October 1976 the Hellfire development contract was awarded to Rockwell International.



***Above left and right:** As the competition to build the AAH airframe progressed, so too did the competition to supply the TADS/PNVS primary mission sensor. The two rival designs, built by Martin Marietta (left) and Northrop (right), are seen here displayed in front of a YAH-64. Directly above is a view of the unsuccessful Northrop design, mounted on an a testbed aircraft. The chief difference between the Northrop design and its rival was the former's pop-up pilot's FLIR (PNVS) mounted above the nose. Northrop did not develop independent FUR and DVO turrets in the TADS, but (perhaps unwisely) combined them in a single 'ball' mounting.*

***Top:** All the early prototypes (this is AV-01) flew with representative FLIR housings. When the definitive TADS/PNVS was fitted, the cheek fairings were extended to accommodate the avionics. Note also the long grab handle beside the cockpit which was deleted on production AH-64s.*

Phase 2 proposals were submitted in two parts: technical and management portions on 31 July 1976, and cost proposals on 16 August. Details were discussed, debated and disputed with the Army programme managers for four months before each manufacturer submitted its final Phase 2 proposal on 22 November. On 10 December 1976, having reviewed the evaluation results, the Secretary of the Army announced that the Hughes YAH-64 was the winner of the AAH competition. Factors which counted against the YAH-63 included doubts about the damage tolerance of its twin-bladed rotor and the small footprint of its tricycle landing gear, which left the aircraft unstable on the ground. Some claimed that Bell's existing production commitments had made it a likely second choice, as the US Army had no wish to interfere with ongoing AH-1 production. Hughes had met the Army's performance demands in all but one area. The YAH-64's maximum speed was 196 kt (362 km/h, 225 mph) compared to the ultimate goal of 204 kt (377 km/h, 234 mph). The rate of climb achieved by the prototypes was 800 ft/min (244 m/min), twice the original requirement, and the Phase 2 aircraft were expected to achieve 1,100 ft/min (335 rn/rnin). Weapons demonstrations were conducted twice - 1,176 rounds were fired by the XM230 Chain Gun* during forward flight at angles up to 90°, and 184 2.75-in rockets were launched from the hover and at forward speeds of up to 130 kt (241 km/h, 150 mph). The streamlined TOW pods developed for the AAH were also test flown, but they subsequently were replaced by a yet-to-be designed Hellfire launcher. These weapon tests brought about a further success for Hughes - the Army's adoption of the M230 as the YAH-64's onboard gun.

Main rotor redesign

There had been some problems during the Phase 1 evaluation. Perhaps the most alarming of these was described by Hughes thus: "Apparently adequate rotor to canopy clearance was provided within this dimension (the requirement to limit vertical height to allow transportation by the C-141 airlifter), however, during flight testing it was found to be inadequate under sever manoeuvring conditions. In tact, under one extreme condition, it was possible to demonstrate an interference of the non-structural trailing edge of the blade with the corner of the canopy." In short, during negative-^ (-0.5 *g)* pushovers the aircraft hit its own blades. The rotor masts on the two flying prototypes were lengthened by 9.5 in (24.3 cm) to allow safe operations up to -0.4 *g*, the first aircraft flying in this revised configuration on 9 February 1976. The rotor mast was subsequently lengthened by an additional 6 in (15.24 cm) for production aircraft to permit NoE flight to the design limit of-0.5 <?, even in a 54-kt (100-km/h, 62-mph) headwind. On the other hand, during NoE evaluations one crew hit the tail wheel hard enough to burst the tyre, but no 'tailboom bounce' back into the main rotors occurred.

A build-up in blade vibrations as the rotor system entered the high-speed regime led to a redesign of the blade tips, which were swept back. The refined tip design reduced noise and increased the AH-64's maximum speed, exceeding the Army's goals. The flat-plate transparencies on the side of the cockpit were rounded, to add stiffness and reduce vibration-induced 'drumming' caused by the frequency of the rotor system.

Black Hole IR suppressors

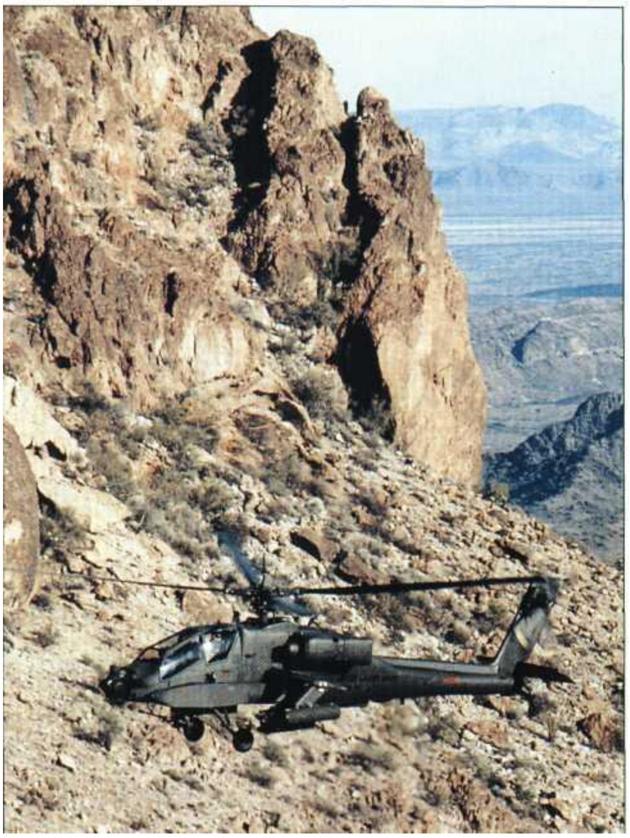
The YAH-64 had a predicted primary mission weight of 13,200 Ib (5988 kg) but the prototypes exceeded this by about 1,000 Ib (454 kg). This figure was significantly reduced through the redesign of the all-important IR-suppression system. Hughes had originally developed an engine-driven cooling fan system which mixed surrounding air with exhaust efflux. This was replaced with Hughes-designed Black Hole IR-suppressors, using a

newly-developed material known as Low Q. The Low Q liner absorbs heat from the exhaust and radiates it slowly into the airflow surrounding the nacelle. Exhaust flow through each duct is used to draw ambient air into the dynamic section of the helicopter, cooling the transmission — via the oil heat exchangers - and the two engines. The fan system drew the equivalent of 50 hp (37 kW) from the 1,536-shp (1143-kW) T700-GE-700 turboshafts, so its removal, coupled with the addition of the lighter (and far less complex) Black Hole system, amounted to a saving of 400 Ib (181 kg) in airframe weight. The bulk of the remaining weight saving came through changes in the tail design. This was achieved through a revision of the prototypes' T-tails (a process detailed elsewhere), but not their transformation to the low-set configuration intended for production aircraft. This lightweight tail, coupled with the extended rotor head, became known as the Mod 1 package.

Phase 2 proceeds

The $317.6 million Phase 2 contract called for the building of three production-standard AH-64s, conversion of the two prototypes and GTV to this standard also, and complete weapons and sensor system integration. The 50-month Phase 2 flying programme began on 28 November 1976, although an AH-64 production decision was not expected until May 1980. Notwithstanding, Hughes made the decision to commit to the massive expansion of its production facilities that would be needed to cater to the AAH. The Army's stated initial requirement now stood at 536 aircraft. Hughes began to issue long-lead materials contracts, recall laid-off staff and lease an additional 157,000 sq ft (14585 nr) of factory space. Its partners were faced with similar decisions. Hughes instigated a computerised management control system to its 'Team to the AAH' programme, one in which the Army was very interested. Flight tests continued to be conducted at the Palomar facility, using the gunnery range at the nearby MCAS Camp Pendleton. Full-scale weapons tests were conducted by the Army at the Yuma proving ground, while some Army flight test activity was carried out at Edwards AFB. Environmental testing was conducted at the indoor controlled climate facilities at Eglin AFB, Florida, and icing tests were conducted at Moses Lake, Washington.

All initial Phase 2 activity was limited to the AH-64 GTV, on which every design change was extensively tested.



As a result, only 21 months of the 56-month programme (financial hiccups had forced its extension) remained when the first flight of the modified AV-02, now in production configuration, took place on 28 November 1977. Pilots Bob Ferry (Hughes's chief experimental test pilot) and Morrie Larsen (dedicated AAH test pilot) logged 9.1 hours in 10 flights on that one day alone. After 50 hours of GTV Pre-Flight Approval Tests (PSAT) intended to check out the transmission and gear box systems, AV-04, the first true AH-64, was cleared to fly on 31 October 1979. Bob Ferry and Jack Ludwig were at the controls for the 18-minute maiden flight, which was the first made with a redesigned low-set all-moving tailplane, dubbed the stabilator.

Above: Phase II testing revealed problems with the AH-64's rotor tips. As a result, the blade tips were swept back, leading to a reduction in compression loads and overall noise signature.

The dramatic desert scenery around the Apache production plant at Mesa, Arizona, has provided a spectacular backdrop for many AH-64 photos. One of the pre-production aircraft is seen here skirting a nearby peak.

Opposite page, top: Early rocket tests were conducted with Mk 40 rockets, which have now been replaced in the inventory by Mk 66s, as seen here.

Opposite page, bottom: Hellfire testing began in 1980 and the problems encountered delayed actual missile production until 1982. Initial tests were undertaken in clear desert conditions and some doubts were expressed as to how the missiles would perform under European conditions. As a result, a trial was held in 1981 involving eight shots fired in fog, smoke, dust clouds and rain. Two missiles failed to hit their targets and the Army had to admit that under some conditions Hellfire would not be 100 per cent reliable.

Above: This Ft Hood-based AH-64A (one of the FY84 production batch) is seen in full 'war fit' with Hydra 70 rocket pods, eight Hellfires and M130 chaff dispenser. The pre-production AH-64's had the M130 dispenser attachment point further forward on the tailboom.

Right: 'Wings' are a necessary evil for the attack helicopter. They are needed to carry weapons, but they distort the aerodynamic effect of the rotors. In autorotation (when engines have failed and the helicopter is relying on inertia and the windmill effect of the blades to sustain lift and motion for an emergency landing), the main rotor system needs to 'store' as much lift as possible to give the pilot enough control authority to make a safe landing. Wings generate their own lift and so dissipate part of this energy. The Apache was designed with full-span flaps along its stub wing trailing edges, not just as control surfaces but as lift dumpers in the event of emergency autorotation. This complicated system was not adopted on production aircraft. This photograph depicts an early production AH-64A - possibly PV-01 on its maiden flight. Note the faired-over TADS/PNVS housing and clean stub wings.

Hcllfirc tests began in April 1979, initially from an AH-1 fitted with a trial Airborne Target Acquisition Fire Control System (ATAFCS). AH-64 tests were conducted at Camp Pendleton. Initially, missiles were fired (by AV-02) unguided from the critical upper inboard station on the left wing, This station was almost in direct line with the tail rotor so the possible effects of rocket plume and associated debris were a cause of concern, which proved groundless. While these early tests provided useful basic information, true weapons tests could not proceed without a complete onboard weapon guidance and fire control system. The two competing TADS/PNVS systems were installed on the AH-64 prototypes - AV-02 carried Martin-Marietta's system and AV-03 Northrop's. A competitive fly-off between the two sensor fits, at the Yuma Proving Ground, was scheduled for December 1979 after the preliminary guided missile test shots. The first of these autonomously-guided Hellfire tests was made by AV-02 in October 1979. Within a month Hellfires were scoring self-guided bullseyes on 10-ft x 10-ft (3-m x 3-m) targets. TADS-guided Hellfire tests were part of the overall Armament and Fire Control Survey (A/FCS) test programme, during the early stages of which the AH-64 test fleet passed the 1,000 flying hours mark. The addition of the full-standard fire control system went hand-in-hand with the Mod 2 changes to the AH-64 which added to the prototypes the long cheek fairings of AV-04, and all subsequent aircraft.

In December 1979 AV-05 made its maiden flight, followed by the last of the Phase 2 batch of three aircraft, AV-06, on 16 March 1980. This final aircraft was the first to fly with the definitive stabilator design and extended (by 10 in/25 cm) tail rotor. By April 1981 the prototypes had amassed over 1,000 flying hours. Performance milestones included a new top speed for the AH-64 of 206 kt (381 km/h, 237 mph) achieved in a dive by AV-04 with a further refined tail rotor design, and manoeuvres of +3^. In April 1980 a crucial landmark in the AAH story was reached with the selection of the Martin-Marietta TADS/PNVS for production. A two-month fly-off comprising day and night firings against autonomously-designated and ground-designated targets resulted in Martin-Marietta achieving a three-hits-from-three-firings record and winning a $45.6 million contract for a further 26-month development programme. Phase 2 concluded with a three-month Operational Test programme, from June to August 1980, during which three aircraft flew representative combat missions against simulated enemy armour, ADA and opposing aircraft. Sadly, 1980 ended on a tragic note. On 20 November 1980 AV-04 departed on a routine tail incidence/drag test, accompanied by a T-28D photo chase plane. Flying in close formation, the two collided, and only the pilot of the T-28 survived.

US Army test phase

In May 1981 AV-02/-03/-06 were handed over to the US Army, in preparation for the AH-64's final Operational Test II (OTII) evaluation at Ft Hunter-Liggett. This marked the first time the AH-64 had flown in service hands since the original 1976 fly-off. Under the eye of Army AAH Project Manager Major General Edward M. Browne (one of the strongest supporters of the AAH since before its inception), 2,500 hours were accumulated in advance of a major exercise with the 7th Infantry Division, in August. The AH-64 was deployed for 400 flying hours in difficult desert conditions where temperatures reached 110°F

Left: The AH-64A flight control system (FCS) consists of hydro-mechanical controls to the main and tail rotors, and an electrical stabilator. A digital automatic stabilisation system (DASE) augments the controls and a back-up control system (BUGS) is provided. Unusually, the back-up FCS on the Apache is a fly-by-wire system, utilising a single-channel non-redundant FCS. To engage the BUCS with a control jam the pilot has to exert enough force on the cyclic to break the shear pins of the SPADS (spear-pin actuated decoupler system). The computer-controlled DASE includes and/or controls the following: stability and command augmentation in pitch, roll and yaw; attitude hold; heading hold; hover augmentation; and turn co-ordination. DASE has a stability augmentation system (SAS) and a command augmentation system (CAS). The CAS augments helicopter response by mechanical control inputs and commands to the pitch, roll and yaw servo-actuators. The SAS reduces pilot workload by dampening airframe movement and weapon's recoil. SAS actuators also enable the Apache's hover hold/hover augmentation system, which provides the pilot with limited station-keeping or velocity-hold during low-speed flight. The Apache's auto-hover facility is restricted and unreliable, and since it uses the existing Doppler system a drift of up to 21 ft (6.4 m) per minute is to be expected.

(43°C). One of the most impressive performances of OPII was turned in by the Martin-Marietta PNVS, which had always been superior to its rival. The same was not true of its associated TADS. Design changes incorporated after Martin-Marietta had won the system fly-off forced a delay of six months in its development, and so defects remained to be corrected. Production go-ahead for the first batch of 13 TADS/PNVS systems was not obtained until 30 April 1982.

AH-64 for the Corps

In September 1981 the US Marine Corps conducted a limited (two-week) assessment of the AH-64's suitability for Marine operations, including shipboard compatibility tests. The Corps had a requirement for 120 AH-64s, for delivery in 1985, and so joined a list of other customers beginning to express an interest in the aircraft. These included Saudi Arabia and West Cermany, which had then launched its PAH-2 attack helicopter requirement. Also in September 1981, the first photographs of Soviet Mi-24 'Hinds' operating in Afghanistan were released. Soviet armed helicopter philosophy was quite different to the West's, particularly the doctrine being developed for the AAH, and so the Mi-24 was a very different beast to the AH-64. Nevertheless, the 'Hind' menace became yet another worry for NATO generals already horrified (in public at least) by Soviet armoured superiority in Europe. It also remained the most obvious 'Red' parallel to the AH-64. It was then, during the final stages of AAH Phase 2 testing, late in 1981, that the name Apache was first applied to the AH-64.

The deadline for an AH-64 production decision, known as DSARC III (Defense Systems Acquisition Review Council), was fixed for 10 December 1981. Funding for the first 14 aircraft (Lot 1) had already been included in the 1982 budget, which would, hopefully, see deliveries begin in November 1983 and IOC in October 1984. However, delays in assimilating the results of OPII delayed this decision until March 1982. It was not until 15 April 1982 that full-scale go-ahead for Apache production was finally given. There then followed a complicated delay in funding, not helped by the rising costs of the programme which had been steadily increasing since the oil crisis and recession of the mid-1970s. The $365 million that had been requested for FY82 was increased to $444.4 million, but now this would buy only 11 helicopters. As a result the next (Lot 2) batch of 48 AH-64s was put on hold until a new deal could be hammered out between the DoD and its contractors.

Below: This is the ill-fatedAV-04 (79-23257) which crashed on 28 November 1980. Before its loss, AV-04 was instrumental in proving the new tail design.

The issue of Hughes own in-house newspaper, **the Observer,** *dedicated to the Apache roll-out recorded the names of all the company executives, US Army officers, public representatives and other dignitaries who attended the 30 September 1983 roll-out of the AH-64-virtually everyone, in fact, except the Apache warrior who held centre stage at the ceremony. At that time the US Army had a requirement for 515 Apaches (by 1988) with 59 under form contract and 112 pending in the FY 84 budget.*

By autumn 1979 both prototypes had flown over 1,000 hours with the T-tail configuration. This had underlined Hughes original mistrust in that configuration, for the fatigue penalties incurred through rotor downwash were severe. As a result, a low-set, all-moving stabilator design was incorporated on AV-04, which solved the fatigue problems and also expanded the AH-64's flight envelope, with the trade-off of some engineering complications caused by its more complex design. The new vertical tail was extended by 3 in (7.6 cm) and the tail rotor repositioned 30 in (76 cm) higher to clear the new stabilator position. Some contractor delays set backAV-04's maiden flight, first scheduled for August, to 31 October 1979. During its first months of flight test activity, AV-04 Mailed several differing designs of stabilator leading to the definitive, smaller production design which was flown in March 1980. These changes were well in hand by the time AV-03 undertook brief naval trials with the US Marine Corps in 1981. This view of AV-03 also clearly shows the new blade tips adopted as a result of OPII testing. The shipboard element of the 1981 USMC evaluation was conducted with the USS **Pelelieu** *(LHA-5).*

Another element of fall-out from OPII was the decision to move to an uprated version of the T700 engine, the T700-GE-701, rated at 1,690 slip (1259 kW). The -701 engine had already been run on the SH-6013 Seahawk (as the T700-401) and the improved performance it promised would greatly benefit the Apache in 'hot-and-high' conditions. On 15 January 1982 AV-05 made its maiden flight with the new turboshaft which would become the definitive production engine for the Apache. Testing was completed by August.

Price wars

While the Apache embarked on a European sales tour in 1982 and completed advanced environmental testing in the US, disputes over its affordability continued. Hughes submitted its production proposals for Lot 2 while AV-02 was amazing the crowds at the Army Air 82 show, held at Middle Wallop - the home of British army flying - and the subsequent Farnborough air show. The US Army had increased its Apache requirement to 536 aircraft, but was then forced to cut this back to 446. On this basis Hughes estimated the total programme cost would be $5,994 million. The US Army had always accepted that the unit cost would creep up from $1.6 million (in 1972 dollars) but was now faced with a price per aircraft of over $13 million (rising to $16.2 million later that year). The AAH was faced with serious political opposition from proponents of a lower-cost Cobra-based aircraft, one which might be far more attractive to other customers such as Germany. (Germany conducted an evaluation of the AH-64 from 25 June to 1 6 July.) However, the Apache had powerful friends. A letter dated 22 July 1982, from General Bernard C. Rogers NATO C-in-C Europe to the Apache's chief detractors in the Senate, spelled out the threat to Europe posed by the Warsaw Pact, and the urgent need for a counter. It ended with the words "we need the AH-64 in Europe now and cannot afford the luxury of another trip to the drawing board."

A reassessment on all sides led to the conclusion of the Lot 2 production agreement in November 1982. Hughes agreed to supply 48 aircraft under the terms of three phased contracts, each worth $105.6 million. The US Army, in turn, increased its intended buy of Apaches to 515. Work continued apace at Hughes's huge newly-developed Mesa, Arizona facility, which had 240,000 sq ft (22300 nr) of floor space. Hughes had committed to build the facility in July 1981, as the November 1983 delivery date for the first Apache had remained constant throughout all the wrangling and uncertainty. Mesa acted as the assembly point for components sourced from 36 states, including the major airframe assembly supplied by Teledyne Ryan Aeronautical in San Diego. It was here that the first production Apache, PV-01, began to take shape in spring 1982. The first production TADS/PNVS set was delivered in July 1983. As the first three production aircraft progressed down the line at Mesa a welcome FY84 purchase of 112 aircraft was approved, bringing the total to 171 to date.

Apache handover

The first Apache for the United States Army was rolled out in a ceremony held at Mesa, ahead of schedule, on 30 September 1983 - eight years to the day of the first flight and just 18 months after ground had been broken at Mesa. The aircraft was accompanied by an Apache warrior, brandishing a rifle and riding a white horse, beneath a massive Stars and Stripes. The stated price of the aircraft, its 'over the fence' cost according to the then-Project Manager Brigadier Charles Drenz, was $7.8 million in 1984 terms or $9 million in real-year terms. This equated to a unit cost of approximately $14 million when development costs were included. Hughes planned to accelerate production to a peak of 12 per month by 1986, with purchases of 144 AH-64s in FY85 followed by 144 (FY86) and 56 in (FY 87) in prospect.

PV-01 made its 30-minute maiden flight on 9 January 1984, flown by chief test pilot Steve Hanvey and Ron Mosely. By then the prototype fleet had logged over 4,500 hours in the air. This noteworthy event was obscured in

the headlines by the announcement on 6 January 1984 that Hughes Helicopters was about to become a subsidiary of McDonnell Douglas. Under an agreement signed by Jack G. Real, President of Hughes Helicopters, Sanford N. McDonnell, Chairman of McDonnell Douglas, and William R. Lummis, administrator of the estate of Howard Hughes, McDonnell Douglas agreed to purchase 100 per cent of Hughes Helicopters' stock for $470 million (and to pay off debts owed to the estate) - a very reasonable price. The reasons for the sale of Hughes Helicopters for such a seemingly bargain basement price were not readily apparent. Certainly, after the death of Howard Hughes in 1976, the huge and complex industrial monster he left behind was labyrinthine and inefficient. Hughes Helicopters should have been in a healthy position, with a secure future and large order book, but Summa Corporation had incurred major debts to the estate of the late Howard Hughes and Hughes Helicopters itself, apparently, had not made a profit in 30 years. Although Hughes initially was allowed to operate under its original identity, its new ownership spelled immediate change. Aircraft production ceased at Culver City and the workforce there dropped from 5,000 to 1,800. It was Hughes Helicopters' 50th anniversary year.

Buy-out negotiations with McDonnell Douglas had been finalised on 16 December 1983, but prior to that Hughes attracted attention from 15 other interested buyers. A possible influencing factor in Summa Corporation's decision to dispose of Hughes Helicopters was revealed in 1985 when the US Army launched an investigation into McDonnell Douglas's accounting methods. Payments were suspended while Army Under-Secretary James R. Ambrose was ordered to investigate "serious charges of accounting irregularity." Major errors dating back to 1983, and beyond, were discovered. McDonnell Douglas defended itself, claiming that these problems predated its total assimilation of Hughes, but the Army disputed these claims, too. In the midst of these negotiations Hughes Helicopters finally disappeared, on 27 August 1985, to become the McDonnell Douglas Helicopter Company. The dispute between the Army and McDonnell Douglas did not directly involve the cost of the Apache, the price of which fell slightly as production continued. In FY86 terms the unit cost of an AH-64 was clown to $7.03 million, or $13.9 million if procurement, acquisition (type R&D and development expenses) and Hellfire development costs were included.

The first handover of an Apache to the US Army took place on 26 January 1984, although this was only a formality since the heavily-instrumented aircraft concerned, PV-01, would remain with Hughes/McDonnell Douglas along with PV-02. PV-03, handed over in May, was the first aircraft to be truly built to production standards, but initially it, too, remained in use with the manufacturer. PV-04 and PV-05 were the first examples to be handed over to the Army, in July 1984, and, along with four of their successors, operated from Mesa and the Yuma Proving Ground as part of the Initial Key Personnel Training (IKPT) programme. PV-08 and PV-10 were tasked with operational trials alongside the subject of the Army's Advanced Helicopter Improvement Program (AHIP) - the OH-58D Kiowa Warrior. These trials were conducted at Hunter-Liggett. It was not until the delivery of PV-13 that an Army crew could fly an Apache away and call it their own.

Air-to-air Apache

In 1984 the prospect of sales to the USMC was resurrected by the display of an aircraft at the annual Marine Corps League convention in Washington, DC. This was remarkable for the fact that the Apache was fitted with two AIM-9H Sidewinders, bolted on to the end of the stub wings. McDonnell Douglas also offered an air-to-air Stinger and anti-radiation Sidearm missile fit, for delivery to the Marines in 1988. The USMC has always wanted to acquire

Above: The AH-64's rotor blades feature a high (21-in/55-cm) constant camber and an additional fixed trailing-edge tab. This upturned tab positions the blades' centre of pressure for best aerodynamic performance (to 27° rather than the usual 25°), cancelling the nose-down pitching associated with a cambered airfoil. The airfoil section was named HH-02 and is based on the NASA 6400 airfoil. Each blade has five stainless steel spars to reduce the effect of a direct hit, coupled with separate skin plates to prevent cracks propagating. Approximately 60 per cent of each blade is load-bearing (stainless steel) structure. The rest of the blade comprises composite Nomex honeycomb and a fibre-glass skin. Each blade has a leading edge of 040-gauge AM355 stainless steel and a submerged de-icing blanket to provide resistance to abrasion. The US Army requirement for resistance to sand erosion specified 450 hours of hovering over sand before replacement.

Above left: This 1989 view of the Mesa plant shows AH-64A production in full swing. The Mesa facility was purpose-built by Hughes Helicopters, which was bought out by McDonnell Douglas in 1984 and became the McDonnell Douglas Helicopter Company in 1985. The plant was expanded, in 1986, from 570,000 sq ft (52950 m²) to an immense 1,904,500 sq ft (176930 m²).

AH-64 Apache and Longbow Apache

Above: The AIM-9 Sidewinder missile was first introduced to the AH-64A as a result of USMC interest in the aircraft. Tests were also undertaken, in 1988, with the Sidewinder-based AGM-122A Sidearm anti-radiation missile.

Right and below: Both Apache crew can use the Honeywell IHADSS helmet-mounted display as their primary flight information display and weapons controller. The helmet's monocle sight can be slaved to the Chain Gun" cannon to follow the crew member's line of sight (below).

Apaches (and has also placed a stronger emphasis on helicopter air-to-air operations that the US Army) but the Apache's price tag has kept it off the Corps' shopping list to this day.

First deliveries, first problems

Initial deliveries were made to US Army Training and Doctrine Command (TRADOC) bases at Ft Eustis, Virginia (home of the Army logistics school), and Ft Rucker, Alabama (the Army's centre of flying training). Qualified pilots transferred from Ft Rucker to Ft Hood, Texas, where units were trained at a battalion level. By the mid-1980s the free-spending Reagan years were in full swing, and in autumn 1984 Defense Secretary Casper Weinberger authorised the acquisition of an additional 160 Apaches (at an FY85 cost of $1.6 billion), bringing the total on order for the Army to 675. This was subsequently increased yet again to 807 aircraft, a number which surprised even the Army. With an eye on the ever-rising costs of the Apache the Army suggested that 48 AH-64s of the FY85 acquisition be delayed, but this was rejected by Congress on the grounds that it would actually add $1.2 million to the unit cost by lengthening the production schedule. Apache acquisition was ultimately amended as follows: 138 (FY85), 116 (FY86), 101 (FY87), 77 (FY88), 54 (FY89), 154 (FY90) and a follow-on batch of 10 (FY95), for a grand total of 827 AH-64A Apaches. The unevenness in these numbers is a reflection of the troubles that hindered Apache production throughout those years. The acceleration to the 12 aircraft per month target *did* not go smoothly, and neither did Hellfire or TADS/PNVS development/production. Then the investigation by the Defense Contract Auditing Agency (as mentioned above)

intervened and by June 1985 the US government was withholding funds amounting to $3,500 million from McDonnell Douglas.

By January 1986, 68 aircraft had been handed over when suddenly a new and more serious problem reared its head. On 15 January routine maintenance discovered a crack in a rotor blade, a component that had a 4,500-hour service life but had in fact only accumulated 330 hours. Another 12 cracks were found across the inventory. On 27 January 1986 the Apache was grounded, and the US Army refused to accept any more deliveries. Hughes/McDonnell Douglas had been proud of the survivability tests the rotor system had passed, and photographs of the blades intact after hits from 23-mm shells were the centrepiece of every company presentation. The outcome of a rapid and intensive investigation was an immense relief to all concerned: the fault lay not with the design or materials or manufacturing process but with a defective tool that creased the trailing edge of the blade. Later that year a second fault arose when a flight critical bolt failed in the flight control system. The hardened bolt, supposedly proof against a 12.7-mm round strike, had suffered hydrogen embrittlement and sheered off. Although these bolts were replaced with a revised material, the example that broke was found to be the only one so affected.

Into the field

The first unit to convert to the Apache was the 7th Battalion, 17th Cavalry Brigade at Ft Hood, which began its 90-day battalion-level conversion in April 1986. The 7-17th was followed by the 1st and 2nd Battalions, 6th Cavalry Regiment, 6th Cavalry Brigade. These two units departed the United States in September 1987 for the Apache's first deployment to Europe. Their 38 AH-64s were part of Reforger '87 (REturn of FOrces to GERmany), flying 725 hours in large-scale exercises in night and bad weather to achieve a mission-capable rate of 90 per cent. Upon completion, the aircraft of the 1-6th remained at Illesheiin to became the first Apache unit to be based in Europe, while its sister battalion returned to Ft Hood. By 1990 Germany had became home to eight AH-64 battalions, with over 160 aircraft. As early as 1987 Apaches were replacing Cobras in Army National Guard units. The first was D Company, 28th Aviation Regiment, North Carolina ANG. By 1991 nine regular Army units were active in the USA and, by 1994, 33 of 35 battalions (including seven Army National Guard and two Army Reserve battalions) were combat ready. By 1 September 1989 McDonnell Douglas had handed over 500 Apaches. The 700th delivery was made in December 1992 and the 800th AH-64 was delivered in July 1993. ARI (Army Restructure Initiative) 'downsizing' cut back the number of intended/deployed Apache units and changed their composition. However, although units were withdrawn from Germany, the first Apaches arrived in Korea in March 1994 with the 17th Aviation Brigade (5-501st AVN). The last of 821 AH-64As destined for the US Army (excluding prototypes) was delivered on 30 April 1996. This was the 915th production Apache.

Over 200 AH-64s have been ordered by export customers. The first of these was Israel, in 1990, followed by Saudi Arabia, United Arab Emirates, Egypt, Greece, the Netherlands and the United Kingdom. Details of these users and other prospective Apache customers can be found in the AH-64 operators section that follows. Confirmed Apache production, in early 1997, stood at 1,040 aircraft for delivery by the year 2000.

HARS (heading and attitude reference system) is the Apache's inertial navigation system which uses a Doppler radar altimeter and stabilised gyros to provide the pilot with attitude signals for pitch, roll, yaw and heading, along with velocities and acceleration. On engine start-up the HARS requires six to nine minutes to spin up and align itself, although a hasty and less accurate start can be made within four to six minutes. Of course, if the helicopter has not moved since the HARS was last shut down, realignment can be accomplished in 90 to 120 seconds. The Apache's reliance on Doppler is one of its greatest shortcomings. Doppler errors are easily induced, particularly over water, so a strap-on GPS kit is essential mission equipment (though it is not approved as a primary flight instrument). This situation will change with the arrival of the AH-64Dandits embedded GPS.

Above: TADS that have been upgraded to OI (optically improved) configuration - that is, most in service - have been modified with a series of optical filters to protect the CPG from laser energy. They will also protect the FUR from video 'bloom' caused by lasers. Four filter setting are available: normal (clear, no protection), S (Short, provides protection against short-wavelength lasers), L (Long, protects against long-wavelength lasers) and MAX (combined L and S filters). The DVO system has filters applied to fixed optics which are thus always in place.

After a long and somewhat troubled development, the Apache began to establish itself as the world's premier battlefield helicopter. The Apache's sophistication brought with it the ability to conduct regimental-sized operations, at night, in the European theatre. The key to its success was its TADS/PNVS sensor system, which for many years had no rival, and the Hellfire missile which has always solidly maintained its claim to be able to destroy any target on the battlefield. Allied with this was the US Army's comprehensive training and exercise system which has evolved to such a degree that the full-scale air/land manoeuvre battles now fought at the US Army's National Training Center are accomplished as a matter of routine. The US Army trains to fight at night. It has poured money into giving all its combat forces - air and land - the ability to manoeuvre and fight around the clock. Desert Storm experience underlined how effective this capability is against an enemy unprepared for fighting in the dark. For Apache crews, night-time operations are perhaps even more crucial, as the AH-64's vulnerability to infantry SAMs and gun fire is immeasurably increased on the daytime battlefield. The AH-64 crew can conduct NoE operations at night, locate, identify and destroy targets and then find their way home again - thanks to the Apache's TADS/PNVS.

TADS/PNVS and IHADSS

Design of the TADS/PNVS system and the AAH went hand-in-glove. The system chosen for the AH-64 was built by Martin-Marietta (now Lockheed Martin Orlando) and approved for production in February 1982. As its awkward acronym implies, the system is divided into two parts - the AAQ-11 Mk III PNVS and AN/ASQ-170 TADS - which are independent of each other. The system comprises a dual FLIR for pilot and gunner with additional optical sensors and a Litton Laser Range-Finder/Designator (LRF/D). The steerable PNVS (Pilot's Night Vision System) is mounted above the Apache's nose and provides wide-angle (40° horizontal x 30° vertical field of view/FoV) FLIR imagery for the pilot. The PNVS can be slewed up to 90° off the aircraft's centreline and +20°/-45° in elevation. When not in use the sensor housing can be rotated through 180° to protect its optics. FLIR imagery can be displayed on the pilot's console 5.5-in x 5.5-in (14-cm x 14-cm) CRT Video Display Unit (VDU). The VDU is used typically as a back-up system, because the Apache is flown, and fought, using the Honeywell IHADSS (Integrated Helmet and Display Sight System).

The huge IHADSS helmet, which incorporates standard visors (including laser protective visors) and radio, has a helmet-mounted sight for the right eye, which uses a bulky side arm to mount a small combiner glass in front of the eye. This is the HDU (Helmet Display Unit), or 'hudu'. The pilot's PNVS imagery can be displayed on the HDU, with flight information overlaid, in the same fashion as a conventional aircraft HUD. The PNVS FLIR produces a one-for-one image - it has no magnification - so the (two-dimensional) image the pilot sees in the HDU should correspond with the view outside the cockpit. The PNVS and IHADSS can be slaved so that the FLIR follows the pilot's head and looks where he is looking. An IR head tracking system mounted behind each Apache crew member's head will slew the PNVS at a maximum rate of 120%ec in azimuth and 93°/sec in elevation, and it can be used to cue the gunner's TADS FLIR.

The TADS (Target Acquisition and Designation System) is more complex, and boasts slightly better FLIR imagery. The TADS system is housed below the PNVS using two roughly hemispherical turrets mounted side-by-side yet capable of independent movement. The complete TADS system can be slewed through 120° and from +3()°/-60° in elevation, and is divided into 'day' and 'night' sides. To starboard is the massive 23-cm (9-in) aperture FLIR which is equivalent to the PNVS FLIR. The CPG's (Co-Pilot/

Right: The Apache's fixed rotor mast allows the transmission and gear box to be removed without interfering with the main rotors. The rotor mast is fixed to the fuselage at eight points and, as the rotor drive shaft runs through it, no flight loads are imposed upon the drive shaft itself. This greatly aids the Apache's agility.

Gunner) FLIR differs from the pilot's in having selectable fields of vision: 50°, 10°, 3.1° and 1.6°. Target tracking can be achieved manually, with the image auto-tracker or the laser spot tracker. The spot tracker facilitates target handover from another laser designator. The image auto-tracker has the capability to offset-track one target while automatically tracking another. Automatic linear motion compensation aids in the tracking of moving targets. All TADS imagery can be relayed to the CPG's 'hudu', or the 'ort'. The ORT (Optical Relay Tube) is a small monochrome display in the front cockpit, positioned in the middle of the 'T-bar' of weapons/laser controls that dominates the CPG's station. From here the co-pilot can control all the Apache's weapons and sensors.

Finding and marking targets is the job of the TADS, and on the port side of the nose are the rest of the systems required to do this. Here the TADS has three windows, arranged like traffic lights, behind a vertical, two-facet optical screen. The uppermost of these sensors is the DVO (Direct View Optics) — an optical telescope with a x4 magnification capability at an 18° FoV or x!6 magnification at 4° FoV. Beneath this is a near-IR TV system which offers up to x127 magnification with a much-reduced FoV (as little as 0.45°). The third station houses the Apache's laser rangefinder and target marker. All the TADS/PNVS have filters to protect the crew from the potentially devastating effects of battlefield lasers. The Apache's own neodymium laser is definitely not eye-safe and has an effective range of up to 20 km (12 miles). All Apache training ranges must have a large (21 km/13 miles wide) laser backstop.

FLIR pros and cons

The TADS/PNVS system was once without equal and there is still nothing better in service. However, it was over 10 years in development and it has been over 10 years since it was fielded, so, needless to say, technology has moved on significantly. Perhaps the biggest flaw in the TADS/PNVS system was incurred at the very beginning of the AAH design. Mounting the sensors on the nose of the aircraft, just about the lowest point on the Apache apart from the gun and the wheels, forces the AH-64 to unmask completely from terrain to find/designate targets. Keeping the optics stabilised and remote from airframe vibration was a major concern, so a mast-mounted solution was rejected from the start. At the time it was seen as too great a technical challenge. A roof-mounted sight was not included on any AAH design, either, so the Apache was built around a nose-mounted sensor fit. The TADS/PNVS uses two sets of gimbals - a 'coarse' outer set and a 'fine' inner set — coupled with rate-integrated gyros to keep the sensor turrets aligned and stable. Apache maintainers know that the system is not perfect and will admit that the bulk of the aircraft's regular down-time is caused by vibration-induced malfunctions — as one said, "90 per cent of my problems are in that nose." Apache crews know that the one rule for TADS/PNVS operations is to "boresight, boresight and boresight", to ensure that the system is always up and running correctly.

Ironically for a helicopter designed to fly and fight on the Central European Front, typical central European cold wet weather causes the biggest problems for the AH-64 FLIR. All FLIRs are subject to IR crossover, a phenomenon encountered when humidity and ambient temperature conspire to turn target and terrain the same cold, flat temperature, and the AH-64A FLIR offers no discrimination between either. In situations where target discrimination is not completely clear the CPG can change the polarity on the targeting FLIR, switching from 'white hot' to 'black hot'. The system also has selectable, infinite gain (contrast). Acknowledged limitations in FLIR performance are an important reason why the Apache has a combined FLIR/TV system.

The Apache has a video-recording system linked to the TADS/PNVS. Although now outdated and bulky (and incompatible with any other outside video system), the tactical benefits of such an onboard system are immense. Having reached its battle position under cover, the Apache will pop up, quickly view the target, record the scene and then remask to watch the tape. This allows the crew the luxury of assessing the enemy at length without endangering themselves. Over the tactical radio net, the Apache teams will then make the final engagement decisions, allocate targets, fine-tune the shooter/designator pairs, and wait for the word to go. A new 'Hi-8'-based video system is currently in flight-test for the AH-64A. Developed by TEAC and Merlin, the new recorder uses an industry-

The Apache is fitted with the AN/APR-39(V)1 or APR-39A(V)1 radar warning receivers. The RWR cockpit display produces a radial strobe showing a line of bearing to the detected radar. An audio signal is emitted from the RW control panel and in the crews' headphones. The alarm's frequency represents the strength of the threat signal. A missile alert lamp is also illuminated. The RWR can be set to alert the crew to specific signals or all emissions in the area. AN/APR-39A(V)1 is more advanced and uses an onboard threat library to identify radars and display appropriate symbology. APR-39A(V)1 also has a more sophisticated aural warning. If a threat is detected a synthetic voice will announce, "SA, SA-8 12 o'clock tracking." A second mode provides a more terse warning: "missile, missile 12 o'clock tracking." Twin RWR antennas are located on the rear of the fin cap and forward on cheek fairings. A single antenna is found under the tailboom.

Above: This array of Apache weapons includes Sidewinder and Sidearm missiles (far left, far right), twin Mistral AAMs (foreground), 1,200 rounds of30-mm shells, 76 2.75-in rockets, 16 Hellfires and wingtip-mounted Stinger AAMs.

Top: The Chain Gun' cannon fires 30-mm M788/789 orADEN/DEFA shells. The gun is mounted in a hydraulically-driven housing capable of slewing the gun up by 11°, down by 60° and up to 100° off the centreline. The gun stows in the full up (+11°) position and in the event of hydraulic loss will return to this position, in the then-current azimuth. The gun duty cycle is as follows: six 50-round bursts with five seconds between bursts, followed by a 10-minute cooling period. If the burst limiter is set to exceed 50 rounds, no more than 300 rounds can be fired in a 60-second period.

standard format that offers sharply increased horizontal line resolution, with output at 525-line standard (the existing Apache system uses a non-standard 875-line resolution).

M230E1 Chain Gun" cannon

The Apache's weapons are divided into two (tactical) categories: area weapons and point weapons. Starting at the front of the aircraft, the M230 Chain Gun" cannon is the Apache's secondary area weapon (due to its relatively short range). The Chain Gun" was a unique invention, pioneered by Hughes as an integral part of the AH-64's development. The concept behind the Chain Gun" is straightforward. The name derives from its ammunition feed mechanism, which uses a one-piece metal chain to feed linkless shells from a central magazine. Hughes had already done substantial research on 7.62-mm and 20-mm chain gun concepts and scaled up their designs to produce the 30-mm M230. Using aluminium-cased ammunition (half the weight of brass), the Apache can carry approximately 1,200 rounds (the AAH requirement was for 320) — 1,100 in the magazine and 90 in place on the chain feed to the gun. The gun's feed mechanism is a continuous, flat rectangular 'loop' driven by a 6.5-hp (4.84-kW) motor. The chain loads ammunition (along the starboard side of the aircraft) into the breech and seals it until the gun is fired - a simple system resistant to dirt and wear. The M230 fires a 'loosely NATO-standard' round, compatible with the UK's ADEN and French DEFA 30-mm shells. The gun fitted to production Apaches is the M230E1, which can trace its lineage back to the XM230A, first test fired in April 1973. It has a maximum rate of fire of 600-650 rounds per minute (60 per second) and 'spools up' to this rate in just 0.2 seconds. Time of flight to 1,000 111 (3,280 ft) is two seconds, and 12.2 seconds to 3000 m (39,843 ft). The Chain Gun" is accurate, but is used primarily as an area weapon for suppressive fire 'to keep heads down'.

One extra item of equipment that crews would have liked during Desert Storm was a laser tracker to follow rounds 'down range'. The Apache does not carry tracer rounds, so, if firing at night, the gunner can only see his fall of shot if rounds are actually impacting on the target at which he is looking. If the gunner is 'head-down' using the TADS and the gun is not correctly aligned, the gunner may have to zoom back out from the target to redirect his fire, possibly losing the target in the process.

Conventional M230E1 ammunition is the M789 HE dual-purpose (HEDP) round. Each shell has a 0.76-oz (21.5-g) explosive charge and a shaped charge liner that collapses, upon impact, into an armour-piercing molten metal jet. The projectile body also fragments up to a range of 4 m (13 ft). In tests, Chain Gun*-fired rounds penetrated more than 2 in (5 cm) of rolled homogenous armour at 2500 m (8,202 ft), but, during Desert Storm, Apaches destroyed T-55 tanks with the Gun alone. For fire training purposes inert M788 rounds are used, while dummy M848 rounds are used for function checks of the gun mechanism.

Rockets — the area weapons system

The Apache's primary area weapons system is its 2.75-in rockets. The rockets in use today are known as the Hydra 70 family, a name which applies to any warhead fitted to the Mk 66 rocket motor. The Mk 66 has replaced the earlier Mk 40 motor and has a longer tube, improved double-base solid propellant and a different nozzle/fin assembly. Increased velocity and spin improve trajectory stability for better accuracy, though its smoke trail and launch signature remain the same as the Mk 4()'s. Mk 66 rockets were developed by the Army's Redstone Arsenal and are carried in a 19-round pod, although a seven-round pod is also available. The pods are inexpensive enough to be disposable, but are sturdy enough to be reused. Rocket warheads come in several forms. The most basic of these is the M151 HE warhead, traditionally referred to as the '10-pounder'. The Ml51 is an anti-personnel, anti-material warhead with a burst radius of 10 m (33 ft). Fragments are lethal up to 50 m (164 ft). The M274 Smoke Signature (training) round is a ballistic match for the Ml51. It carries a potassium perchlorate/aluminium powder charge to provide 'flash, bang and smoke' for training.

The M229 HE warhead is referred to as the '17-pounder' and uses 4.8 Ib (2.17 kg) of B4 high-explosive, the same as in the Ml 51. The M247 HE warhead is no longer in production but is held in reserve stocks. It uses a small shaped-charge warhead of composition B explosive.

The 13.6-lb (6.16-kg) M261 HE multi-purpose submunition (MPSM) warhead can be used against light armour and vehicles. It adds an M439 fuse, programmable to detonate between 550 m (1,640 ft) and 7000 m (22,966 ft), along with nine M73 submunitions. The M73s are dispensed approximately 150 m (492 ft) above the target. Each

bomblet has a steel body and a 3.2-oz (91-g) shaped charge to penetrate armour. The submunition then explodes into approximately 195 fragments, each travelling at 5000 m/sec (16,404 ft/sec). At 1000 m (3,280 ft) a single M261 warhead will cover an oval area of 56 x 17m (184 x 56 ft), decreasing to 22 x 13 m (72 x 43 ft) at 5000 in (16,404 ft). Each M73 can penetrate up to 4 in (10.16 cm) of armour. The M267 Smoke Signature (training) round uses three M75 practice submunitions with small pyrotechnic charges. The M267 fulfils the same training role as the M274.

The M255E1 flechette warhead contains 1,180 60-grain hardened steel flechettes and is primarily an anti-personnel/ soft target weapon, although it does have a limited air-to-air application. Ml56 White Phosphorous (smoke) rounds are used for target marking and incendiary purposes. The Ml56 has a 2.2-lb (1-kg) WP filler with a small HE bursting charge. The M257 Illumination warhead provides one million candlepower over an area of 1 knr (10,764 sq ft) for at least 100 seconds (descending on a parachute at 4.5 m/sec; 15 ft/sec).

Close-in tactics

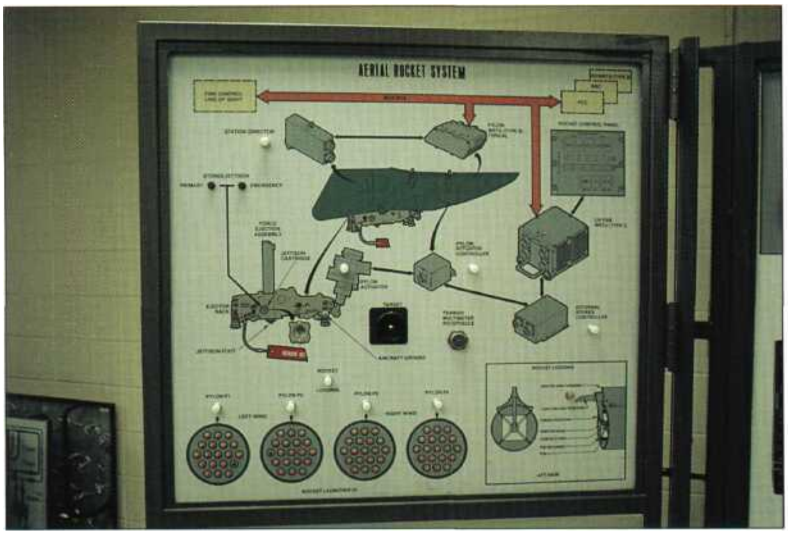
Rocket and gun attacks can be made from the hover, as running fire or as diving fire. Before any attack, it is crucial to remember to check the 'four Ts' -- Target (verify azimuth, and that target is correct), Torque (select the correct torque required to maintain altitude and do not change it), Trim (horizontal and vertical) and Target (check it again). When firing in the hover the AH-64 pilot may not be able to see directly over the aircraft's nose and will have to use other reference points to maintain position. When engaging a target with running fire the Apache crew will select an IP 8 to 10 km (5 to 6.2 miles) from the target, then depart the IP flying NoE to mask the helicopter's approach. At 6 km (3.7 miles) the Apache will pop up just enough to reacquire the target visually, then level out. Rocket engagements can begin at 5000 m, cannon at 1500 m, and the aircraft will enter a shallow (3° to 5°) 100-kt (184-km/h, 115-mph) dive before opening fire. The pilot should disengage at 3000 m (using rockets) or 1000 m (using guns) to break for terrain cover. The helicopter should never overfly the target.

Diving attacks are used only in circumstances where there is minimal ADA (air defence artillery) and LoS to the target is obstructed, or a high concentration of firepower is needed at a precise point, or weight/temperature restrictions prevent hover fire. From approximately 3000 ft AGL the Apache will dive at 10° to 15° (30° for a steep dive) and engage the target before breaking away above 1000 ft AGL. Dive recovery has to be planned in time to avoid the controls 'mushing' from an abrupt recovery at high airspeed.

The altitude from which rockets are fired, and the range to target, determine the angle of impact and fragmentation pattern. Rockets fired with a high angle of impact produce fragmentation patterns that are close together. A rocket fired at NoE altitudes produces an elongated pattern.

Of course the key to the Apache's success as a tank-killer is its point target weapons system - the Rockwell AGM-114 Hellfire missile. Each Hellfire is just 7 in (17.8 cm) in diameter, 64 in (162.5 cm) in length and weighs 99.5 Ib (45 kg), except for the AGM-114F which is slightly longer and heavier. The basic weapon, the AGM-114A, is no longer in production and stocks are being used in live-fire training. The AGM-11413 is a version for naval use with HERO (Hazard of Electronic Radiation to Ordnance) safeguards. The AGM-1 14G is the baseline model in current Army

The Apache training system



All aviators who come to Ft Pucker for Apache training begin their studies in the classrooms of the Goodhand Simulator complex, learning about the basic systems of the AH-64. This elementary, but essential, phase involves a series of animated 'billboards' and a lot of 'book learning'.

More sophisticated systems training is undertaken on the TSDT- TADS Selective Task Trainer. Ft Pucker has eight TSDTs (including two on the flight line at Hanchey AAF),which use Silicon Graphics computers to generate FUR imagery and symbology, and teach basic cockpit 'switchology'.

Left: The third stage in Apache training sees students progressing onto the CWEPT (Cockpit, Weapons and Engine Procedure Trainer). Students start in the back (pilot's) seat to learn engine start/shut-down procedures. This is often their first encounter with twin-engined helicopter operations. In 1996 Ft Pucker trained 275 Apache fliers, 75 of whom were for the US Army.

Below: This is the control desk for the unique Apache Crew Trainer, from where missions are monitored and controlled.

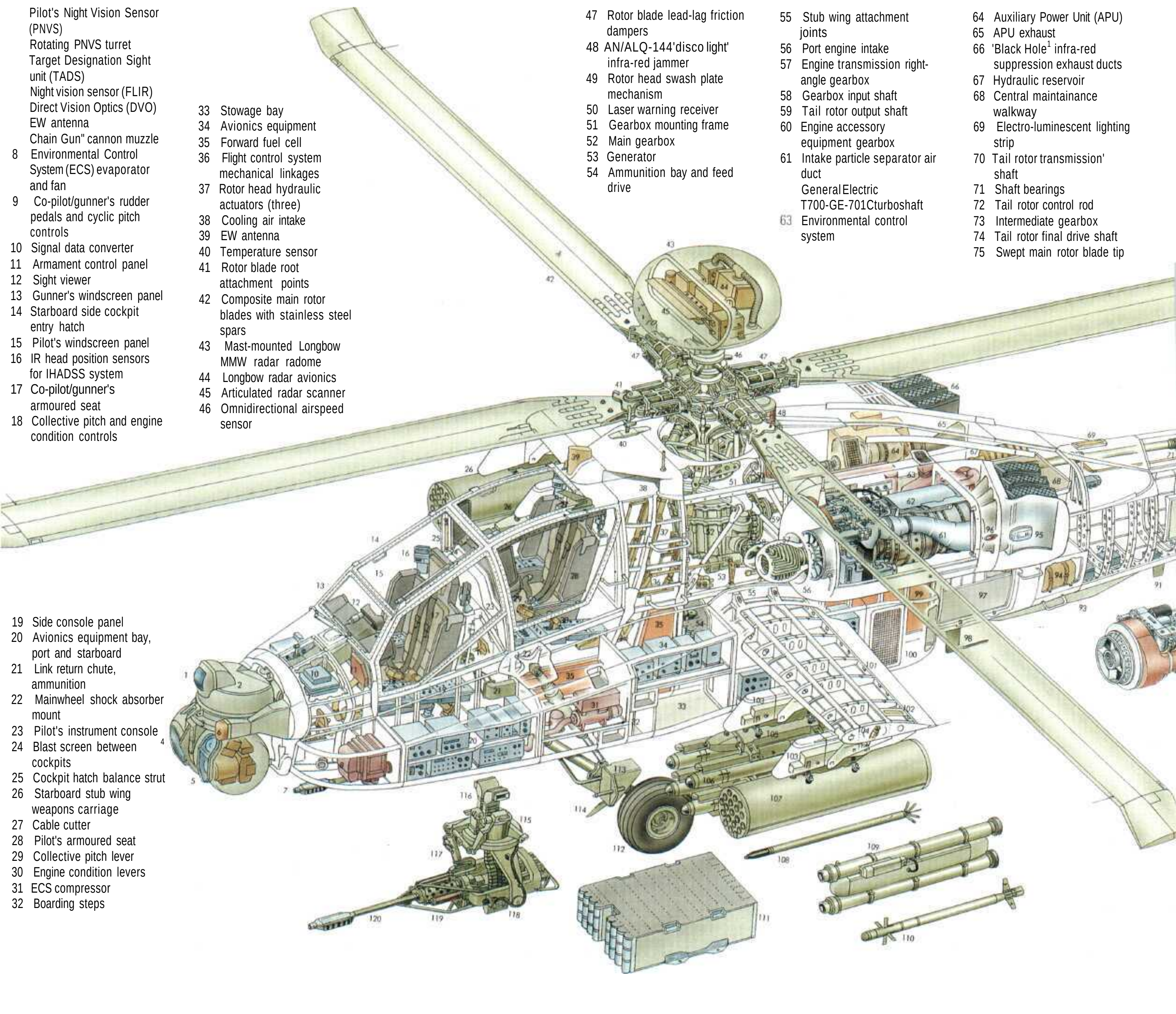
Above: A single Apache Crew Trainer (ACT) has been built from a modified CWEPT, to which has been added wrap-round screens plus an Evans and Sutherland 3-D graphics system. The ACT allows crews to fly realistic missions (using a complete graphical terrain database of Ft Pucker), while integrating FLIP and HDU flying. A developed version of this system, for the AH-64D, will allow missions to be 'flown' and linked to other participants, via satellite - a revolutionary mission planning aid.

Right: Ft Pucker's AH-64A full-motion simulator was developed at a time when computer graphics technology did not have the capability to accommodate two crew in one station, so pilot and CPG sit separately while 'flying' the same aircraft.

Left: *The front (CPG's) cockpit of the AH-64A is dominated by the ORT and its 'T-bar' handgrip. On the front console the CPG has a fire control panel (left) and a set of basic flight instruments (right). On the port side-console (from front to back) can be seen the Hell fire missile control panel, data entry keyboard, anti-icing controls, power lever quadrant, fuel control panel, interior lighting controls and circuit breakers. The starboard side-panel contains the communications system control panel, AN/ARC-186 radio controls, Doppler control panel and a blank area (with provision for KY-58 secure voice control) used for map storage. The pilot and CPG have identical collective controls, but slightly different cyclic grips. The CPG cyclic (centre stick) is folded to the floor in this photograph.*

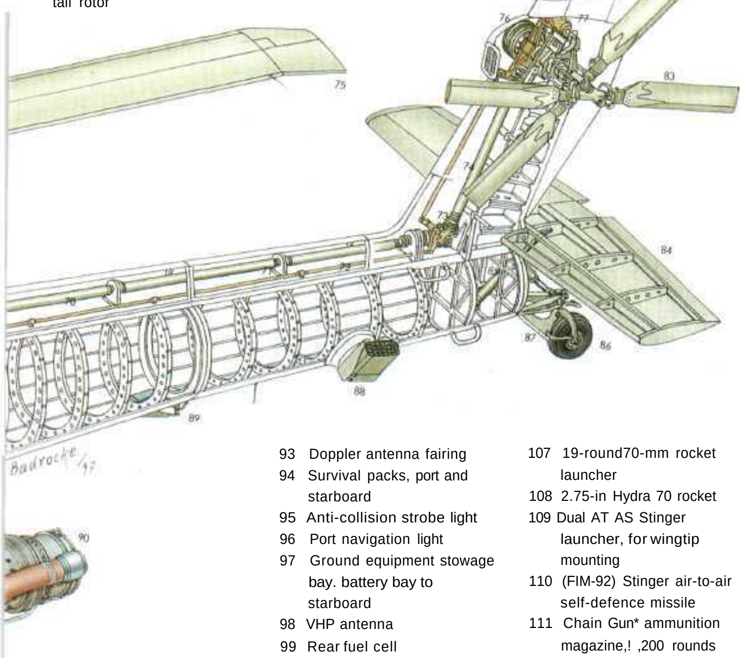
Above: The ORT (Optical Relay Tube) is the primary station where the CPG can monitor TADS/PNVS imagery, then select, designate and shoot targets. Its bulky construction is also the greatest threat to the CPG's well-being in the event of a crash. The hooded monocle display at the top can be used head-down, while the screen below allows the CPG to remain 'head-up'. Beneath the open screen are video-source (TADS or PNVS) and filter selection switches. Flanking the open screen are gain, brightness, grey-scale and FoV adjustment switches. On the left-hand grip can be found the sensor select switch (FLIR, DVO, DTV), weapons action switch (gun, rocket, missile), weapons trigger, primary FoV (wide, medium, narrow, zoom) controls and image autotracking controls. On the right side of the 'T-bar' grip can be found the laser spot tracker controls, manual turret slew controls, FLIR polarity switch (black/white), video recording switch, main laser trigger and boresighting controls.

AH-64D Longbow Apache



Pilot's Night Vision Sensor (PNVS)
Rotating PNVS turret
Target Designation Sight unit (TADS)
Night vision sensor (FLIR)
Direct Vision Optics (DVO)
EW antenna
Chain Gun" cannon muzzle
8 Environmental Control System (ECS) evaporator and fan
9 Co-pilot/gunner's rudder pedals and cyclic pitch controls
10 Signal data converter
11 Armament control panel
12 Sight viewer
13 Gunner's windscreen panel
14 Starboard side cockpit entry hatch
15 Pilot's windscreen panel
16 IR head position sensors for IHADSS system
17 Co-pilot/gunner's armoured seat
18 Collective pitch and engine condition controls
19 Side console panel
20 Avionics equipment bay, port and starboard
21 Link return chute, ammunition
22 Mainwheel shock absorber mount
23 Pilot's instrument console
24 Blast screen between cockpits
25 Cockpit hatch balance strut
26 Starboard stub wing weapons carriage
27 Cable cutter
28 Pilot's armoured seat
29 Collective pitch lever
30 Engine condition levers
31 ECS compressor
32 Boarding steps
33 Stowage bay
34 Avionics equipment
35 Forward fuel cell
36 Flight control system mechanical linkages
37 Rotor head hydraulic actuators (three)
38 Cooling air intake
39 EW antenna
40 Temperature sensor
41 Rotor blade root attachment points
42 Composite main rotor blades with stainless steel spars
43 Mast-mounted Longbow MMW radar radome
44 Longbow radar avionics
45 Articulated radar scanner
46 Omnidirectional airspeed sensor
47 Rotor blade lead-lag friction dampers
48 AN/ALQ-144'disco light' infra-red jammer
49 Rotor head swash plate mechanism
50 Laser warning receiver
51 Gearbox mounting frame
52 Main gearbox
53 Generator
54 Ammunition bay and feed drive
55 Stub wing attachment joints
56 Port engine intake
57 Engine transmission right-angle gearbox
58 Gearbox input shaft
59 Tail rotor output shaft
60 Engine accessory equipment gearbox
61 Intake particle separator air duct
General Electric T700-GE-701C turboshaft
63 Environmental control system
64 Auxiliary Power Unit (APU)
65 APU exhaust
66 'Black Hole' infra-red suppression exhaust ducts
67 Hydraulic reservoir
68 Central maintainance walkway
69 Electro-luminescent lighting strip
70 Tail rotor transmission' shaft
71 Shaft bearings
72 Tail rotor control rod
73 Intermediate gearbox
74 Tail rotor final drive shaft
75 Swept main rotor blade tip

76 Final drive right-angle gearbox
77 Tail rotor pitch control servo actuator
78 VHF/FM antenna
79 Electro-luminescent formation lighting strip
80 GPS antenna
81 Rear radar warning antennas
82 Tail navigation light
83 Dual twin-bladed teetering tail rotor
84 All-moving tailplane
85 Tailplane hydraulic actuator
86 Castoring tailwheel
87 Cable deflector
88 Chaff/flare launcher
89 ADF antenna
90 Rolls Royce/Turbomeca RTM 322 alternative engine for British army aircraft
91 IFF antenna
92 ADF loop antenna



93 Doppler antenna fairing
94 Survival packs, port and starboard
95 Anti-collision strobe light
96 Port navigation light
97 Ground equipment stowage bay. battery bay to starboard
98 VHP antenna
99 Rear fuel cell
100 ECS condenser
101 Port stub wing
102 Electro-luminescent formation lighting strip
103 Weapons pylons with articulated carrier/ launchers
104 Articulated carrier hydraulic actuator
105 Four-round missile launcher
106 Hellfire anti-armour missiles, maximum load 16
107 19-round70-mm rocket launcher
108 2.75-in Hydra 70 rocket
109 Dual AT AS Stinger launcher, for wingtip mounting
110 (FIM-92) Stinger air-to-air self-defence missile
111 Chain Gun* ammunition magazine,! ,200 rounds
112 Port mainwheel
113 Boarding step
114 Cable cutter
115 Swivelling ventral gun turret mounting
116 Ammunition feed and link return chutes
117 Gun elevation hydraulic actuator
118 Articulated gun mounting frame
119 Cable deflector framework
120 M230 Chain Gun" 30-mm cannon

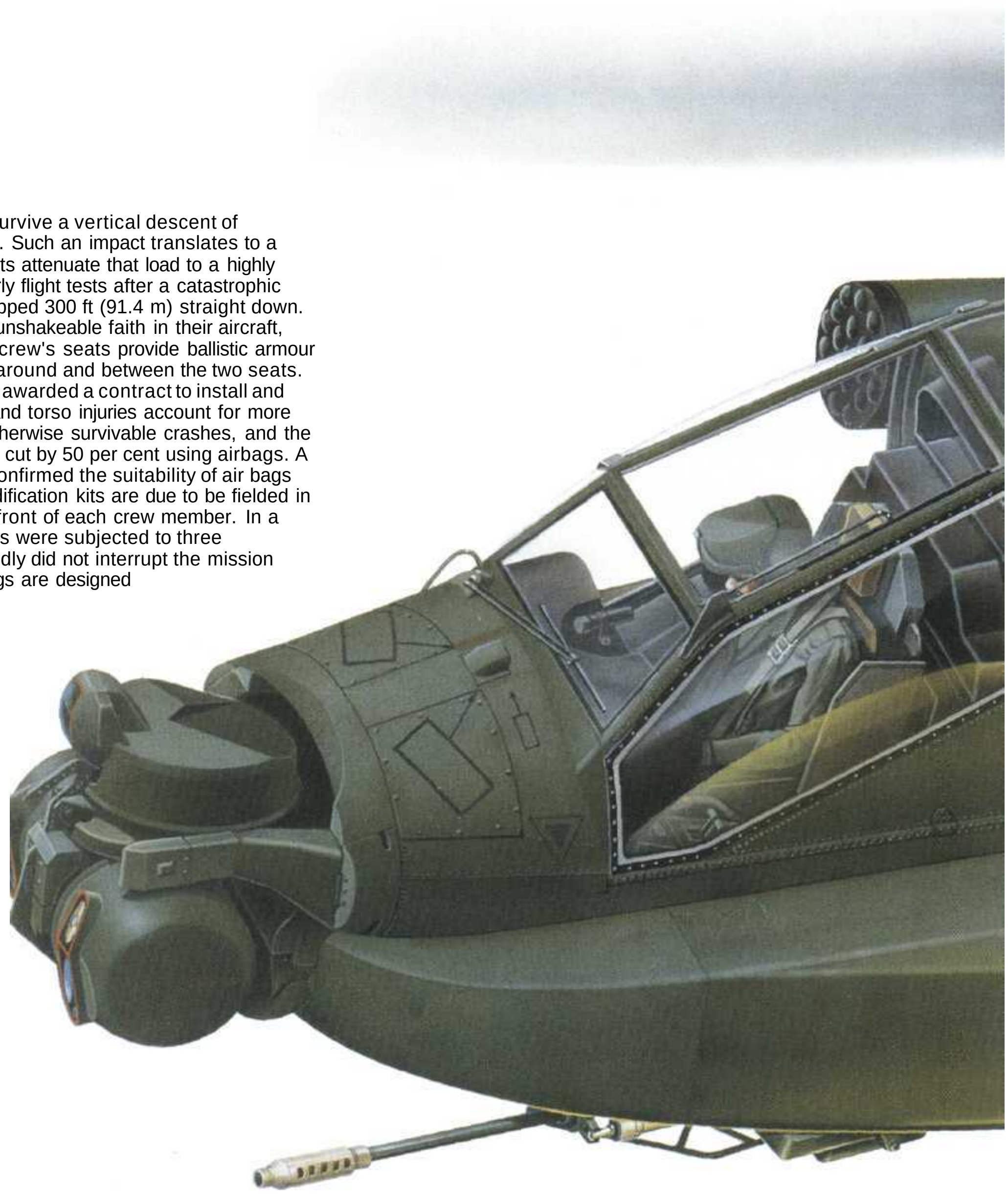
Above left: The rear (pilot's) cockpit on the AH-64A has an instantly more spacious feel to it than the CPC's. The screen in the console centre is the video display unit (VDU) and beneath it are the horizontal situation indicator (HSI) and smaller, hydraulic systems gauges. To the left are the airspeed indicator (A5I) and standby ASI. Further left are the strip indicators for the Apache's engine torque, turbine gas temperature, engine gas generator, oil and fuel levels. Below and beside them, on an 'L-shaped' panel, are the fire control switches. The black and yellow canopy jettision handle is clearly marked. On the right side of the console are the radar altimeter, radio-call placard, encoding barometric altimeter, RWR display, vertical speed indicator (VSI), clock, HARS controls and accelerometer. To the far right can be seen the (red and yellow) icing severity meter, radar/IR countermeasures panel, chaff dispenser control and RWR control panel. Below them is a bank of caution/warning lights. The circular lens above the coaming on each Apache cockpit is the boresight reticle unit. The rear cockpit side-consoles are dominated by a bank of radio (and some weapons) controls.

Above and below: Both cockpits in the AH-64D have been transformed by the addition of twin Bendix King MFDs, while still retaining some of their 'old-style'feel. The 6 x 6-in (15 x 15-cm) screens were monochrome on development AH-64Ds, but will be full-colour in production aircraft. The first colour displays were delivered to McDonnell Douglas in late 1996. Note how instruments have been raised above the coaming in the pilot's cockpit.

McDonnell Douglas AH-64D Longbow Apache

US Army Material Command/OPTEC/TEXCOM

The first 'AH-64D' to fly was an AH-64A with a dummy radome. The six pre-production aircraft that followed were full-standard AH-64D conversions - though the last two of these were not equipped with the Longbow MMW radar. This aircraft is the fourth AH-64D development aircraft (90-0423), which first flew on 4 October 1993. The Longbow flight test programme is currently split between Mesa, Arizona,and Ft Hood, Texas - in the charge of the US Army Material Command's Apache Attack Helicopter Project Manager's Office.



Crew protection and crashworthiness
The Army specified that the Apache crew must survive a vertical descent of 42 ft/sec (12.8 m/sec) applied to the landing gear. Such an impact translates to a *37-g* load on the crew. The Apache's sliding seats attenuate that load to a highly unpleasant, but survivable, 13-0 load. During early flight tests after a catastrophic engine failure one of the Apache prototypes dropped 300 ft (91.4 m) straight down. The crew walked away. All Apache crews have unshakeable faith in their aircraft, provided it does not come down sideways. The crew's seats provide ballistic armour protection through blast/fragmentation shields, around and between the two seats. In October 1995 Phoenix-based Simula Inc. was awarded a contract to install and test a system of airbags for the AH-64A. Head and torso injuries account for more than half of the crew injuries sustained during otherwise survivable crashes, and the Army has determined that such injuries could be cut by 50 per cent using airbags. A series of 30 drop tests conducted during 1993 confirmed the suitability of air bags for an attack helicopter. The Apache air bag modification kits are due to be fielded in 1997. Air bags will be located to the side and in front of each crew member. In a series of simulator tests held at Ft Rucker, crews were subjected to three 'inadvertent' air bag deployments which reportedly did not interrupt the mission or compromise the aircraft. The Apache's air bags are designed not to obscure critical flight instruments.

Hellfire launch
In a LOAL (Lock-On After Launch) engagement the AGM-114K Hellfire II can be fired in three pre-launch programmed trajectories. Two launch modes are available - normal (sometimes referred to as 'rapid') and ripple. In normal mode only missiles coded on the priority (autonomous guidance) channel can be fired. In ripple engagements priority and alternate (remotely designated) channel missiles are fired, alternately.

Longbow Hellfire
Martin-Marietta (now Lockheed Martin Orlando) and Westinghouse won a two-year $30.5 million US Army contract for initial production of the AGM-114L Longbow Hellfire II in January 1995. Up to that point Rockwell had been the Army's sole supplier of Hellfires. Allied with the initial $31 million production funding contract for the fire control contract, the contract provided a major boost for the two firms at a time when the RAH-66 had been officially shelved. In June 1995 Lockheed Martin and Rockwell formed a joint company to manufacture the AGM-114L. This ended fierce competition between the two for production batches of the AGM-114L. Belfast-based Shorts Missile Systems is the prime contractor for the UK's acquisition of Hellfire II and Longbow Hellfire missiles.

Self-protection fit

Behind the Apache's rotor mast is the AN/AI_Q-144(V) IR countermeasures set-the 'disco light' jammer. ALQ-144 transmits modulated radiation at high and low frequencies using an electrically heated source, to confuse IR-guided SAMs. The Apache also has ah onboard radar jammer, the AN/ALQ-136, to defend it from ground-based fire control radars. The ALQ-136's signals induce range and angle errors in the hostile tracking radar. The transmit antenna for the ALQ-136 is located on the TADS housing, between the FLIR and DVO turrets. The receive antenna is situated above the fuselage, behind the pilot's canopy.

Main rotor head

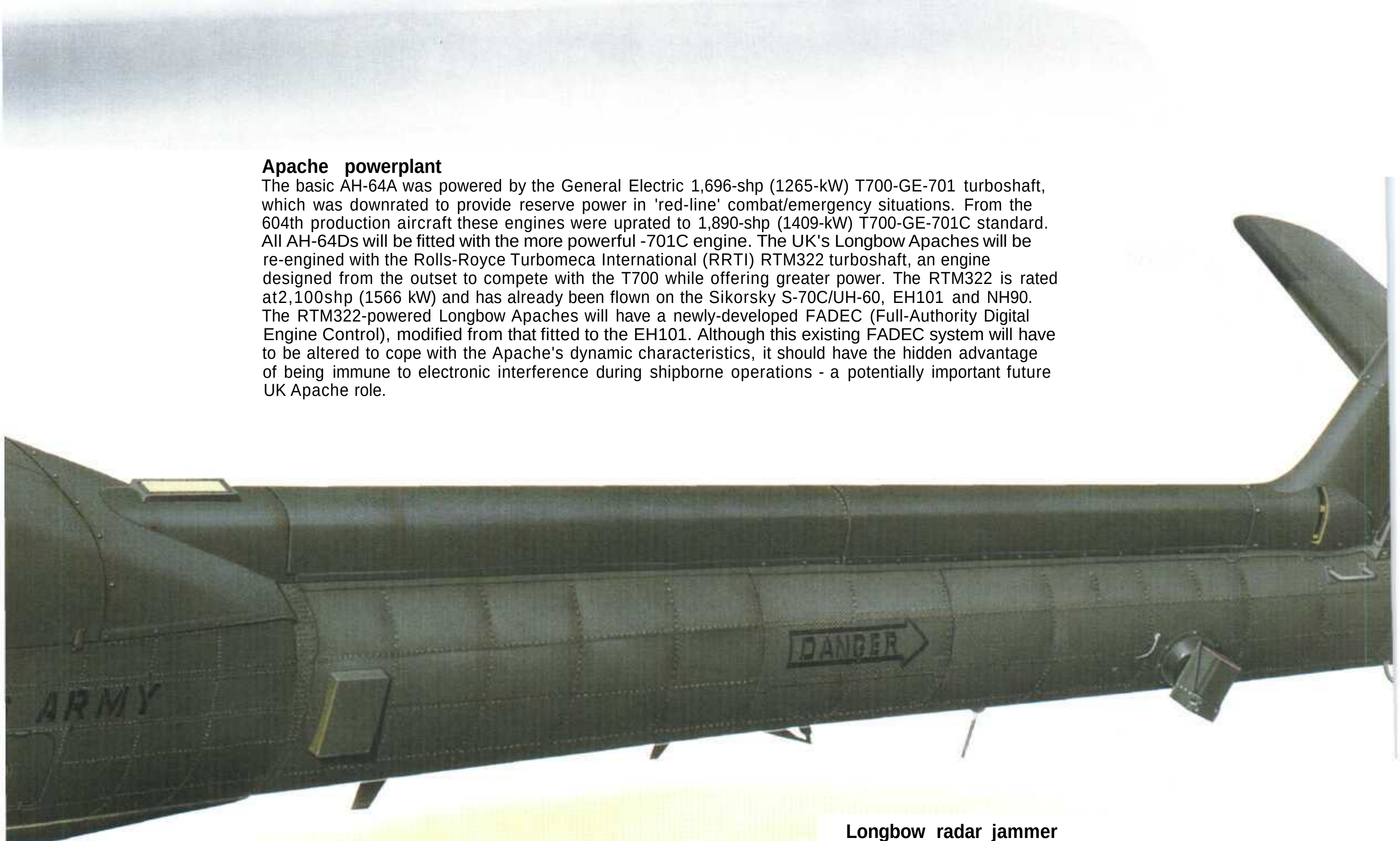
When it came to designing the Apache rotor system, Hughes did not forget its Vietnam experience. Even though the OH-6 was worlds apart from the YAH-64, it had a profound effect on the latter's design. This was most obvious in the YAH-64's fully-articulated rotor head, which was essentially a scaled-up version of that of the OH-6A. A series of 22 redundant laminated straps are used to fix the blades to the fully-articulated rotor head. These straps are flexible enough to permit blade flapping and feathering, and fatigue tests have shown that up to 10 can fail and the Apache will still remain flyable. The blade retaining bolts are expandable, a design feature first incorporated on the OH-6, to permit easy blade folding for transportation. The main rotor mast is a static, non-rotating design. It houses an inertia-welded Nitralloy drive shaft which, like all elements of the main rotor system, has a fatigue life of +4,500 hours. Even if the drive shaft were to fail, the mast carries much of the rotor loads and controls would not be affected for an autorotation. The mast is bolted directly to the fuselage and will sustain an impact of 20g before collapsing. Like the OH-6 before it, there has never been a recorded case of the AH-64 suffering a mast failure in flight or in a survivable crash.

Swept blade tips

Results from the flight test portion of Phase 2 testing forced a revision in the blade tip design of the AH-64. The original straight tips were cambered, and a constant-thickness and constant-chord section were added. Coupled with a 20° sweep applied to the final 20 in (51 cm) of the blade, and tip weights inside the blade, this new design delayed the onset of drag divergence as tip speeds approached Mach 1, the so-called 'Mach truck' effect (the build-up of a large shock wave in front of the blades was likened to the 'bow wave' of America's giant Mac trucks). The new tips also provide a useful dynamic twist by using the upload on the retreating tip to decrease the angle of attack. The blade tips are designed to be replaced every 1,000 to 2,000 flying hours but are susceptible to abrasion faster than the rest of the blade.

Apache powerplant

The basic AH-64A was powered by the General Electric 1,696-shp (1265-kW) T700-GE-701 turboshaft, which was downrated to provide reserve power in 'red-line' combat/emergency situations. From the 604th production aircraft these engines were uprated to 1,890-shp (1409-kW) T700-GE-701C standard. All AH-64Ds will be fitted with the more powerful -701C engine. The UK's Longbow Apaches will be re-engined with the Rolls-Royce Turbomeca International (RRTI) RTM322 turboshaft, an engine designed from the outset to compete with the T700 while offering greater power. The RTM322 is rated at2,100shp (1566 kW) and has already been flown on the Sikorsky S-70C/UH-60, EH101 and NH90. The RTM322-powered Longbow Apaches will have a newly-developed FADEC (Full-Authority Digital Engine Control), modified from that fitted to the EH101. Although this existing FADEC system will have to be altered to cope with the Apache's dynamic characteristics, it should have the hidden advantage of being immune to electronic interference during shipborne operations - a potentially important future UK Apache role.



Longbow radar jammer

The AH-64D will be the first US Army helicopter to receive the Advanced Threat Radar Jammer (ATRJ), under development by ITT Avionics for the US Army's Communications and Electronics Command (CECOM). ATRJ is being developed under a $54.7 million contract for various US military aircraft including the OH-58D, RAH-66, UH-60/MH-60, MH-47, MH-53 and V-22. ATRJ will counter continuous wave and coherent/non-coherent pulse radars, with a multiple threat handling capability. It will also have a Precision Direction Finding (PDF) capability linked into the Longbow's sensor- and weapons-cueing systems. A production decision for the system is expected in September 1998, with the first of up to 1,000 units in service by 2000. ATRJ is one of several systems currently under development by the Joint Integrated Avionics Working Group (JIAWG) and its MIL-STD 1553 architecture will make it compatible with the Apache's AN/AVR-2A laser detection/warning system and the ATIRCM/Nemesis active IR-countermeasures systems now under development.

Starstreak/Helstreak

Shorts Missile Systems and Lockheed Martin have combined (with McDonnell Douglas) to market the high-velocity Starstreak anti-aircraft missile for the AH-64A/D. If the missile is adopted by the US Army, Shorts would manufacture the components in Belfast, while Lockheed Martin would assemble the missiles in Troy, Alabama. An air-launched version of Starstreak (dubbed Helstreak) is the 'preferred choice' of the UK's Army Air Corps to arm its AH-64Ds. Starstreak is a laser-beam-riding anti-aircraft missile, capable of Mach 3/4, with an effective range of 300 m (984 ft) to 7000 m (22,966 ft). Starstreak has a reported single-shot Pk of 96 per cent. Each individual missile is 1.4 m (4.6 ft) in length, 13 cm (5.1 in) in diameter and has a launch weight of 16 kg (35.27 lb). After launch the missile body deploys four fins which spin-stabilise the missile. The nosecone is discarded to expose three metal darts. The darts disperse after motor burn-out and are guided to the target using a laser matrix. Each dart has a small explosive charge but causes most of its damage to the target through kinetic energy. Shoulder-launched Starstreaks require the operator to track the target with the laser until impact. As a result, Starstreak is largely immune to ECM and IRCM, but can be hampered by electro-optical countermeasures, terrain or poor weather.

Laser-guided rockets

Although a Hellfire missile is the Apache's most accurate weapon, it is also the most expensive (the unit cost of a basic Hellfire is in excess of $35,000). In an attempt to provide the AH-64, and other helicopters, with a precision weapon that does not cost more than some of its targets, Texas Instruments has unveiled a laser guidance package for 2.75-in rockets such as the Hydra 70 or CRV7. The system uses an adapted Paveway seeker head with small thruster ports arranged around the forward section of the projectile for manoeuvre control. Thus modified, the cost of individual rockets is estimated at between $10,000 and $12,000.

Tail section and rotor

The Apache features a semi-rigid, teetering, twin-bladed tail rotor mounted at offset degrees of 60° and 120° rather than *90°*. Each pair of blades has one stainless steel spar and two aluminium spars and is fastened to its own delta-hinged hub. The airfoil is a NASA 63-414 section. This unusual design has provoked some disagreement, not least within the Apache community, as to why it was implemented. The accepted answer has always been for reasons of noise reduction. Certainly, the tail rotor's low rotation speed of 634 ft/sec (193 m/sec) cuts back on aircraft noise, but the offset position was also definitely a function of the T-tail and the need to accommodate the Apache in a C-141 B. The teetering twin-blade approach is unique, to date, and did away with the need for conventional centrifugally-loaded oscillating bearings. However, the resultant Coriolis loads (whirling blades deforming into a cone shape rather than a flat disc) during operation called for a high-strength titanium rotor fork. The original AAH mock-up had featured a folding tail, a design feature that was retained by AV-01 and AV-02. However, field tests proved that by careful positioning two AH-64s could be accommodated in the hold of a C-141B (the dimensions of which had been the constant limiting factor for AAH designers) without removing the tails. This allowed Hughes to dispense with the heavy and fatigue-sensitive structure.

Tailplane design

The Apache was originally designed with a horizontal stabiliser mounted on the fuselage, at the base of the vertical tail. The design was first trialled on a modified OH-6A, which led to concerns about the effect of rotor downwash on aircraft handling. The stabiliser was repositioned to the top of the tail, resulting in a T-tail and a problem. The stabiliser had been designed as a work platform for field maintenance and so was a heavy, load-bearing structure. Time did not allow the production of new, lighter units for the T-tail, so AV-01/-02 initially flew with this weight penalty. The design of the stabiliser for Phase 2 flight tests was reversed: a straight leading edge replaced a swept one and the trailing edge was swept where previously it had been straight. This new lightweight T-tail, fitted to AV-02/-03 only, was part of the Mod 1 package. However, the position of this fixed T-tail ultimately resulted in an unsatisfactory nose-up attitude, hindering NoE flight and sensor suite operations. The T-tail was finally replaced by a low-set all-moving tailplane, lengthened (by *TA* ft 70.76 m) and linked to the flight control system. The new stabilator design was first flown on AV-04. The unit was fitted with an electric folding motor to facilitate air transportation.

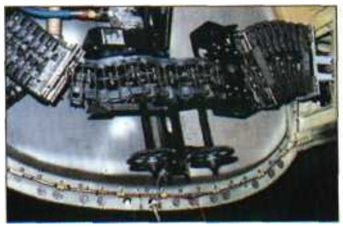
Air transportability and self-deployment

The basic requirement for the AH-64A was for two aircraft to be carried in the C-141 B and six in the C-5A. Fitting two Apaches into the StarLifter was a complicated task, requiring the removal of the entire rotor head, folding the vertical tail and stub wings, plus kneeling the landing gear to allow the aircraft to 'scrape' in. On a Galaxy the rotors and wings simply had to be folded back, but the tail and rotorhead remained untouched. The Apache was granted its air transportation certificate in November 1981 when Hughes loaded two aircraft onto a C-141 B in 80 per cent of the allotted time. With rotors, stub wings and other components removed (transport configuration), three AH-64As can be carried by the C-17, along with two cargo pallets and 50 personnel. If the Apaches remain in tactical configuration (wings and major components in place) two aircraft can be accommodated by C-17, along with four cargo pallets and 38 personnel. AH-64D loads are similar, with the added need to remove the mast-mounted radar, The AAH requirement also called for self-deployment ability of an 800-nm (1481-km, 920-miles) ferry range with a 20-kt (37-km/h, 23-mph) headwind and a 45-minute reserve. This permitted a wartime Reforger deployment from the US to Germany via Goose Bay (Canada), Frobisher Bay- now known as Iqaluit - on Baffin Island (Canada), Sondrestrom (Greenland), Reykjavik (Iceland) and Prestwick (Scotland).

Longbow directional infra-red countermeasures

Increasing attention is being paid to improving the protection of low- and slow-flying aircraft - chiefly large transports and helicopters - from the universal threat of IR-guided SAMs. As missile seeker technology becomes more advanced and the missiles themselves become faster, conventional (passive) chaff/flare technology is lagging behind the missile's ability to discriminate and destroy its target. As a result, much current research has been devoted to active IR countermeasures, so-called Directional Infra-Red Countermeasures (DIRCM), which can detect, track and disable an incoming missile using an intense beam of modulated energy. The high-value Apache is seen as one of the prime applications of this new technology and the UK MoD has already selected one system for integration on AAC AH-64Ds. This is the ARI 18246 NEMESIS DIRCM, developed by Northrop Grumman, GEC-Marconi Radar and Defence Systems, British Aerospace Systems & Equipment (BASE), Rockwell International and Westinghouse. The Westinghouse AN/AAR-54 Passive Missile Approach Warning System (PMAWS) detects the IR signature of a missile plume and classifies it as a threat. Up to six sensors located around the airframe can give 360° coverage and the PMAWS's fine angle-of-attack sensor allows the missile track to be handed over to the IRCM tracking sub-system at long range and in all weathers. Rockwell provides the NEMESIS Fine Track Sensor (FTS) which optically tracks the missile using a high-resolution, large-area focal plane array. FTS can continue to track a missile even after its motor has burned out. The missile seeker head is then jammed and disabled by NEMESIS'S high-powered, modulated arc lamp transmitter, developed by Northrop Grumman. GEC-Marconi supplies the system's transmitter unit - an agile, four-axis turret (similar to that used in the TIALD system) housing the complete FTS and jamming system. BASE is involved in NEMESIS component assembly, integration and development to meet future threats. When the technology becomes available, NEMESIS can integrate a laser powerful enough to burn out missile seeker heads. A similar system is under development by Lockheed Sanders. Lockheed's ATIRCM (Advanced Threat IR CounterMeasures) system combines a laser and xenon lamp optical jammer plus advanced chaff/flare combined with the existing AN/AAR-47 missile warning system. Cued by the AAR-47, the ATIRCM transmitter focuses on the missile seeker head to jam it with a deceptive IR waveform.

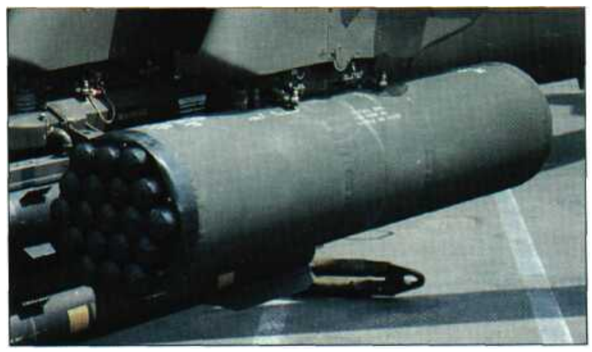
Apache weapons and walk-round



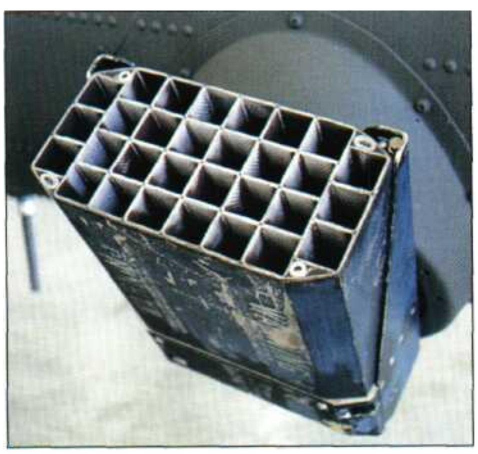
Left and above: The M230E1 30-mm Chain Gun has a void space above it, to fold into in the event of a crash, protecting the crew. The Chain Gun's 'chain' can be seen above, at the point where it interfaces with the ammunition flatpack. The chain carries rounds to the right to feed the gun*

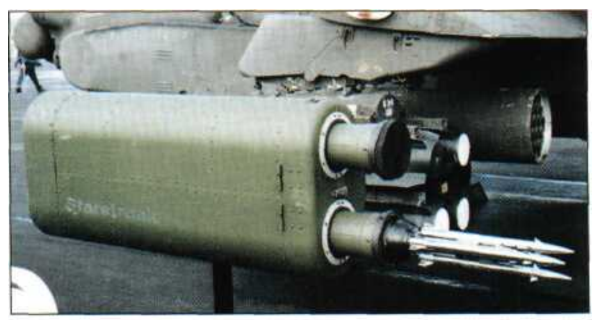
Above: 30-mm rounds are loaded using the motorised uploader/downloader which propels shells up a flex chute, along the port side of the fuselage and into the flatpack or 'ammo can'.

Above and left: All AGM-114 Hellfires are painted black, with olive drab markings. Yellow (3 x 3-in) square markings on the front of the missile denote an HE warhead. Brown squares to the rear signify a solid propellant motor. Inert handling training rounds are designated M34; training rounds with functional seeker heads (above) are M36s.

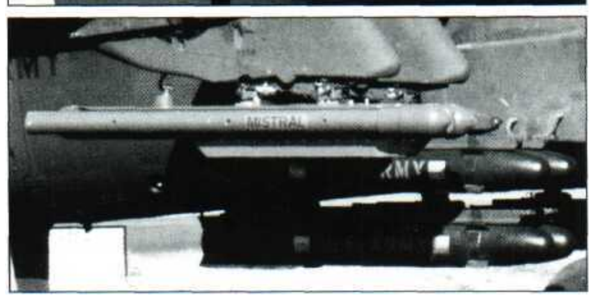


Above and left: US Apaches use 2.75-in Hydra 70 rockets, typically fired from 19-round M261 pods. Rockets are packed with their fins taped up, prior to loading. Blue warheads denote training rounds. Live rockets are olive drab with yellow warheads.



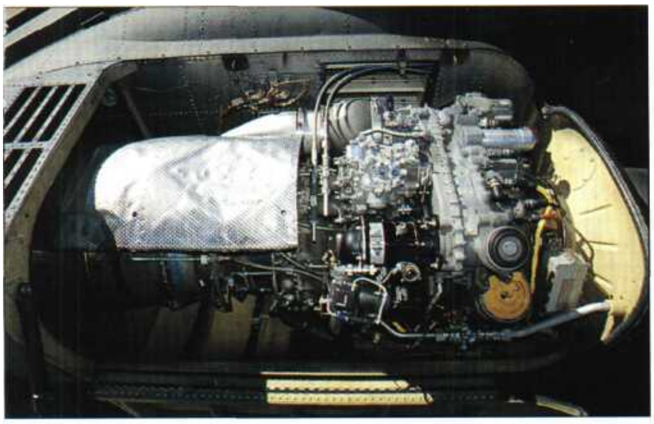


Right: The Shorts Starstreak/ Helstreak air-to-air missile will most likely be carried by the UK's WAH-64Ds in a two-round wingtip canister, as seen here. The three darts of the missile's warhead are plainly visible on this model.



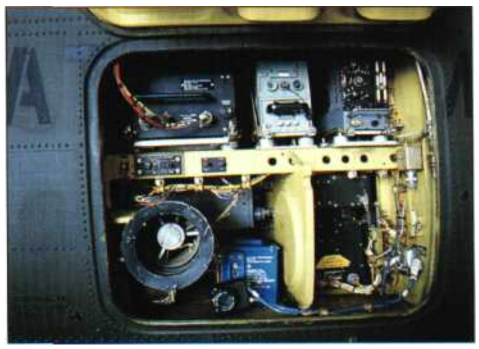
Right: The MATRA Mistral has been carried for 'form and fit' tests on the AH-64, but no test firings have ever been made. Air-to-air Mistral is already operational on French army Gazelles.

Left: The 30-round M130 chaff launcher is located on the tailboom. Apaches do not routinely use flares - they are ineffective at low-level, tend to hit the tail rotor and can set surrounding vegetation on fire.



Above: At regular intervals (approximately every 45 days) Apaches are thorougly washed down. Accumulated dust and dirt can affect the Apache's overall weight by as much as 100 lb (45 kg) if not kept under control. Note how the tailplane can be used as a maintenance platform. The same is true of the engine cowlings.

Left: A T700-GE-701 turboshaft fitted to an AH-64A. The engines are built in Lynn, Massachusetts.

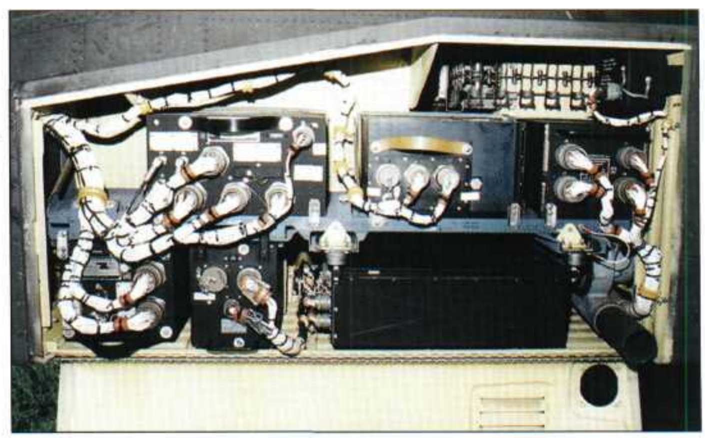


Above: Visible above the TADS optical and laser turret (right) is the LRU-28 transmitting antenna for the Apache's ALQ-136 radarjammer. The Apache's laser - the lower-most of the three components in the turret - is a neodymium-yttrium aluminium garnet (Nd-YAG) laser. The glass panels of the TADS turrets are heated to protect against icing. Note the wire deflector between the turrets and the cutter above them, in front of the PNVS.

Left: The AH-64's video recorder is housed in an avionics bay, in the starboard fuselage, below and behind the engines.

Left: The three secondary nozzles (vents) of the Black Hole infra-red suppressive system are seen from above.

Right: This view of the port cheek fairing shows LRUs (line replaceable units) for the TADS and laser systems (top row), dimmer controller, IHADSS symbol generator and fire control computer (bottom row).



Above: The Apache's rotor head is fully articulated, allowing the blades to 'hunt' (lead or lag) individually. The flexible elastomeric bearings, which regulate this effect, are the large rectangular blocks seen at the end of each blade.

Left: The Sperry-built air data sensor, positioned above the rotor head, is referred to as the 'Pacer System'. It monitors air velocity, temperature and pressure, and is vital for the flight instruments and weapons fire control system.

Right: The AH-64D's Longbow MMW radar.

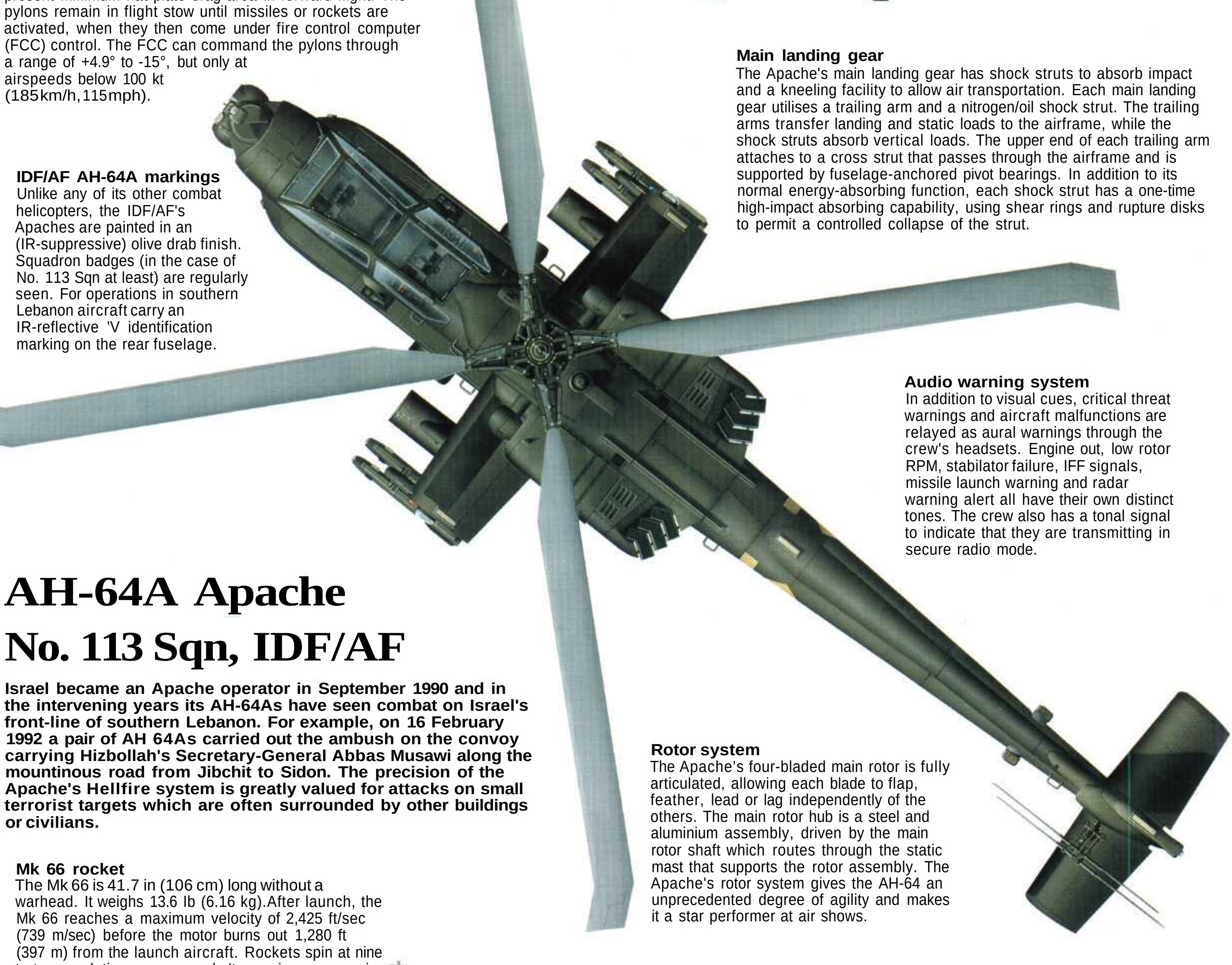
Above: The Apache's rotor blades are each attached to a delta-hinged hub. The whip FM/AM antenna above the fin is not found on all AH-64As. Two AN/APR-39 RWR antennas are located to the rear of the fin cap.

Wire strike protection system
Unlike some other helicopters, the Apache's wire strike protection system (WSPS) is discreet and not immediately apparent. The WSPS has six cutter assemblies and 11 deflectors. The deflectors are mounted along the canopy hinges, windscreen wipers under the tail and tail wheel, and around the TADS/PNVS and gun assembly. Cutters are located above the TADS/PNVS, below the rotor hub, in front of the gun and on both main landing gear legs.

Black Hole IR suppressors
The Black Hole system developed by Hughes was originally dubbed the 'Black Hole Ocarina'. (An ocarina is an obscure musical instrument, a small whistle, shaped like a sweet potato. Apaches have a distinctive whistling noise, some more than others.)

Weapons pylons
The Apache's external stores subsystem (ESS) consists of a stores controller and up to four pylon assemblies. The stores pylons are articulated to provide the desired elevation for various fire control modes and for aerodynamic/handling purposes. When an Apache lands, or is on the ground, the pylons automatically translate to ground stow mode so that they are parallel with level terrain. In flight stow mode the pylons tilt to present minimum flat plate drag area in forward flight. The pylons remain in flight stow until missiles or rockets are activated, when they then come under fire control computer (FCC) control. The FCC can command the pylons through a range of +4.9° to -15°, but only at airspeeds below 100 kt (185km/h,115mph).

Main landing gear
The Apache's main landing gear has shock struts to absorb impact and a kneeling facility to allow air transportation. Each main landing gear utilises a trailing arm and a nitrogen/oil shock strut. The trailing arms transfer landing and static loads to the airframe, while the shock struts absorb vertical loads. The upper end of each trailing arm attaches to a cross strut that passes through the airframe and is supported by fuselage-anchored pivot bearings. In addition to its normal energy-absorbing function, each shock strut has a one-time high-impact absorbing capability, using shear rings and rupture disks to permit a controlled collapse of the strut.



IDF/AF AH-64A markings
Unlike any of its other combat helicopters, the IDF/AF's Apaches are painted in an (IR-suppressive) olive drab finish. Squadron badges (in the case of No. 113 Sqn at least) are regularly seen. For operations in southern Lebanon aircraft carry an IR-reflective 'V identification marking on the rear fuselage.

Audio warning system
In addition to visual cues, critical threat warnings and aircraft malfunctions are relayed as aural warnings through the crew's headsets. Engine out, low rotor RPM, stabilator failure, IFF signals, missile launch warning and radar warning alert all have their own distinct tones. The crew also has a tonal signal to indicate that they are transmitting in secure radio mode.

AH-64A Apache
No. 113 Sqn, IDF/AF

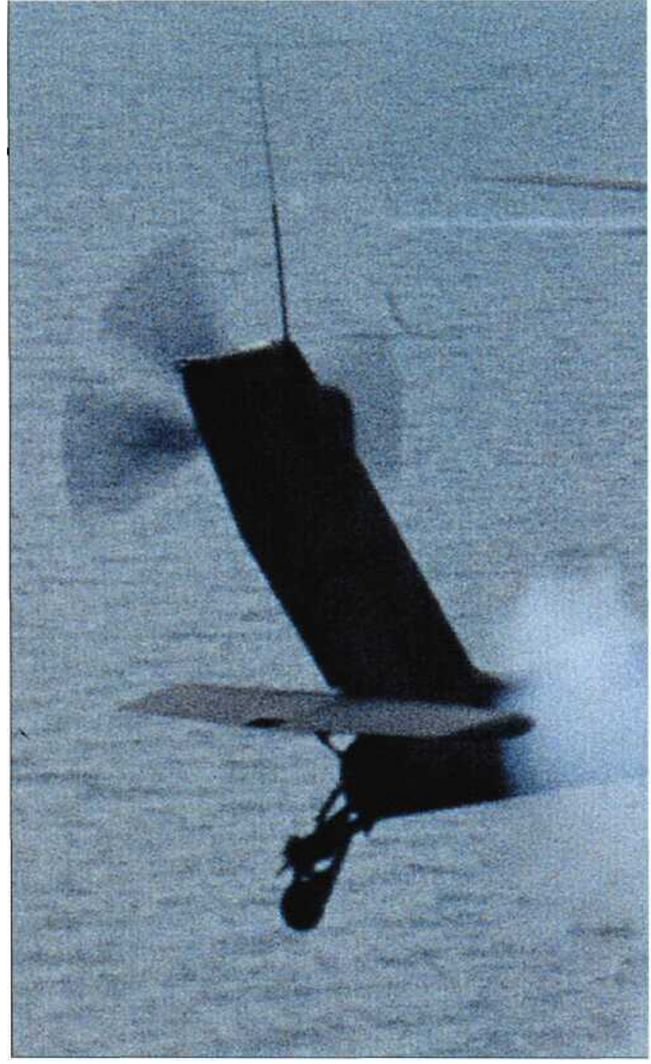
Israel became an Apache operator in September 1990 and in the intervening years its AH-64As have seen combat on Israel's front-line of southern Lebanon. For example, on 16 February 1992 a pair of AH 64As carried out the ambush on the convoy carrying Hizbollah's Secretary-General Abbas Musawi along the mountinous road from Jibchit to Sidon. The precision of the Apache's Hellfire system is greatly valued for attacks on small terrorist targets which are often surrounded by other buildings or civilians.

Rotor system
The Apache's four-bladed main rotor is fully articulated, allowing each blade to flap, feather, lead or lag independently of the others. The main rotor hub is a steel and aluminium assembly, driven by the main rotor shaft which routes through the static mast that supports the rotor assembly. The Apache's rotor system gives the AH-64 an unprecedented degree of agility and makes it a star performer at air shows.

Mk 66 rocket
The Mk 66 is 41.7 in (106 cm) long without a warhead. It weighs 13.6 Ib (6.16 kg).After launch, the Mk 66 reaches a maximum velocity of 2,425 ft/sec (739 m/sec) before the motor burns out 1,280 ft (397 m) from the launch aircraft. Rockets spin at nine to ten revolutions per second. Its maximum range is 10425 m (34,203 ft) compared with 8080 m (26,509 ft) for the previous Mk 40 rocket.

Chaff/flare fit
The Apache can carry removable 30-round M130 chaff dispensers on a mounting on the rear of the tail boom, to starboard. The M130 can fire M1 chaff cartridges to defeat radar-guided weapons.

AH-64 Apache and Longbow Apache



Above: An AH-64A manoeuvres hard with a load of Hell fire training rounds and Hydra 70 rocket pods. Note how the TADS sensors have been rotated inwards to protect their optics in flight, while the PNVS is exposed.

Right: The Apache's Hydra 70 rockets can be fitted with M433 multi-option fuses. Impact fusing allows surface and subsurface warhead bursts. Targets in open terrain will be engaged with superquick fuses that detonate upon contact. Targets with overhead protection, such as heavy tree cover or in fortified emplacements, will be engaged with a delay/forest penetration setting. Timed fuses produce airbursts and are most effective against targets with no overhead protection. Flechette, smoke and illumination warheads incorporate timed fuses, which are controlled by motor burnout. MPSM warheads can use M439 fuses, remotely set from the aircraft with range (time) to target information. Once fired, the forward motion of the rocket initiates fuse countdown. At a point slightly above and before the target, the submunitions are ejected and their ram air decelerators inflate. This arms the submunitions and places them in a near-vertical descent over the target.

service. It has a semi-active laser seeker and an improved low-visibility detection capability, compared to the A model. The AGM-114C also flies a flatter trajectory to the target with a low-smoke motor. The AGM-114F (sometimes referred to as interim Hellfire) has a tandem warhead for use against reactive armour.

The next version was developed as a result of Gulf Wai- experience and began life as the Hellfire Optimised Missiles System (HOMS), now referred to as the AGM-114K Hellfire II. The AGM-114K has been totally redesigned and features improved tandem warheads, electro-optical countermeasures hardening, a semi-active seeker head and a programmable autopilot for trajectory shaping. This new autopilot works by regulating launch speed from 300 kt to Mach 1.1, allowing a steeper terminal dive. The AGM-114K's seeker has been improved to overcome backscatter interference (as discussed later). All previous models of Hellfire used an 8-kg (17.6-lb) conical shaped charge warhead with a copper liner cone. The HE charge shapes the liner into a supersonic jet of molten metal that is effective against every armour technology known today. In the Hellfire II the copper liner has been replaced by molybdenum steel with a larger precursor charge. Hellfire II is believed to have a maximum range in excess of the 8000-m (26,247-ft) range quoted for earlier versions. Hellfire has been extensively tested on US ranges against Soviet (and modern US) armour and on the battlefield during Operation Desert Storm. When used against the Iraqi army the striking power of Hellfire was absolute — a single Hellfire strike would destroy any target, except perhaps at the edges of the engagement envelope. Prior to the war US intelligence reported that Iraqi T-72s were being fitted with armoured fences set 18 ft (5.5 m) away from the tanks to defeat tandem, shaped-charge warheads. A T-72 was set up in this configuration in the US and shot, and destroyed, with a single Hellfire. Longbow Apache will use a version of the Hellfire based oi/AGM-114K, the AGM-114L. This version will be laser- or MMW radar-guided.

Hellfire employment

When a Hellfire leaves the rail it accelerates at l0jj and reaches Mach 1.3 within six seconds in a £-bias climb (i.e., the missile climbs sharply on a defined parabola to a predetermined altitude, to begin searching for the laser spot). Depending on the type of missile, range to target, launch altitude and designation mode, the missile climbs to between 500 ft (152 m) and 1,500 ft (457 m) for a terminal dive on the target. The minimum range for a Hellfire engagement is 500 m (1,640 ft) and textbook maximum range is 8000 m (26,248 ft). Because the missile needs to climb to engage a target, a low cloud ceiling will hamper Hellfire operations as the missile can lose lock-on. This is one realm where the radar-guided AGM-1 14K will transform Apache operations.

Hellfire can be launched in two designation modes: Lock-On Before Launch (LOBL) in which the AH-64 self-designates, and Lock-On After Launch (LOAL) in which the target is designated by another laser, on the ground or in the air. The Apache can designate its own targets up to +10° off-boresight. If another Apache is designating for the 'shooter' (indirect designating) the maximum angle between the laser LoS (Line of Sight) and shooter LoS must be ±60° for the designator to remain visible. The Hellfire's trajectory shaping and seeker scan-pattern force minimum engagement ranges to increase, in LOAL mode, if launch altitude increases above target altitude. As launch altitude increases the missile's ability to see the target at shorter ranges decreases. With an AGM-114F, minimum LOAL range is 2000 m (6,561 ft) if the launch aircraft is 50 ft (15.24 m) above the target (800 m/2,625 ft for AGM-114C). In LOBL mode, minimum range decreases to 1400 m (4,593 ft) for an AGM-114F and 800 m (2,625 ft) for an AGM-114C. During the early stages of Desert Shield Apache crews were afflicted with 'dirt diver' Hellfires that came off the rails and plunged straight into the desert. The problem was one of laser backscatter, wherein the beam was diffracted by dust and sand in the air and reflected back at the designator. This problem is not unique to a desert and can be caused by fog, snow or haze. If the missile seeker is tracking backscatter the seeker head LoS and designator LoS should differ (by more than 2°) and this should alert the CFG that he needs to re-acquire the target. In the desert the backscatter was caused by the Apache's own dust cloud so the solution was to launch a missile and wait several seconds before firing the laser to allow the missile to get clear.

Laser technique

A target must remain illuminated by the laser 'sparkle' once the Hellfire is in terminal phase; once the seeker is tracking, the laser cannot be turned off. To achieve 90 per cent Pk (probability of kill) the target must be illuminated for eight to 10 seconds. The CFG has to be conscious of illumination faults such as boresight error, spot jitter (caused through motion of the designator), beam divergence (the further the laser is from the target, the wider the spot will be on the target), attenuation (the beam will be scattered by obscurants or bad weather), overspill (placing the spot too high on the target so it 'slips' over onto the terrain behind) and underspill (placing the spot too low on the target so that false targets are created in the foreground).

Servicing the target

To fire a Hellfire the CFG must consider four elements — mode, code, quantity and type. The mode will be LOBL or LOAL (with LOAL-LO and LOAL-HI options depending on the desired trajectory of the missile). The code is a NATO-standard four-digit code that matches the missile seeker head to the pulsed frequency of the laser. Missile codes are issued in blocks, at a unit level, and then allocated at a company level. Each Apache will have its own code, but can also store up to eight codes (A to H) to designate for other aircraft if required. Codes are entered via the Apache's data entry keyboard. Since laser codes are allocated to individual aircraft, knowing which 'chalk' has been allocated which codes is an essential element of the mission brief. The CFG selects the number of missiles he wishes to allocate to a code, then selects 'type', which will always be laser-guided in the AH-64A. A maximum of two codes can be used at the same time, referred to as upper and lower channels. Normal procedure is to allocate the upper channel to the Apache's own code and the lower channel to a remote designator. It is possible to allocate both channels to remote designators, so that the shooter can remain hidden while firing missiles at two separately designated targets.

The laser rangefmder provides distance to target and LoS provides azimuth. For an LOBL engagement the missiles seeking the first selected code will lock-on if they are within the laser spot LoS. A solid box appears on the HDLJ target display, indicating that the laser return is valid. The CFG verifies that the range to the target is within limits and that the laser has a firm hold on the target. Missiles can be fired with the laser on or off, but the laser must be engaged

The accuracy and effectiveness of any weapons launch from a helicopter is dictated by the aircraft's flight conditions. Hellfires, for example, are not always silver bullets. Rotor downwash acts on any projectile, causing its trajectory to change. A noticeable change in trajectory will occur when the Apache is operating below effective transitional lift. This distortion is most pronounced with rockets, but will also trouble guided missiles, especially if they are fired at short range. If the Apache is hovering in ground effect, air flowing down through the rotor system causes the missile to pitch up as it leaves the rail. When the missile passes beyond the rotor disc, air flowing upwards (bouncing off the ground) causes the missile to wobble and can induce lateral (azimuth) and linear (range) errors. When the Apache is hovering out of ground effect, the downwash strikes the missile only once. However, the increase in velocity of this downwash (increased because of the additional power needed to maintain the hover out of ground effect) may further worsen linear dispersion.

Above: This sequence of photos shows the first launch of a production-standard Hellfire, at the Yuma Proving Ground, in 1984. In January 1985 the Hellfire officially entered the inventory.

Above right: Positive threat ID with the FUR system is acknowledged to be difficult. While the crew can easily detect the heat signature of a potential target, determining whether the 'blob' is friend or foe is less straightforward. The phenomenon of IR crossover - caused at night when targets have cooled to the same temperature as the surrounding terrain - can make even acquisition impossible. IR crossover occurs most often when the environment is wet, as moisture in the air creates a buffer in the emissivity of objects. The PNVS FUR lacks the magnification of the TADS and so cannot reliably detect wires or other small objects.

for terminal guidance. It takes an eight-second (approximate) 'sparkle' to ensure the missile will find the target. For an engagement at maximum range an AH-64A may have to remain exposed for 45 seconds (including acquisition time and 37 seconds of flight). For a remote LOAL engagement the shooter's wingman will lase the target and provide the range and azimuth information. The shooter points at the target and can fire with, or without, a solid lock. Upon firing, the shooter calls the time of flight for the missile and calls for 'laser on' from the designating aircraft. In a LOAL engagement the shooter can remain permanently masked, and out of harm's way.

If the engagement is autonomous (self-designating) or remote (designated from another source), with all missiles on the same code, a proficient crew could reasonably expect to have two or possibly three Hellfires in flight simultaneously. Crews generally train to fire (depending on range) with an eight-second separation to allow adequate time to transition from one target to another. If the LOAL engagement is a 'ripple' (missiles on two separate codes), a good crew could have four missiles (two autonomously- and two remotely-guided) in the air at once. Launch separation times between an autonomous missile and a remote missile can be as little as two seconds.

JAAT - co-operative tactics

In 1986 a new form of combined Army/Air Force operations was pioneered by 7-17 Cavalry, 6th Cavalry Brigade, almost by accident. A phone call from the AFRes's A-10-equipped 917th TFG, requesting the use of the AH-64's weapons range at Ft Hood, led to a deal. The 'Hogs' could come and drop their bombs if the 7-17 Cav could try out their laser designator with the A-10's Pave Penny marked target seeker. When the A-lOs hit the target first time using the Apache's laser, both teams realised that a small revolution was in prospect. This early exercise lead to formal AJAAT (Advanced Joint Air Attack Teams) trials at Nellis AFB. The Ft Hood Apaches (which had become the 3-6 Cavalry) joined with the USAF's 422nd TES in 1987 to conduct operations in high- and low-threat environments on the Nellis ranges. Phase II saw the team moving to Ft Hood in December for night-time/bad-weather operations, and in Phase III the AJAAT trials moved to Ft Still, to work out against an unfamiliar target array. The success of the 300 missions flown paved the way for today's JAAT tactics. To the Army, JAAT becomes AJAAT when an 'Advanced' helicopter, such as the Apache, is designating rather than troops on the ground (for example).

The AH-64's optics allow it to find and identify targets at ranges unavailable to A-10s. This in turn translates to safer stand-off ranges for the A-lOs, whose Pave Penny trackers can see the Apache's lasers at ranges in excess of 8000 m (26,246 ft). A-10 pilots could, for example, make blind firing passes at targets hidden in tree lines that they never saw, simply by following the HUD cues. Although the A-10's GAU-8 cannon has a well-deserved reputation for destruction, the 'Hog' has to close to a range of 2,000 ft (610 m) for it to be guaranteed effective. The longer-ranged IR Maverick is the A-10's preferred weapon, but its seeker head has a magnification capability of just x6 compared to the Apache's x!27 system. This alone underlines the value of the Apache to the JAAT mission.

Apache FACs and scouts

JAAT also brought about the birth of two-ship Apache scout teams. During the early trials traditional scout helicopters were too slow to keep up with the JAAT teams, so the 3-6 Cav started to use three two-ship Apache sections in favour of traditional scout/gun combinations. The role of the Apache scout is crucial. The scout conducts the target brief and relays it to the Air Force aircraft, if there is no FAC. This is the 'nine-line' FAC-to-fighter brief, which specifies IP, heading to target, target elevation, target description, target co-ordinates, target marks (laser code), friendly forces, egress direction plus any necessary remarks (hazards, restrictions, threats or abort code).

If no FAG is available the scout will also hand over the incoming aircraft to the designating AH-64s. The scout maintains communications to higher headquarters and acts as 'traffic cop' to marshall the next troop of AH-64s entering the area. The Apaches should not be fighting an engagement alone but should be calling up artillery support to drive the enemy into the kill zone, break off comms antennas and button up the tanks. The squadron Fire Support Officer (FSO) is the link between the aviators and the gunners, and it is he who must have pre-planned the artillery engagement to the flanks or the rear of the kill zone. The artillery unit's Forward Observer (FO) should be airborne with the scouts, to best integrate his battery's fire.

The A-10s fly in four-ship formations which permit pairs of aircraft to make independent attacks. If both pairs are needed for a single attack, they will be controlled by two Apaches simultaneously. When conducting this type of four-ship attack, each A-10 section is given its own laser code. A single AH-64 works a four-ship section by putting all the A-10s on a single code for a sequential attack.

The Apaches do not remain passive on the battlefield. While designating for an A-10 an AH-64 can also be shooting a target that has been coded and designated by its wiiigman. It can also cover the A-10 coming off its attack. The A-10's Pave Penny seeker has a laser-to-target offset of 60° (similar to the Apache's own limit), and although attacks can be made outside that range they are undependable. Ingressing to the target, the A-10s may make a recce 'bump' at their IP to find the Apache's laser then remask to maintain terrain cover en route. The laser is detectable at ranges up to 20 km (12.4 miles). At the IP the A-1()s will expect the initial brief from the scout commander on the common UHF frequency (which is a Have Quick secure radio). FM radios are used to talk to the ground forces, while the Apaches use an internal VHP net.

Running the attack

Once handed over to the designating AH-64, the A-lOs receive the specific target brief. This comprises target location (a six/eight-digit map UTM), target description (e.g., 'northernmost tanks'), elevation (derived from the AH-64's fire-control system and input to the A-10's sight), laser code (chosen to deconflict with the Hellfire codes in use and entered to the Pave Penny through cockpit switches — a typical training code would be 1668), laser-to-target line (ensures that the A-10 is within the parameters to see the laser and also allows the A-10 pilot to calculate the AH-64's position by drawing a back azimuth from the target),

The Apache/'Kiowa 'gun' and 'scout' team has fallen into disuse. This is largely due to the US Army's massive API restructuring which has forced aviation units to do more with less. Though the number of Apaches deployed by each attack helicopter battalion has increased, so too have the demands made of them, and Apaches must now undertake their own scout and security missions. It is also true that the AH-64 outclasses the available scout helicopter, the OH-58C Kiowa. With the advent of the OH-58D, the scout/cavalry community now has a far more capable mount, arguably more capable than the AH-64 in some respects.

AH-64 Apache and Longbow Apache

This Apache is loaded with a varied air-to-air missle armament. On the port pylon is an AIM-9M Sidewinder AAM, with a FIM-92 Stinger to starboard. The Air-To-Air Stinger (ATAS) is the weapon with which the US Army has conducted the most extensive trials (note the cameras on the wingtips to film separation tests). Its small size allowed two missiles to be carried on each station - at the expense of fuel, rockets or Hellfires. A wingtip-mounted twin-launcher has been developed as a result. Opponents of an air-to-air role for the Apache believed that adding AAMs might distract crews from their primary mission. However, the arrival of the AH-64D Longbow Apache will undoubtedly bring with it an expanded air-to-air role for the Apache.

restrictions (an optional call, perhaps to keep the A-l()s from overflying impacting artillery) and remarks (requesting the A-10s to call when departing the IP so the designator is ready). Every Apache within the AJAAT team must be capable of making this brief and designating targets. This vital task is notionally the responsibility of the aviation commander, but he will frequently have to delegate.

Co-ordination between A-lOs and Apaches of the 2-22nd AVN during the 101st Airborne Division's assault on Objective Toad, in Iraq, on 20 February 1991 was cited as a perfect example of JAAT in action. Two teams of A-lOs working with the Apache's Air Liaison Officer and Air Battle Captain attacked Iraqi bunkers with Mk 82 bombs and CBUs. Only the lack of any Iraqi armour prevented the use of the A-10's Mavericks. With the A-10 no longer dominant in the close-air support role, the AH-64 is capable of working equally well with the LANTIRN-equipped F-16. The F-16 brings with it the added dimension of being able to operate at night, which was never the A-10's forte/

Air-to-air weapons

The US Army does not yet anticipate a major air-to-air combat role for the Apache or the Longbow Apache, which is more suited to the task. US Army units do not train for this mission, unlike US Marine Corps attack helicopter pilots. As a result, a dedicated air-to-air weapon for the Apache has been frequently discussed but never deployed. Initial US trials were conducted with AIM-9 Sidewinders, at the White Sands Missile Range in November 1987. Although further Sidewinder trials were undertaken, seriovis attention moved to a modified version of the FIM-92A, the AIM-28 Air-to-Air Stinger (ATAS). ATAS trials also began in 1987 and by 1989 test firings had been undertaken at the Yuma Proving Ground. The Stinger could be carried in a two-missile box housing on the ends of the AH-64's stub wings. Only a single (larger) Sidewinder could be carried on a specially-developed rail. Trials were also undertaken with the anti-radar Sidearm, a modified RF-homing AIM-9 developed as a small and affordable anti-radiation missile. Successful Sidearm trials were conducted at China Lake Naval Weapons Center in April 1988. Captive carry trials of the Shorts-developed Helstreak/Starstreak anti-aircraft missile began in 1990, followed by six live firings at the Yuma Proving ground in 1991. The Helstreak is the main contender for the UK's air-to-air weapon and is also being regarded with some seriousness by the US Army. The first of the US Army Starstreak trials resulted in access panels on the AH-64 being jarred open by the missile's Shockwave. This problem was quickly solved and the firing programme encountered no debris damage from the missile plume - one of the major concerns regarding the high-velocity Starstreak.

In early 1997 the US Army drafted a Mission Need Statement calling for an improved air-to-air armament for the AH-64. Limitations of the Stinger were acknowledged, including its lengthy engagement 'time-lines' - during which the Apache is exposed to enemy fire. The US DoD now anticipates a further two-year trial of what it dubs the Air-to-Air Starstreak (ATASK) under the supervision of Army Aviation's Applied Technology Directorate, Ft Eustis. A series of 20 firings will be made against drone targets during this phase. As a result, the UK decision to acquire Starstreak/Helstreak, once expected in 1997, will be delayed perhaps until 1999. The BAe/MATRA Mistral AAM is also an outside contender for the UK requirement.

Standard Apache weapons have a limited air-to-air application. In fixed gun mode the M230E1 has a round impact set at 1575 m (5,157 ft) with a time of flight of 3.9 seconds. Hydra 70 rockets with M255E1 flechette warheads are perhaps the AH-64's best anti-helicopter weapon. Upon detonation the flechettes are deployed at a 12° angle, and the flechette cloud becomes cylindrical in shape after 150 m (492 ft) of travel, over 15.7 m (49.7 ft) in diameter. Test firings indicate that at ranges of 2000-2500 m (6,562-8,202 ft) three pairs of rockets will have a 75 to 82 per cent chance of scoring a hit. Hellfire can be used to engage

Above: The first launch of a Sidewinder (AIM-9M) was made by an Apache at the White Sands missile range, New Mexico, in November 1987. Several factors led to the adoption of the Stinger missile in favour of the Sidewinder, but one of the most significant of these was the Sidewinder's dramatic launch signature.

Left: This photograph shows the first launch of an Air-To-Air Stinger (ATAS) at the Yuma Proving Ground in 1989. Like the aircraft above, this Apache is fitted with cameras above the stub wings and on the rear fuselage to record the launch. ATAS capability was one of the primary elements planned for the AH-64A+/AH-64B upgrades, using a newly-developed two-round box launcher, but this never progressed beyond the trials stage. There is now a good possibility that the US Army might adopt the Shorts Starstreak/ Helstreak AAM, which is undergoing joint US/UK trials for Britain's Army Air Corps.

targets at up 8000 m (26,247 ft). The preferred employment method is to designate the target indirectly, allowing the Apache to fire from cover.

Ft Rucker - where it all begins

Before any Apache pilot can come to grips with the AH-64's technical sophistication and tactical employment he, or she, must be fully conversant with the aircraft's basic qualities. All flying training for the US Army begins in the pleasant surroundings of Ft Rucker, Alabama, home to the network of airfields, training areas and 500 helicopters of the US Army Aviation Center. The 1st Aviation Training Brigade handles the huge amount of flying conducted at Ft Rucker. Basic flying training for helicopter pilots is increasingly undertaken on the Bell TH-67A Creeks of the 1-212 AVN (Training). Once students have become IFR qualified with the TH-67As of 1-223 AVN, those destined for the Apache move to the 1-14 AVN at Hanchey AAF. 1-14 AVN conducts all Apache flying at Ft Rucker (with 48 AH-64As at its disposal) and AH-64D training will begin in 1997.

New students, arriving with 'bars and wings', are faced with three stages of AH-64 training. The complete AH-64 qualification course takes 62 training days. Five days of introductory academics are followed by the Contact Phase (Day 6-15). This is literally the students' first contact with the aircraft, comprising seven days in the CWEPT (Cockpit, Weapons, Engine Procedure Trainer). For many

AH-64 Apache and Longbow Apache

All US Army, and a great deal of non-national, Apache training is conducted at Ft Pucker. The full conversion course lasts for 12 weeks and two days. Apache flying at Ft Pucker is based at Hanchey AAF, home to the 1-14AVNATB. 'D' Company is 1-14's active AH-64 unit. It has seven flight platoons, which in order (first to seventh) are - Apache, Loco, Cochise, Geronimo, Natchez, Mescalero and Apache (again). The names derive, in the most part, after famous Apache warriors or Apache tribes.

students this will be their introduction to twin-engined helicopter operations and they will learn basic operational procedures (start-up, shut-down, emergency routines) from both seats. This portion of the training also involves a sizeable amount of classroom learning 'by rote', aided by large animated schematics of onboard systems such as the hydraulic, fuel, electric systems. Flying training follows, alternating with returns to the classroom for half-day periods. One Instructor Pilot (IP) will be allocated to two students for their first 12.4 hours of contact flying in the AH-64. They will undertake basic take-off and landing training, emergency procedures (engine failures at altitude or in the hover) and flying in mission configurations (using rolling take-offs to simulate a full weapons load, for example).

The second phase (days 16-36) of training is the most demanding, and perhaps the most demanding flying training requirement anywhere. The student must master flight using only the PNVS, at day and night, flying in the 'bag'. The 'bag' is a shrouded Apache rear cockpit, where all light is blocked out to simulate night-time operations. Students fly with only the PNVS and Helmet-Mounted Display (HMD). Basic flight information is superimposed over the FLIR imagery in the HMD monocle, so with just one eye, in the dark, the student pilot must learn to handle the Apache as if it were the most routine of afternoon trips. PNVS day training (all in the 'bag') comprises 18 flight hours followed by 7.2 hours of actual night operations. Throughout this demanding stage the IPs of 1-14 AVN are not trying to fail pilots, and those students who experience difficulty will be allowed a recheck. However, for some the stress of flying with just a 1 x 1-in black-and-white TV 'window' is just too much.

The third phase, the Gunnery Phase (days 37-55), is the students' introduction to the Apache's weapons system and its tactical employment. It involves a substantial amount of simulator training and live-fire experience. After 10.5 hours of simulator training the Apaches go to the ranges for four live firing days, which still have to interleave with training in the classroom. The student will fire all Apache weapons, spending one day in the front seat, then one day in back, then repeating that sequence at night, culminating with a check ride. Having learned how to fly the aircraft, by day or night, and used all of its systems, the student then returns to the simulator complex for Combat Skills training and the final evaluation (days 56-62). This is where the attack mission is taught — deep attack tactics, mass engagements, zone/route reconnaissance tactics, BDA, gunnery fire correction. In the words of one senior IP, "(we teach) everything, which seems to be our mission of late."

Apache and the US Army today

The Apache force, and the US Army with it, is currently in some doctrinal confusion about the exact role of the AH-64 on the battlefield. Not so long ago, the situation was clear: the US Army had two combat helicopter missions - Attack and Scout/Cavalry. Attack units flew Apaches to destroy enemy (armoured) forces or leveraged targets. The Scout/Cavalry mission was more diverse. While it included scouting for the attack force, the OH-58s and AH-1s of the 'Cav' undertook guard and screening missions for their own armoured units, route and logistics site reconnaissance, and still maintained the capability to engage in (limited) shooting matches of their own.

Once the Apache was operational in Europe the division between these two roles disintegrated, not least because the AH-64 had better sensor systems than its scouts, which in any case were not fast enough to keep up with the Apaches. While the OH-58C/AH-1F team in Cavalry units continued to work well (and just how well has long been a cause of friction between Apache and Cobra

Right: This is the 'bag' - the screened-off rear cockpit of an Apache from where the student pilot must fly the aircraft using the FUR alone. 'Bag' training is conducted by day and by night and is the most strenuous element of the Apache flying training course. Note the grey outline around the canopy. This is detonating chord to blow off the canopy in the event of an emergency rescue.

Right: This student is attempting one of the most demanding elements of flying training at Ech (pronounced 'Ek') Field, one ofHanchey's busy satellite airfields. Ech is the scene of slope training, where students learn to land the aircraft safely on an incline. This Apache is positioning for a slope landing in the 'bag'. The pilot cannot see the ground behind and around him and forward vision is provided by the FUR alone.

communities), both of these ageing types are about to disappear from the inventory in favour of the OH-58D Kiowa Warrior (see *World Air Power Journal,* Volume 15). This will transform the scout role in the US Army and should pave the way for the reintroduction of workable Scout/Attack teams once more.

The Army's ARI (Army Restructure Initiative) has reinvented many aspects of Army aviation by virtue of the inventory cuts and budget restrictions inherent in it. Under ARI, surviving Apache battalions were boosted from 18 to 24 aircraft, because the Apache must now act as its own scout. (Previously, battalions had operated with a mix of 18 AH-64As and 13 OH-58Cs.) The Hellfire-capable and Mast Mounted Sight-equipped OH-58Ds will not routinely scout for Apaches because, as one Apache pilot put it, "they'll be too busy with their own things to do"; what's more, there will not be enough to go around. Today, the Apache is firmly its own scout. ARI diluted the Apache's role from 'classic, pure attack' to one of security. Now the Apache, expressly designed to kill tanks in the Fulda Gap, and its crews, must undertake the screen, guard and other missions that were never its forte. Obviously, the Apache has many strengths that lend themselves to this mission, but attack crews have their misgivings. Some question the wisdom of placing the Army's most capable and expensive asset so consistently in harm's way - in a role, after all, that the OH-58 once fulfilled. However, it is inevitable that as Army doctrine increasingly coalesces around 'Stability and Support Operations' (the emerging tenet replacing the cumbersome Operations Other Than War/OOTW concept) the Apache will find itself on unfamiliar ground, and one need look no further than Bosnia to see the truth in that.

Attack helicopter units

Each divisional commander will employ his attack helicopters as he sees fit. Under ARI two (Apache) attack helicopter battalions (ATKHBs) are attached to heavy divisions and one to light divisions. The few AH-lFs that survived into 1997 with these units are being replaced by OH-58Ds. Each Apache ATKHB has 24 aircraft divided into three companies (ATKHC), plus a headquarters/headquarters company (HHC) and aviation unit maintenance (AVUM). The AVUM provides unit-level maintenance for the battalion. The three ATKHCs provide an offensive capability against armour, personnel and infrastructure/logistics targets. Each company has its own headquarters section, a scout platoon (three AH-64s) and an attack platoon (five AH-64s). The expected fully mission-capable (FMC) rate is 75 per cent - six aircraft. A two-ship 'lead/wingman' team (platoon) is the basic operational grouping, as its offers a high degree of flexibility and mutual support between teams. Each team will have a platoon leader, while the company commander will fly as a member

Apaches at Hanchey: the uppermost aircraft is exiting a tiny forest clearing after let-down and departure practice, while the aircraft above is engaged in the long sequence of slope training.

During normal peacetime operations US Army Apache crews fly, approximately, 70 hours every six months. This annual figure of 140 flying hours might seem very low - and is one reason why there is a certain amount of resistance from other US Army aviation helicopter crews to joining the AH-64 community. It is not, however, an unusual total in the military helicopter community as a whole. System reliability for the Apache itself (originally specified as 2.8 hours MTBF) has improved from 3.83 hours to 4.15 as the aircraft became mature.

The OH-58C Kiowa scout was a successful partner to the AH-1 Cobra, but far less so for the AH-64. The Kiowa has none of the sensors and equipment of the Apache, nor the performance to keep up with the larger helicopter in the field. Kiowa crews rely on their aircraft's small size and NoE flying to survive, but can be forced to operate within lethal range of enemy ADA to carry out their missions. As the OH-58D Kiowa Warrior enters wider service, remaining OH-58C units are preparing to trade in their Kiowas for Warriors. (To US Army crews a 'D' is never an AH-64D but always an OH-58D. The AH-64D is always the 'Longbow'.)

A masked Apache presents a small target but its nose-mounted sensors are also hidden from the target. This is where the crew must make maximum use of their aircraft's agility to pop up, acquire the target and remask. The AH-64 autopilot even has a 'bob-up' mode to facilitate this. The Apache's noise signature is negligble beyond 1 km (3,270 ft) - 75 per cent of that noise is caused by the tail rotor.

of the third team, positioning himself as required. An Air Assault Division, such as the 101st, follows the same aviation battalion organisation, while an Airborne Division (such as the 82nd) will have a single OH-58D ATKHB.

Attack helicopter tactics

The ATKHB is an instrument of precise firepower, with the manoeuvrability to mass combat power at a decisive time, yet one which should always work as part of a combined arms team. The Apache is tasked with nine primary missions: to attack massed armour or light formations, to attack in depth to extend the influence of its own land forces, to dominate avenues of approach, to reinforce ground forces by fire, to defeat enemy penetrations, to protect the flanks of a friendly force - be it on the move or static, to provide security for the movement and passage of lines by ground forces, to conduct reconnaissance and, finally, to conduct search and attack missions.

The Apache's role in offensive missions is categorised in several ways. The first of these is a 'movement to contact' - to gain or re-establish contact with the enemy, though not necessarily to engage it. Engagements from a manoeuvre to contact should be against targets of opportunity, or through chance rather than design. The primary function of a movement to contact is to place the Apache battalion in a secure position to conduct its pre-planned attack.

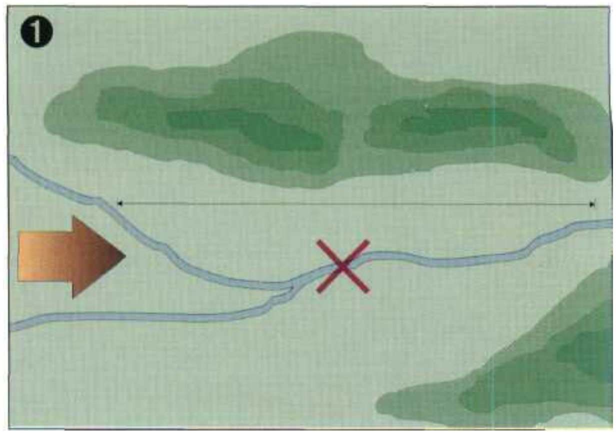
Attacks are sub-divided into two categories, 'hasty' and 'deliberate'. A hasty attack takes advantage of an enemy's weakness or sustains the momentum of the main attacking force. A deliberate attack is conducted against an enemy that is well-organised and cannot be turned or bypassed. It will be pre-planned and briefed using all the intelligence, and time, available. After a successful attack comes 'exploitation', to prevent the enemy from regrouping or withdrawing. The ATKHB will still be operating as part of a larger force and will attempt to strike the flank and rear of the enemy force. Then conies the 'pursuit', in which the Apache ATKHB will leave flank and contact engagement to the ground forces and instead reach deep to cut off the retreating enemy force and block any relieving forces. This calls for precise and well-planned C^2 co-ordination between friendly forces.

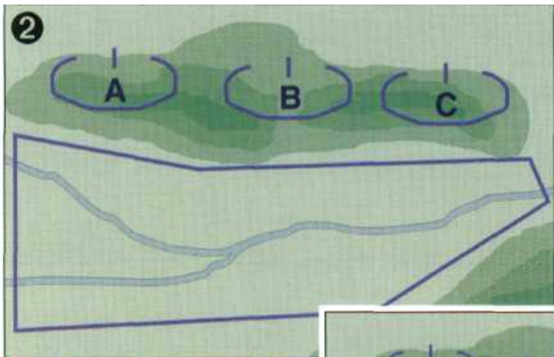
There are two forms of defensive operations which concern the ATKHB, 'area' and 'mobile'. ATKHBs conduct area defence in terrain where the enemy has a mobility advantage and must be denied avenues of approach or specific areas. A mobile defence allows the enemy to advance to a point where it is vulnerable to attack

AH-64A anti-armour deep attack

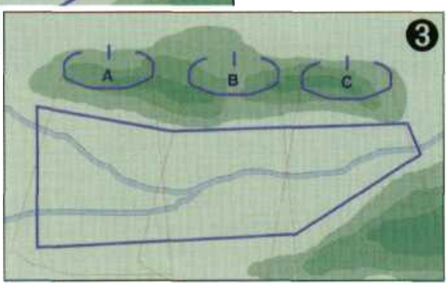
This series of diagrams describes a typical AH-64 deep attack mission - an attack directed against enemy forces not currently engaged but which could influence division or corps operations within the next 24 to 72 hours. This particular mission could also be termed an interdiction against a moving force. Deep attacks are made against high-risk/high-payoff targets, but the attack helicopter battalion (ATKHB) itself is a high-value target and this must always be born in mind before committing it. Deep attacks by corps ATKHBs help the corps commander to shape the battlefield and set the terms for close operations.

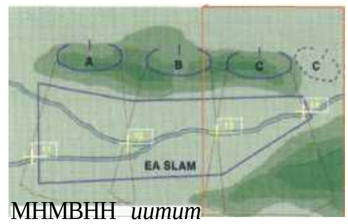
O Rig hi: *The arrow indicates the direction of movement of an enemy armoured column. The engagement area (EA), a valley, will have been scouted by other aircraft from the aviation unit, or determined from map terrain analysis or overhead imagery. A 15-km (9.3-mile) bracket has been choosen, though this will vary in relation to the size of the unit, terrain and avenues of approach. The red cross marks the 'trigger point' where the armoured column will be directly in the centre of the engagement area and where maximum firepower can be brought to bear. Attack helicopters use terrain for masking and concealment. They may be behind terrain fetaures, but also among terrain features concealed by intervening folds in the hill 'mass' or by vegetation.*





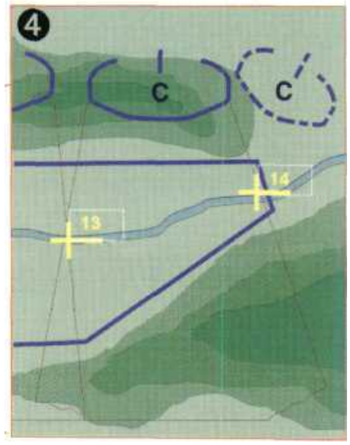
© Above: *Company-sized battle positions (BPs) are established - A, B and C. BPs are selected to provide good fields of fire, cover, concelaed routes of entry and exit, range and relationship to targets. BPs must allow the attacking units to cover their own rear and flanks.*



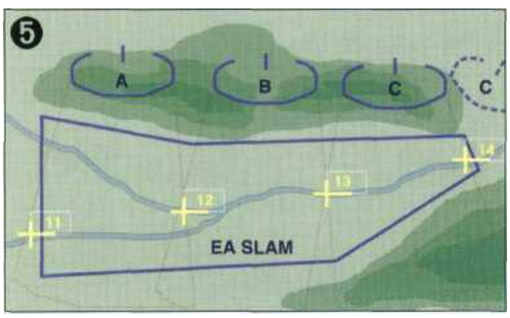


MHMBHH *uumum*

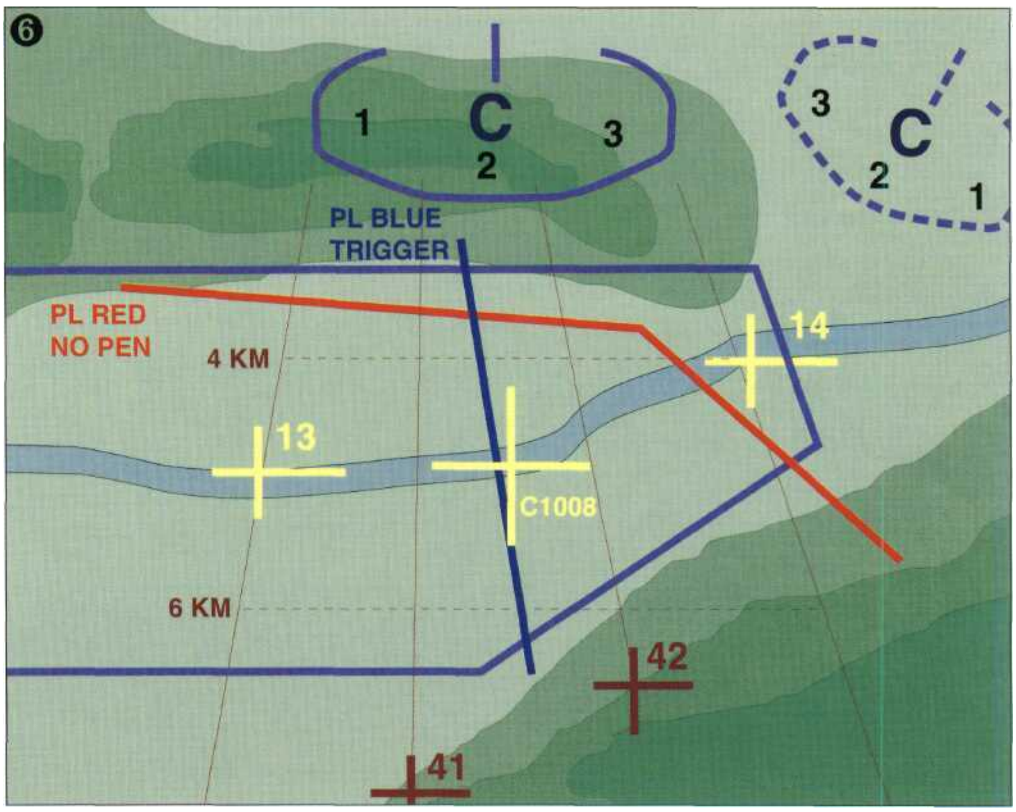
© Left: ***The EA must have recognisable boundaries, 'channelisation' of moving enemy elements and limited escape routes. Fields of fire are established, taking into account the need to prevent overkill while covering all the targets.***



O Above: ***Target reference points (TRPs) for supporting artillery fire are set up by the fire support officer.***



© Above: ***The engagement area is always given a name ('slam' is a generic title). TRPs (yellow crosses) are used as aiming points or references for quickly shifting fire (left, right, add, drop). The placement of these RPs at the intersections of sector boundries would allow them to be used for smoke markers to define those boundries during the battle. Alternative BPs are set up, for use if the primary BPs become unusable, threatened or if the engagement has to be repositioned to continue the attack.***



@ Right: ***Each battle position (A, B, C) will be occupied by three two-ship Apache teams. Phase lines (PLs) are used to mark and control areas, and trigger actions. Like EAs, they are always named. The vertical PL 'Trigger' serves as a 'trip wire' to initiate the engagement. PL 'Red' is a 'no-penetration' line. If enemy forces reach this point the Apaches will have to shift to alternate BPs. Range markers are set up to define the theoretical maximum range of the Hell fire (8 km) and enemy ADA fire (6 km). Red crosses serve as range markers for individual battle positions.***

by two sub-divided units, one to contain the advancing force and one to destroy it.

Task Force Normandy was a classic example of an ATKHB 'deep' operation, an attack mission directed against forces not currently engaged but one which will shape the outcome of future events. Deep operations are high-risk, high-payoff missions.

Traditional scout missions are now part of the Apache crew's repertoire. Such missions fall into two broad categories, reconnaissance and security. Reconnaissance missions may be conducted for a zone (covering all routes, obstacle and terrain in a defined area), an area (gaining detailed information on a specific area such as a ridge line or woods), a route (alone which ground units may be preparing to travel) or as a reconnaissance in force to provoke the enemy into revealing itself. Security missions can be categorised as screen (to provide early warning), cover (operating independently of the main force to distract the enemy), guard (keeping the enemy out of range of the main force), area (securing a specific area such as a convoy route) and air assault security (protecting an LZ).

The defined capabilities of the Apache ATKHB include mobility, speed, range and versatility. Mobility: the ability to rapidly move the force to the decisive place at the

Hughes Danbury Optical Systems produces the AH-64's AN/AVR-2A(V) laser detecting set (LDS). TheAVR-2Ais both an essential operational item and a useful training aid. It detects, identifies and characterises laser-aided weapons directed against the Apache from a 360° hemisphere around the aircraft, and in ±45° of elevation. The AVR-2A will also detect laser training devices during MILES/AGES (Multiple Integrated Laser Engagement System/Air-to-Cround Engagement System) field training exercises, such as those conducted at NTC. The AVR-2A(V) operates in conjunction with the Apache's AN/APR-39(V) radar warning receiver. The two combined systems provide the AH-64 crew with visual and aural warning of gun/missile threats on a cockpit display. Exterior sensors come in the form offourSU-130A(V) antennas - two facing forward, two facing aft.

optimum time. The area of operations for the ATKH13 will be the entire corps or divisional sector. Speed: attack helicopters move across the battlefield at speeds in excess of 3 km (1.86 miles) per minute. Planning airspeeds are 100-120 kt during daytime and 80-100 kt at night. Range: targets can be attacked up 150 km/93 miles across the PLOT, without additional fuel. Versatility: no longer are there specific airframe-based mission responsibilities. The AH-64 can carry 16 Hellfires, which allow the battalion to engage 384 enemy targets at ranges up to (and beyond) 8 km (5 miles).

The specific limitations imposed on the Apache ATKHB include the weather and Combat Service Support/CSS. With a 500-ft (152-m) cloud ceiling the Hellfire's engagement profile forces the Apache to get too close to the target and exposes it to enemy ADA. The same is true if visibility is reduced to >3 km (1.86 miles). For CSS, an ATKHB will normally require two established FARPs, one for a specific mission and one for future operations, stocked with fuel, ammunition and spares. Each FARP will typically have four rearm/refuel points, allowing the entire battalion to be turned around in two hours, or less.

AH-64 at NTC

Since 1982 the US Army has been training with battalion-sized exercises at the National Training Center (NTC), located in the desert at Ft Irwin, California. These exercises entail an entire battalion deploying to the NTC for a period of several weeks to train in air and ground manoeuvres against the Army's OPFOR (OPposing FORces) units, which use Soviet equipment and tactics. Sessions at the NTC are conducted semi-annually, perhaps every 18 months, and involve up to six weeks in the field. Before deploying, units form hard crews who will fly together consistently. Apache units do not fly uniformly during peacetime with hard crews, in order to spread experience around the unit and avoid crews becoming complacent with each other. In time of war, this practice would cease and hard crews would be flown constantly. Pre-NTC training will be undertaken for several months without distraction, before the battalion deploys.

Train the way you fight

The first week at NTC is given over to outfitting every aircraft with the Loral MILES (Multiple Integrated Laser Engagement System) laser simulation system and transponders essential for accurate scoring on the ranges, followed by a work-up flying period. The second and third weeks are spent in the 'box' (the NTC manoeuvre area) deployed in the field, living with aircraft and following the OPFOR engagement syllabus. Conditions in the NTC are demanding. The Santa Ana winds can blow at up to 30 kt (55 km/h; 34 mph) and the high ambient temperatures make it easier to over-torque rotors. All operations are conducted under the supervision of the central 'Star Wars building' centre which runs the exercise, backed up by Operational Controllers deployed in the field. Missions begin on day one of the war against the 'Krasnovian' forces who have invaded Mojave from the east. Blue forces start west and work east. The Apaches fly screening missions looking for forward security elements of the invading forces. Operating in pairs for the scouting mission, the Apaches fly 'at the same altitude as the tanks' in front of the advance Bradley IFVs of their own ground forces, operating

The Apache's AN/ARC-201 secure radio is an airborne VHF/FM transceiver for use in the SINCGARS system. SINCGARS provides a jam-resistant radio capability by using a frequency-hopping transmission system that changes frequency many times a second, in an apparently random manner. For successful communications the radios in use must be synchronised and on a common net. Each AN/ARC-201 has an internal clock; one radio set will be designated as the 'master', and any time differences will be adjusted on the others.

on a common radio net. Apaches operating in the traditional deep attack role will go deep to attack Krasnovian installations and armour, through weak points in the defences.

The mission planning imperative

All Apache missions begin with an in-depth mission brief, no matter what the objective or the urgency of the mission. A typical mission analysis begins when the unit commander, operations officer (S3), intelligence officer (S2) and fire support officer (FSO) receive the tasking from higher command. The mission analysis team assembled as a result will include the above personnel and their assistants, plus the unit adjutant (SI), supply officer (S4), liaison officer (LNO), individual company planners (as many as are attached to the regiment), EWO, safety officer and senior IP. This team will spend as much time as it can (up to 90 minutes) on its mission analysis, even under the most extreme circumstances. The S2 will update the IPB (intelligence preparation of the battlefield) and conduct the terrain analysis. This utilises the OCOKA procedure (Observation and fields of fire, Cover and concealment, Obstacles and movement, Key terrain and Avenue of approach). The S2 also conducts weather analysis and threat evaluation to produce the 'illustration of the enemy', which is a situational map and enemy course of action (COA) sketch. The assistant S3 integrates the brigade's mission with other operations in the area. He ensures that the practical details for the mission — battlefield calculus, battle position/engagement area graphics, communications cards - are ready. The FSO will co-ordinate required field artillery support, determining what units are available, where they are deployed, types of ammunition and available stocks, and target priorities. If NBC operations (including smoke) are anticipated, then substantial additional planning is required. An assessment of the enemy ADA capabilities is essential - their available weapons, their employment parameters and how they are integrated with the primary target. The battalion S4 identifies the logistics required for the missions and the constraints on them and comes up with the battalion combat power assessment. The SI determines medevac and casevac procedures. The XO (executive officer) has the ultimate responsibility of analysing the level of risk inherent in the mission and whether or not it is acceptable. Finally, the battalion commander reviews the mission intent, adds his own guidance, and approves the course of action.

The results of this mission analysis will include draft route and communication cards, mission graphics, an assessment of friendly forces in the operational area, the mission statement, the commander's intent, the enemy assessment and course of action sketch. A battlefield matrix will have been developed that combines seven defined elements: artillery, C^2, intelligence, manoeuvre forces (infantry, armour and aviation assets), mobility/counter-mobility (engineering support), combat service support and deployed AAA/ADA.

Above and top: Apache units deploy to the National Training Center every 18 months or so and are well-versed in desert operations as a result. Conditions in the Mojave are demanding and can stretch the capabilities of men and machines. However, the frequent complaint of many flyers - lack of power, particularly in hot-and-high conditions - is not one heard from Apache crews.

AH-64 Battle Drills

US Army Aviation battle drills are essential, basic 'collective actions' used by aviation units that have suddenly encountered a threat. They are learned by every crew through exhaustive, repetitive training, so that they become second nature in combat situations. They should require little or no orders to execute and are generally applied to platoon-sized or smaller units. Battle drills are initiated by the first element of the platoon in response to a specific threat from a given direction. The primary objective is to warn the other crews, then initiate a reaction. Battle drills for air threats or ground threats can be categorised in four ways - break, dig, split or static drills.

A break drill allows aircraft to respond to a threat from the flank. In a break the AH-64s will turn to orientate on the threat while manoeuvring to avoid, threaten or engage it.

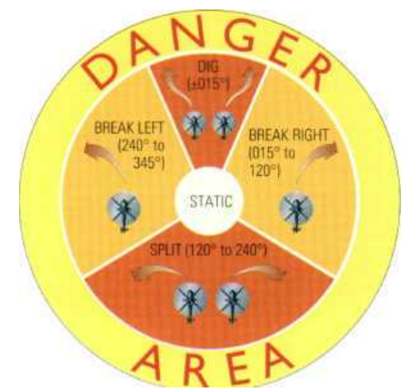
A dig drill is designed for an air threat approaching from ±15° to the Apache formation's direction of flight. The objective is to separate friendly elements to avoid the threat or distract the threat while other AH-64s manoeuvre against it.

A split drill is carried out in response to a threat from the rear and (almost by definition) the aircraft will be responding from a disadvantageous position.

A static drill is designed for friendly aircraft operating from a static position, such as a BP (Battle Position) or during slow forward flight (such as a screening operation).

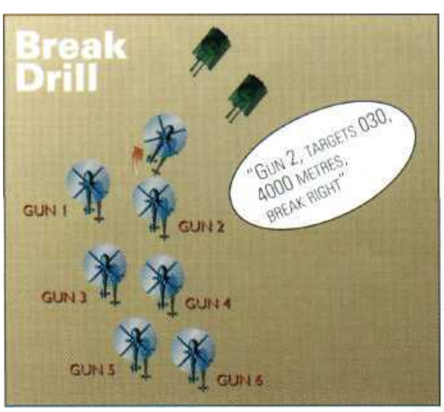
Battle Drill Templates

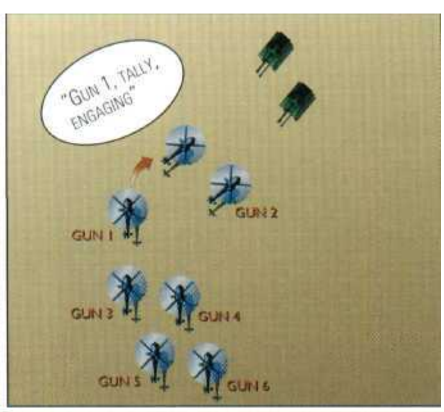
Battle drills are run on the assumption that a two-ship element (of the platoon) is the basic and most efficient manoeuvring element. This battle drill template (left) shows the appropriate response to a threat (dig, break or split) depending on how it is encountered. If a threat encroaches upon the Danger Area there will hopefully be enough time for one aircraft to make the essential alert call and initiate the appropriate drill.

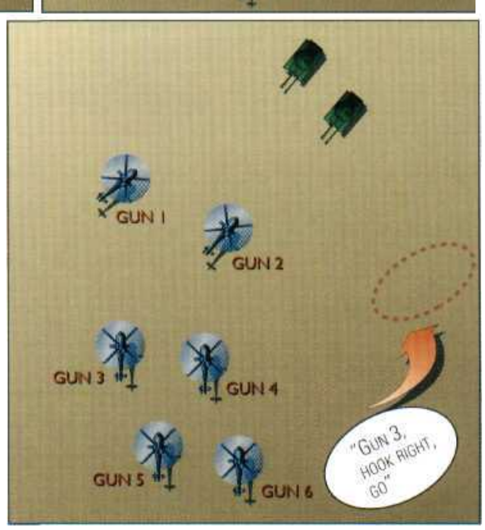


ALERT CALLS ***are the most critical element of the battle drill. The call consists of key words and phrases and initiates a specific response. The first crew to observe the threat must*** **ACT** ***to manoeuvre on the target and maintain visual contact. Secondly it must*** **DETERMINE THREAT STATUS** ***- known or unknown, 'bandit', 'bogey' or 'target'. Then this crew must*** **TELL** ***the rest of the formation - stating its own callsign, threat status, distance to threat, required drill and any other essential information. The rest of the formation must act immediately to perform the drill or mask, or to continue, as required. If there are*** **FOLLOW-ON ELEMENTS** ***behind this formation they will support the engaged platoon if required, bypass the engagement or mask to avoid the threat.***

The **FORM OF AN ALERT CALL** **is** ***tightly defined, and will follow the pattern of: "Gun 2, target tanks, 300 metres, break right, engage" or "Gun 1 targets, 360, 5000 metres, dig."***







Gun 2 of the lead platoon sees attacking targets at bearing 030° to the formation.

He acts (orientates on the threat) and determine's its intentions.

As Gun 2 manoeuvres to cover the tanks he alerts the rest of his platoon and the follow-on Apache platoon.

Gun 1 acts (manoeuvres to a vantage position and engages the threat to cover Gun 2).

Gun 2 tells Gun 1, and the remainder of the company, that he sees the threat and is engaging.

The second platoon leader hears Gun 2's alert call. He executes a hook right to place his platoon in a position to support the first platoon.

From this position the engagement is extensively wargamed in an attempt to predict every possible enemy action and the Apaches' counter to it. It is a major task, but an essential one for every AH-64 mission. Each wargame is run with a strict timeline. The S2 plays the enemy, the S3 plays friendly forces. The FSO supports the S3, and any NBC operations are also included. The S4 organises support measures, such as FARPs, while the SI runs medevac. The company commanders manoeuvre their units on the imaginary battlefield and the 'games' are run and rerun until time expires; there are no real answers, only potential ones. The US Army has a mission planning system called Terrabase, which is similar to the USAF's Elvira system. Terrabase uses US military mapping information to generate a three-dimensional, computer-based model of the engagement area. This is of crucial importance when it comes to working out the battle positions of each Apache team. A 3-D model allows the wargames to see the actual fields of fire and identify the 'dead space' where Apaches cannot be seen or cannot see the target.

The final 'production of order' will reunite the planning team to produce all the mission-relevant information for the entire battalion. This will include area of operations maps and sketches, holding area maps, engagement area maps, order of battle, ADA threat, communications frequencies, en route/navigational information, fire support graphics, FARP plan, medevac locations and a mass of other details, which must be digested by every crew.

The entire planning process can take up to six hours with an experienced team, or up to eight hours with new staff. During an NTC deployment, for example, this is exactly what each unit will strive to achieve for maximum training benefit. In time of emergency, such as when planning for a hasty attack, the planners will have to go straight to the wargame phase, leaving the S2 to catch up as best he and his team can. Before the mission (approximately 90 minutes prior to launch), the battalion will ideally conduct a rehearsal, but the most important element remains the mission analysis procedure. This intense planning requirement obviously affects the operational tempo of the unit. Although 'sortie' levels depend on the mission, an attack battalion will, hopefully, be allocated just one deep attack mission per night as a function of planning.

Mission launch

Once inside the aircraft, the crew run through the pre-start checklist: batteries on, APU on-line, cool the TADS/PNVS, boresight, HARS (Heading and Attitude Reference System) position input, then engine start. Once the engines arc running the rest of the onboard systems come on line. The AH-64 handles well, but nothing is 'hands off in the Apache and the pilot has to maintain control input for every second the aircraft is in the air. The pilot flies with the PNVS if required, but can also use the TADS FLIR in an emergency. The pilot may also be allocated control of the rockets while the gunners uses the 30-mm cannon. Once in the air the CPG runs through his SWRM ('swarm') procedure: Sight (select HDU or TADS, day or night), Weapons (activate, select appropriate type and fusing), Range (manual — set at 3 km/1.8 miles as an *en route* 'battlesight' - or automatic, using the laser rangefinder) and Messages (who has control of which weapons, and when). There is a third ranging system, dubbed 'automatic', that uses a flat-earth, line-of-sight/slope-to-target calculation combined with the Apache's radar altimeter. It is little used but, like the manual setting, has the advantage of not requiring the laser — making the Apache that much more undetectable.

The lead/wingman team offers maximum operational flexibility, since it enables proper look-out techniques, aggressive manoeuvring, rapid weapons employment and good mutual support. There are two basic tactical formations: combat cruise and combat spread. In a combat cruise

Left: Night operations are generally undertaken using the onboard FUR systems, and not NVGs (though it is noteworthy that TF Normandy used both systems). The PNVS is superior to NVGs as it combines FUR imagery with overlaid flight symbology on the HDU or cockpit displays, allowing the pilot to fly 'head-up and eyes-out'.

Below: The AH-64A has g limits of +3g/-2g. The Apache has operational pitch limts of ±30° and roll limits of ±60°. The Apache has been rolled, but finding someone who will admit to doing so is another matter.

spread the wingman positions himself to best cover the lead, offset to the lead's right side by 10° to 45°. This is also the basic night-flying **formation.** The combat cruise keeps aircraft staggered, passing through hostile areas with the minimum footprint. Aircraft should avoid flying in trail; if the enemy is alerted by the first aircraft, it is a simple task to shoot at those following in a straight line behind. However, combat trail formations are used when speed is required, or when transiting through defiles or close terrain. The combat spread formation allows both aircraft to cover each other as the two Apaches fly roughly parallel by ±10°. The team must be scanning the terrain, ready to spot incoming fire, and at no time should both crews be looking in the same direction.

Attacks can be made from a variety of attack patterns, dictated by the number of Apaches involved and the type of target, weapons capabilities (enemy and AH-64), disposition of friendly forces and the need to reattack. The cloverleaf pattern allows a team in combat cruise to attack a small target from several differing directions, firing on the inbound leg of each 'leaf. The 'L' pattern uses a four-ship to attack from two different directions (at 90° to each other) and places maximum firepower on a point for a short duration. In an 'L', the fire of one team should cross the line of the other, forcing the enemy to attempt to engage in two directions at once. The 'inverted V is a disengagement pattern from combat cruise if the team suddenly takes fire. Lead engages with cannon and breaks away covered by his wingman, firing rockets. Continuous fire can be directed from 'racetrack' or 'wagon-wheel' patterns, particularly used to cover air assault landings and pick-ups.

Panamanian debut

In 1989, eager to flex the Apache's muscles in combat, 11 aircraft from 'B' Company, 1st Battalion, 82nd Airborne Division were deployed by C-5A to Fort Armador, Panama, in advance of Operation Just Cause (the US military ousting of Panama's President Manuel Noriega). The

Apache's first taste of combat was brief and indecisive. Operating as Task Force Wolf, the Apaches undertook combat missions in conjunction with AH-lEs and OH-58Cs, from the early hours of 20 December 1989 until the ceasefire was declared on 9 January. This was the first combat use of NVGs by US Army aviation units, and also the combat debut of the Hellfire. During the assault on General Noriega's headquarters, two Hellfires were fired through selected windows in the building from a distance of 4 km (2.5 miles). Apaches chalked up 247 combat hours during Operation Just Cause, and several aircraft were hit by ground fire, including one aircraft which was hit 23 times and survived. In all, the Apaches of TF Wolf achieved an 81 per cent mission-capable rate.

It was in Iraq that the Apache finally won its true battle honours, during Operation Desert Storm. Army aviation units did not have the experience of the 39-ciay air war, before troops moved into Kuwait and Iraq, but the AH-64 had an essential part to play in the success of the air campaign. Three Iraqi radar sites close to the Saudi border had to be destroyed to allow the first wave of coalition

Below left and below: As the armoured build-up in Saudi Arabia accelerated in Operation Desert Shield, the AH-64 became even more in demand. Despite the hectic pace of training during the months leading up to G-Day, only a single AH-64A was lost (on 20 January 1991), and its crew survived.

Above: Much has been made of the Apache's supposedly poor serviceability during Operation Desert Storm, but criticisms of the aircraft's record do not bear up to the facts. One 1st Cav veteran of the war in Iraq remembers thatofthe18AH-64s attached to his battalion only one ever needed an engine change. In contrast, each of the OH-58Cs attached to his unit needed to have engines changed and one UH-60 lost three in succession.

Above right: FARPs (Forward Air Refuelling Points) were established by UH-60s and CH-47s that carried fuel and supplies into Iraq, ahead of armoured units. This allowed the Apaches to jump far into Iraq, scouting for and engaging enemy units.

Opposite top: Apaches came to Saudi Arabia by sea. For example, the aircraft of the 4th Brigade, 1st Armoured Division self-deployed from their base at Katterbach, Germany, to Valkenburg AFB, Holland, on 29 November 1990. From there they were loaded onto ships at Rotterdam. It took seven days to get from Katterbach to Rotterdam, butia further three weeks before all 124 helicopters were on board and underway to the Kuwaiti theatre of operations. They arrived in Saudi Arabia on 2 January 1991.

Opposite centre: These aircraft are seen deployed at a forward airstrip, 50 km (31 miles) south of the Kuwaiti border, just prior to Desert Storm.

Opposite bottom: It is almost impossible to discern the Apache in this photograph, which dramatically illustrates the 'brown-out' dust-storms that so hamper desert operations. The key to surviving this sudden loss of visibility is to expect it and keep the aircraft level while climbing away or executing a rolling landing.

attack aircraft safely into western Iraq to attack the Iraqi 'Scud' sites that threatened the political fabric of the coalition forces.

Task Force Normandy

CENTCOM planners decided that the mission could be accomplished in one of three ways: inserting SOF troops to destroy the sites, inserting SOF troops to laser designate for AH-64s, or allowing Air Force aircraft to attacks the sites. Using SOF personnel always entailed an element of risk if the troops were compromised before reaching their target. USAF aircraft could attack the radar sites but could not guarantee that they had been 100 per cent destroyed - the crucial requirement which General Schwarzkopf repeated again and again. Only the AH-64s could bring enough fire-power to bear on the targets and undertake the 13DA required to confirm that they had been destroyed. The obvious choice for the mission was the AH-64As of the 1st Battalion, 101st Aviation Brigade, which was one of the US Army aviation units most experienced in night operations. The 1-101st teamed up with the USAF's 1st SOW, whose GPS/INS-equipped MH-53Js would lead the attack force into Iraq. The operation was codenamed Eager Anvil, but Lieutenant Colonel Richard A. Cody named the task force Normandy, in honour of the troops of the 101st who parachuted behind enemy lines into Normandy in advance of H-Hour on D-Day.

Training for the mission began on 26 September 1990 when Lieutenant Colonel Cody's Apaches began to train at night with MH-53Js of the 2()th SOS in the FOB Bastogne area. (FOB Bastogne was a Forward Operations Base established to defend the lOlst's massive Area of Operations, AO Normandy, 85 km/53 miles south of the Kuwaiti border. It was named after the Belgian town of Bastogne where the 101st Airborne famously held out against besieging German forces during the Battle of the Bulge in 1944.)

The team's helicopters flew the same mission profile that would be required of them on the night — 50 ft (15.24 m) AHO (above highest obstacle) at 120 kt (110 mph; 177 km/h) — and engaged their target with Hellfires and rockets. The route was never flown for real, to ensure their mission was never revealed. Three teams had been organised for the three targets — Red, White and Blue — each with three Apaches plus Pave Low Ills. It was later determined that the northwestern-most radar site was. not linked to the others, so it was dropped from the target list. As a result, the Blue Team was integrated with the others and the mission was flown by four AH-64s, with one spare. On 14 January 1991 the two teams made their way from the lOlst's tent-city home of Camp Eagle II (CEI1) over 220 iim

(407 km, 253 miles) to King Khalid Military City. The helicopters arrived radio-silent, refuelled, and departed for Al Jouf, doing their best to look like just another training flight. Al Jouf was a small single-runway staging strip, northeast of Tabuk, that was the closest Saudi airfield to the Iraqi border. Only on 15 January did Cody and his S2 (intelligence officer) reveal details of the mission and its target to the rest of the task force. At around 14.00 the following day, word arrived that H-Hour would be 03.00, 17 January 1991.

The first mission of the war

At 00.56 on 17 January 1991 Lieutenant Colonel Cody lead the White team of two MH-53Js and four AH-64As out of Al Jouf. The Red team, led by Captain Newman Shufflebarger, departed 12 minutes later. In all there was a total of nine AH-64As, two MH-53Js and one UH-60 in the air. One Apache acted as a back-up and the Blackhawk was a SAR aircraft, which waited at the border. The Apache crews flew with their FLIRs and ANVIS-6 NVGs. Formation was kept tight, with just three rotor spans between aircraft, and no external lighting. The Pave Lows dropped chemical lights at specific GPS reference points which the AH-64s used to update their onboard Doppler navigation systems. The flight to the target area would take 90 minutes and the round trip back to CEII would be 900 nm (1667 km, 1,036 miles). Even though Al Jouf was

'close' to the border, it was still far enough away to require the Apaches to refuel en route. Ordinarily a FARP would have been established in northern Saudi Arabia, but the danger this would cause in exposing the task force called for a another solution. Lieutenant Tim DeVito came up with the 'single tank option', fitting just one 230-LJS gal (870-litre) fuel tank to the right inboard pylon and giving the aircraft a 440-nm. (815-km, 506-mile) range while still carrying eight Hellfires, 19 Hydra 70 rockets and 1,100 rounds of 30-mm ammunition.

TF Normandy was fired at twice over Iraq, by ground forces alerted by the sound of their passing, but no-one was hit. At 20 km (32 miles) south of the target the MH-53Js delivered their last position update and then peeled off to orbit at their RV. The Apaches approached the radar sites at 60 kt (111 km/h, 69 mph), then each team split into two two-ship groups positioned 500 m (1,640 ft) apart. The two radar sites were close to the Iraqi/Saudi border — the furthest of the pair was only 7 miles (11 km) behind the border - but approximately 69 miles (111 km) lay between them. Each radar site had a combination of Spoon Rest, Squateye and Flatface dish radar antennas, a tropo-scatter radar, generators, EW vans, barracks and ZPU-4 AAA. At 02.37 both teams were in position and marked their targets with the laser spot tracker from 12 km (19 miles) out. At 02.37.50 came Tom Drew's "party in 10" call, followed 10 seconds later by "get some." At a distance of 6 km (3.7 miles) each Apache fired two Hellfires at its primary target, an element of the radar system. The ZPU-4 guns did not come under fire until the radar sites were seen to be destroyed. Some aircraft got as close as 800 m (2,624 ft) to attack targets with their Chain Gun" cannons. The raid was over in 4M minutes. The Pave Lows were waiting for confirmation of the mission, to relay it to Riyadh. Codeword 'Charlie' meant minimal destruction, 'Bravo' partial and 'Alpha' total. 'Alpha, Alpha' meant no friendly casualties. The Red team had been allocated objective 'Nebraska' and White team objective 'Oklahoma'. From his Apache, named *Rigor Mortis*, Lieutenant Colonel Cody transmitted the phrase, "White Six, Oklahoma, Alpha, Alpha."

A 20-mile (32-km) wide strip had been opened in the Iraqi radar network and SF troops were inserted by MH-47 to place 11 radar reflectors marking the safe corridor for coalition aircraft. As the Apaches turned south to regroup they flew at 100 ft (30.5 m) and 140 kt (259 km/h, 161 mph). Minutes after the firing had begun, the first wave of F-15Es and EF-llls swept overhead at 400 ft (122 m) to knock out fixed 'Scud' sites near H2/H3 airfields. The Apache crews could see them coming through their NVGs until the jets extinguished their external lights 20 miles (32 km) from the border. At 02:51 F-117s knocked out the air defence control centre for the region, completing the job. TF Normandy returned to Al Jouf at 04.30 to debrief. Early the next morning they flew back to KKMC, rearmed with Hellfires and returned to CEII — only 15 hours after the attack — ready to face any potential Iraqi counter-attack against the 101st.

The AH-64 was one of the success stories of Operation Desert Storm. Yet, despite the amount of literature generated by that brief war, the Apache's achievements go largely unrecorded. One senior commander from a Europe-based attack battalion remembered events thus: "As an aviator who had fought Cobras in Vietnam, (in) my mind's eye (I) expected to see a period of rapid improvement from the initial combat missions. This did not happen. From the first mission on, each aircrew and unit functioned in full synchronization. I attribute this to peacetime training and the great stand-off range of the Apache. The Apache crews very quickly and methodically killed enemy formations in order of priority - tanks with Hell fires, BMPs with rockets and 30-mm, and wheeled vehicles with 30-mm...a great measure of our success (in Desert Storm) can be attributed to the Aviation Branch."

Apache in Operation Desert Storm

The three-day, 100-hour ground war that commenced at 04.00 (local) on 24 February 1991, G-Day, was accomplished with lightning speed thanks to the mobility of the coalition armoured divisions. US Army aviation's chief contribution to the victory came through its airlift and airmobility assets. The Army deployed 1,193 helicopters in support of Desert Shield/Storm, and only 277 of these were Apaches. On G-Day, an entire brigade of the 1()lst Airborne Division was moved into Iraq, by air, to Forward Operating Base Cobra, 35 km (22 miles) southeast of As Salman. Apaches were always in the air running screen and security missions for their own ground forces. Their importance to the ground forces was summed up by the words of Major General Griffith, commander of the 1st Armored Division, who said, "I don't want another minute to go by without Apaches out in front of this division."

Apart from TF Normandy the first Apaches into Iraq were 18 aircraft from 2-6th Cav, based at Illeshcim, ('Fighting Sixth'), which crossed the border to attack Iraqi communications and surveillance facilities on 16 February 1991. Ten days later 2-6th led the 3rd Armored Division into Iraq and the unit claimed 211 Iraqi armoured vehicles

Right: Throughout Desert Storm and subsequent regional operations Apaches retained their dark-green (IR-suppressant) finish.

Below: The Operation Provide Comfort deployment to Turkey was frustrating for all those invoved, as political restrictions prevented them from defending the Kurdish refugees they were supposed to be protecting.

destroyed in the space of just 45 minutes. Elements of the 3-227th Aviation Brigade ('Spearhead Attack') are credited with pushing further into Iraqi territory than any other US unit. The 3-227th deployed from Hanau in September 1990 and, during one deep attack mission, it advanced 400 km (249 miles) to attack tanks in the Euphrates valley. The 2-227th Aviation Regiment, also based at Hanau, deployed in December 1990 and by the end of the war had flown over 3,200 hours. The unit is credited with destroying 200 Republican Guard vehicles and maintaining a 100 per cent mission-availablity rate during combat. The l-82nd Aviation Brigade ('Wolfpack') deployed from Ft Bragg in August 1990 and flew 1,893 hours until April 1991. The 3-1st Aviation Regiment ('Night Eagles') deployed from Katterbach and over a three-day period flew 280 combat hours. Its Apaches flew deep attacks against Al Busayyay, destroyed two Iraqi divisions and over 200 tanks/APCs, and captured 248 Iraqi troops. Apaches from the Ft Rucker-based 2-229th Attack Helicopter Regiment ('Flying Tigers') flew 5,900 incident-free hours to the end of Desert Storm. The unit was involved in the destruction of Iraqi forces along the A-Hammar causeway bridge and the Basrah highway. Apaches from 2-1st Aviation Regiment ('Strike Eagles') flew 235 combat hours and all of its missions were 'cross-FLOT' (Forward Line Of Troops), in day and night. The 2-1 st engaged targets of opportunity up to 60 km (37 miles) behind enemy lines, destroyed 35 tanks and took the surrender of over 400 prisioners. The Ft Hood-based 1-3rd Aviation Regiment, (now the 2-101st 'Death Angels' based at Ft Campbell) flew 750 combat hours, including the destruction of Iraqi fire trenches. The 1 -3rd was credited with one of the highest direct-fire tank kill totals of the war. Weisbaden-based 5-6th Cavalry Regiment ('Knight Raiders') conducted operations across its corps' sector, including deep attacks and armed reconnaissance. At the time of the ceasefire it was preparing to attack elements of the Republican Guard.

A significant contribution

Singled out for special mention among all the Desert Storm Apache units was the 4-229th Attack Helicopter Regiment ('Flying Tigers'). Deploying from lllesheim, and logging 1,478 hours from January to April 1991, the 4-227th destroyed 100 armoured vehicles in the US Army's first night 'cross-FLOT' and deep attack mission of the war. The 4-229th then made an unprecedented reattack of Iraqi armoured targets, through intense enemy fire, to destroy a brigade-sized element and block reinforcement of the Iraqi frontline. For this achievement the 4-229th was awarded the Army's Valoros Unit Award.

The Apache is fitted with the RT-1296/APX-100(V)1 and RT-1557/APX-100(V) IFF system. APX-100 operates on Modes 1, 2, 3/A,3/Cand4, transmitting specially coded identification of position or emergency signals as required. Each mode offers progressively more code combinations and ease of use. Mode 4 is the classified operational mode for security identification. IFF antennas are installed on top of the fuselage aft of the canopy, and under the fuselage as an integral part oftheUHF-AM antenna. Some Apaches have an IFF antenna located on the work platform forward of the main rotor mast and aft of the tailboom jack pad. IFF transmission from the upper antenna can cause the PNVS to malfunction and slew to the centreline before returning to the pilot's LoS. If this occurs, the transponder must be disengaged or rerouted to the lower antenna.

As part of its WAH-64D Longbow Apache acquisition, the British Army Air Corps will acquire the CRV7 70-mm rocket system. Developed by the Canadian firm of Bristol and the Canadian Department of National Defence, the CRV7 (Canadian Rocket Vehicle) is already in RAF service and was used operationally by Jaguars during Operation Desert Storm. The CRV7 had a hasty introduction to service during the Gulf campaign, answering an RAF need for a high-velocity precision weapon, capable of destroying hardened targets such as aircraft shelters. The version fitted to UK Apaches will be based on the model C17 rocket motor which utilises a low-smoke HTPB solid propellent. Its rapid acceleration will mean that CRV7 rockets are less prone to interference from rotor downwash. CRV7 can be fitted with a range of 70-mm (2.75-in) warheads including RA79 HEISAP (high explosive incendiary semi-armour-piercing) anti-ship, M151 HERD (high-explosive incendiary point detonation) anti-personnel, M156 smoke (white phosphorus), M257 illumination, and M261 MPSM (multi-purpose submunition) high-explosive. A newer range of4.5-kg (10-lb) warheads is under development including tungsten kinetic energy penetrator anti-armour rounds, and tungsten flechette anti-personnel rounds. This AH-64D is seen during CRV7 firing trials at the US Army's Yuma Proving Ground.

AH-64s flew around the clock, ahead of the advance, engaging Iraqi units as they found them, until it almost became routine. Of all the gun camera/FLIR imagery seen during the war, a team of AH-64s brought back one of the most chilling sequences. Through the TADS of one aircraft a column of Iraqi AFVs could been seen, stationary on a road where their crews believed themselves to be hidden by the smoke from Kuwait's burning oil fields and immune from attack. From a distance of 5 km (3.1 miles) the Apaches could see clearly through the smoke and engaged the column with Hellfires. The silent TADS video showed the lead and trail vehicles destroyed first, to cut off any escape route, and then, methodically but in less than a minute, the dozen or so remaining APCs were wiped out. The Iraqi crews who had been standing in groups, smoking, had no warning and no way out.

Apache ascendant

Any targets that were found were destroyed — over 800 tanks and tracked vehicles, 500 other military vehicles, 60 bunkers/radar sites, 14 helicopters, 10 combat aircraft plus innumerable artillery and AAA positions were claimed by Apaches. A total of 2,876 Hellfires was fired by AH-64s. One Apache was shot-down, by an RPG round fired point-blank from a surrendering Iraqi position. The Apache was hit in the rotor system and crashed, but both crew walked away. All aircraft damaged during fighting returned to base. The overall mission-capable rate for the AH-64 in the desert was over 85 per cent. One unit flew its 36 aircraft constantly for four days, with limited maintenance support, and all remained fully mission-capable. One AH-64 killed two tanks with the same Hellfire. During the appalling weather of 25/26 February, Apaches were the only Army aviation asset to remain operational. During Desert Storm, Apaches did not fly definable 'sorties', for they were active and moving almost constantly. In seven days of operations one AH-64 pilot logged 70 combat hours, which was by no means unusual. The bulk of missions flown were movement to contact and hasty attacks. The war in Iraq was the ultimate 'fluid environment'. Typically, two-ship teams operated, with the lead Apache carrying rockets for area security and the wingman in 'heavy Hellfire' (16 missiles) configuration. Many pilots in action in Iraq had never fired a live Hellfire before and many remember the (standard) two-second delay after trigger-pull, encountered for the first time, with a mixture of terror and amusement. When the Iraqi surrender was accepted at Safwan it was six Apaches (from 4-229th AVN and 2-6th Cav) that escorted the C-in-C's Blackhawk to the meeting. Even then the Apache's mission in Iraq was not quite over.

The last action of a brief war

On 2 March 1991, after the ceasefire of 28 February, AH-64As from 1-24th Attack Battalion (24th ID) were patrolling the Euphrates valley when the 'battle of the Rumaylah oil fields' broke out. Elements of the Republican Guard's Hammurabi Division were attempting to escape further north, but began shooting at US troops. The US responded with withering MLRS and tank fire, backed up by three companies of AH-64As from the l-24th. The Apaches fired 107 Hellfires (for 102 hits), 100 70-mm rockets and 2,000 rounds of 30-mm ammunition to destroy 32 tanks and 100 vehicles over the course of an hour. Successful Hellfire engagements began at 6700 m (21,982 ft) - a remarkable distance — and the shooting continued until 15.00. A single US soldier was wounded. One M1A1 tank was damaged and another desroyed, both by secondary explosions from Iraqi vehicles.

After the ceasefire came Operation Provide Comfort and Operation Haven, a hastily prepared humanitarian mission to protect the Kurds in northern Iraq. Iraq's Kurdish population immediately came under attack from the Iraqi army after their uprising against Saddam Hussein failed when the

The ocean-going Apaches

Hughes and McDonnell Douglas made several attempts to adapt the AH-64A for a dedicated naval role. The first of these 'marinised' versions came in 1984. An Apache equipped with Harpoon or Penguin anti-ship missiles, Sidewinders for self-defence, TOW missiles and a mast-mounted radar was proposed for both USMC and USN use. In USMC service the proposed 'sea Apache' could operate in support of amphibious operations from LHAs or LHDs to protect the assault force at sea and on the beach-head. USN aircraft could be based on frigates to provide distant protection for battle groups from surface threats. The 'sea Apache' would have had a combat radius of 142 miles (228 km) and a mission endurance of 2.8 hours

These ideas matured into a more developed 'Naval Apache' concept which was unveiled in 1987. This aircraft was radically modified through the addition of a completely redefined forward fuselage (plus IFR probe) with the avionics shifted to a ventral housing, increasing the fuel load. TADS/PNVS sensors and cannon were replaced by a Hughes AN/APG-65 radar. Redesigned stub wing/undercarriage sponsons could mount Sidewinder missiles and the 'Naval Apache' retained its Harpoon anti-ship missile capability. Hopes for over 100 sales proved to be premature.

US refused to actively back them. In April/May 1991, Apaches were deployed to Turkey and provided 24-hour armed support for the fleet of transport helicopters supplying the Kurdish refugee camps in the mountains. The aircraft involved were from the 6th Squadron, 6th Cavalry Regiment and self-deployed from Illcshcim on 24 April 1991 for the 23-flight hour, 3,000-mile (4828-km) journey to Turkey — a unique achievement. The Apaches of the 'Sixshooters' operated with four Hellfires, 38 rockets and a full load of Chain *Gun"* cannon ammunition in temperatures of over 1()0°F (37.7°C). Their night-fighting capability was particularly useful against Iraqi units operating under cover of darkness.

Lessons of Desert Storm

During Operation Desert Storm some operational problems were encountered, of varying degrees of seriousness. Sand ingestion led to beter filtration. Ingestion problems in the air turbine starters and fuel boost pump were caused chiefly by the dust clouds spun up by aircraft landing and taking off alongside each other, and not by routine flight. Abrasion of the Hellfire seeker heads was encountered, and the 'dirt diver' missile problem was another minor irritant. For the pilot, the greatest hazard (true of any desert operations) was 'brownout' — losing contact with the ground in the dust cloud created by the rotor. When taking off the pilot simply had to anticipate the problem and ensure that the aircraft remained straight and level until out of the 'dust storm'. When landing, the technique was to roll ahead of the cloud until safely on the ground — an option not available to a helicopter with skids. The Apache's dust cloud can also betray its position to the enemy. NTC experience has shown that the AH-64's dust signature can be seen up to 10 km (6.2 miles) away, so the pilots must choose their operating conditions with care.

The most important lesson of Operation Desert Storm, learned with tragic effect, was that the Apache can kill at distances that far exceed its ability to identify the target. At night, FLIR contrast was negligible and aircraft needed to get within 2 km (3.2 miles) of a target before making a positive ID, which placed the Apache well within any ADA envelope. This also opened up the possibility of blue-on-blue kills, or 'friendly fire', which, as it turned out, was the greatest threat to coalition forces. On 17 February 1991 the lead pilot in a formation of three Apaches, in error of his actual position and inaccurate in his vehicle ID, fired on a US Army Bradley and Ml 13, destroying both with Hellfires. Before deploying to Iraq some units had undergone a hasty exercise at Ft Riley where every type of Iraqi combat vehicle likely to be encountered in the desert was paraded for the crews to give them some additional recognition practice. The Apache crews found they could not positively ID the targets as hostile beyond 3 km (4.8 miles). Since then, major R&D effort has been expended on developing an effective battlefield IFF system for the US Army. A visual 'threat library' of IR imagery is under development for the Apache and other aircraft, but remains a long-term project. What is needed is an improved battlefield sensor system, one that retains the benefits of the AH-64A's optics with an added level of sophistication and discrimination. That solution, along with many others, will be found in the AH-64D Longbow Apache.

Apache improvements

Since the earliest days of AH-64A operations there have been attempts to upgrade the aircraft. In the mid-1980s McDonnell Douglas began studies of the Advanced Apache/Apache Plus, which was later referred to, unofficially, as the 'AH-64B'. The AH-64B would have had a revised, updated cockpit with a new fire control system, Stinger air-to-air missiles, a redesigned Chain Gun* and a fin-mounted video camera. AH-64B was aimed at the US Army, but a similar AH-64G was proposed for the German anti-tank helicopter requirement, now filled by the Eurocopter Tiger. In 1988 funding was released for an AH-64 Multi-Stage Improvement Program (MSIP) to improve the Apache's sensor and weapons suites while integrating new digital databus and communications systems. The MSIP was abandoned before it reached the hardware stage. The

Below right: The US Army maintains a large fleet of Apaches for test and trials duties. This is one of the aircraft attached to the Airworthiness Qualification Test Directorate, now based at Ft Pucker. Until 1996 AQTD was based at Edwards AFB as the Aviation Engineering Test Activity (AETA).

Right: Seen here is AV-05, in use with McDonnell Douglas Helicopters as a technology demonstrator for the US Army's LHX programme. McDonnell Douglas and Bell Helicopter Textron joined forces as the 'Superteam' to bid for LHX. The competition was eventually won by the 'First Team' combination of Boeing/Sikorsky with the RAH-66A Comanche. The YAH-64 was dubbed the ACE (Advanced Cockpit Evaluator) and (over the course of several incarnations) was fitted with fly-by-wire controls, a sidestick controller and advanced cockpit avionics. It joined a dedicated trials group of helicopters which included a Bell 222 with the high-agility 680 tail rotor system and a NOTAR MD500.

reason was that new technologies, which had always been 'earmarked' for application to the Apache, were finally becoming real — and with them came the possibility for transforming the already formidable Apache into something even better. A scries of upgrades was proposed after Operation Desert Storm, the so-called AH-64A+/Desert Storm fixes. These included VHF/FM NoE communications improvements (a long-recognised Apache problem), a desert filtration kit, ground-proximity warning system, TADS/PNVS and Chain Gun" accuracy improvements, GPS, new HF radio, SINCGARS secure radio, improved IFF and flight control computer upgrade. Like the proposed MSIP these changes were abandoned in favour of a far-reaching and highly integrated transformation of the AH-64A, through the addition of a revolutionary new radar system and completely revised onboard systems.

Millimetre-wave (MMW) radar guidance had always been an option for Hellfire guidance, but was rejected for the AH-64A as the technology was not mature enough. In the Airborne Adverse Weather Weapon System (AAWWS), Westinghouse, in collaboration with Martin-Marietta (now Lockheed Martin Orlando), developed the Longbow MMW radar. Longbow is now being integrated into the US Army's Apache fleet, transforming existing aircraft into AH-64D Longbow Apaches. MMW technology overcomes the existing limitations in the Apache's targeting optics/laser combination. At present, the AH-64A can simultaneously engage two targets using its own designator, at a range of up to 8000 m (26,247 ft), day or night. However, the laser and FLIR are constrained by atmospheric conditions and the Hellfirc's range is limited if the cloud ceiling is less than 400 ft (122 m) AGL. To make a self-designated kill at maximum range, the AH-64A must unmask for 37 seconds.

Longbow — the next generation

The Longbow radar is largely impervious to atmospheric interference, allows the Apache to fire-and-forget all 16 AGM-114Ls in rapid succession, and gives the aircraft a new lethal SEAL) capability. The Longbow system comprises the mast-mounted fire control radar (FCR), a programmable signal processor and the Longbow Hellfire missile. The Longbow radar can scan a 50-knr (19.3 sq-mile) swathe of territory and detect up to 1,024 potential targets. Of these, 128 can be classified and displayed simultaneously, and software improvements will increase this to 156. The system will prioritise 16 targets depending on the desired engagement criteria and the target characteristics (wheeled, tracked, airborne, moving, static etc.). Longbow programme officials are keen to point out that while the radar can 'classify' a target, it does not 'identify' it. It can, however, determine if a contact is a wheeled vehicle or a tank or an air-defence system. The FCR has a detection range of 8000 m (26,247 ft) against moving targets and 6000 m (19,685 ft) against static ones. The Longbow's SEAD capability is provided by its radar frequency interferometer (RFI), a sophisticated RWR that can identify and target any emitting (ADU/air defence unit) system on the battlefield. The RFI has 360° coverage — 'fine' in its 180° forward hemisphere, and 'coarse' in the rear 180°. The system will provide an azimuth to target, although not a range. The Longbow radar also gives the AH-64D an effective air-to-air targeting capability. Longbow's MIL-STD 1760 databus will accept ATAS on its wingtip stations, but Stinger integration is not a priority purely on cost terms.

Digital warrior

The AH-64D has a totally new digital databus/systems fit, which is at the heart of the Longbow. Although the AH-64D is based on the AH-64A, the modification process involves reducing each Apache to a shell before the new equipment is added. The first item to be stripped out is the AH-64A's old wiring, to be replaced by four dual-channel MIL-STD 1553B data buses and lightweight wiring. The

***Above:** Greece was the first European customer for the Apache and was subsequently followed by the Netherlands and the UK - who both opted for the AH-64D. There are still several small batches of Apaches to be sold in Europe, but Boeing/McDonnell Douglas is now looking further east for the next round of substantial sales.*

***Top:** In 1990 Israel became the first export customer for the AH-64A. In Israeli service the Apache is known as the Peten (Cobra) and the Israel Defence Force/Air Force is believed to operate three squadrons of the AH-64As. Israel is an obvious potential customer for the AH-64D Longbow Apache.*

Apache over Bosnia

United States Army ground forces were committed to NATO's peacekeeping effort in Bosnia-Herzegovina in December 1995 after the Dayton peace accords brought the country's three-year civil war to an end. Spearheading the US Implementation Force (IFOR) contingent was the 1st Armoured Division under the command of Major General William Nash. The deployment of the division from its bases in Germany was a major logistical task, and its AH-64A Apache attack helicopters played a key role in ensuring that US forces were able to successfully deploy into Bosnia.

At the start of the deployment the division's aviation component, its 4th Brigade, was based at Hanau, near Frankfurt. It contained two Apache-equipped units - the 2-227th and 3-227th Attack Helicopter Battalions. The 7th Combat Aviation Battalion provided logistic support with Sikorsky UH-60 Blackhawks, and the 1 st Squadron, 1 st Cavalry had OH-58Ds for scout and target-marking work. Getting the brigade to Bosnia was difficult due to snow storms in central Europe that delayed its self-deployment to US staging areas around Taszar air base in southern Hungary. By the end of December 1995 advanced elements of the brigade had leapfrogged from Taszar to a forward operating base in Croatia, nearZupanje, to provide close air support for US Army engineers building a huge pontoon bridge over the River Sava for the main tank units of the division. Boeing CH-47 Chinooks were used to airlift the pontoon sections and the Apaches flew security patrols around the site to prevent interference with the bridging operation.

It took another month for all of the US division to be established in its bases around IFOR's North East Sector, and for the 4th Brigade to set up its main operating base at Tuzla air base alongside the USAF's 4100th Air Base Group. The old Yugoslav air force base proved an ideal location because of its runways and old hardened aircraft shelters. As US troops - along with Russian, Nordic, Polish and Turkish troops - began to separate the warring factions in the northeast of Bosnia, the Apaches were regularly tasked to fly patrols along the Zone of Separation to deter infringements. Helicopters had to fly in pairs due to US concerns about hostile attacks on their forces, and when VIPs were airborne in helicopters two Apaches were always tasked to 'fly shotgun'. Twenty four AH-64As have been deployed to Bosnia, some with improved systems fit to enhance their operational capabilities. Six aircraft have a real-time datalink to allow them to send FLIR/DVO video imagery to local command units. Three of these have an additional SATCOM capability to allow direct transmission to national command authorities in the USA.

The Apaches were called upon during February and March 1996 to support IFOR operations in Sarajevo. They flew security missions around the city on 3 September when US Secretary of State Warren Christopher came to visit.

By the summer of 1996, the IFOR mission was all but complete, with the warring factions so impressed by its firepower - particularly the heavily armed Apache - that they had been all but confined to barracks. The two US Apache battalions continued their patrols but also began to carry out live firing training on the large British run ranges at Glamoc, firing their cannon, rockets and Hellfire missiles in a series of very impressive firepower demonstrations. They also participated in joint firing exercises with allied air and ground forces. In December 1996 IFOR began to withdraw and the 4th Brigade started to deploy back to Germany, handing over its duties to aviation elements of the 1st Infantry Division, the US ground component in NATO's new Stabilisation Force (SFOR) for peacekeeping into 1997. The Apache's deadly reputation played a major part in ensuring Bosnia's warring factions were not tempted to take on IFOR. Peace through superior firepower.

Tim Ripley

*An **IFOR** Apache lands in typical winter weather at Taszar, in Hungary.*

new databus is allied with totally integrated 6-32 bit processors and coupled with an uprated onboard electrical system which can cope with peak loads of 90 kVA (the Improved Electrical Power Management System/IEPMS). This digital architecture empowers the Longbow's 'manprint' (manpower integration) cockpit layout. Gone are the dials and 1,200 switches of the AH-64A, to be replaced by a Litton Canada upfront display, two AlliedSignal Aerospace 15-cm x 15-cm (6-in x 6-in) colour (initially monochrome) CRT displays and just 200 switches. The CRT displays and helmet-mounted displays use improved Honeywell raster-generated symbology to combine the DVO, FLIR and radar sensor data. The display processors (which 'drive' the screens) are capable of handling a digital colour moving-map, when such a system becomes available. An improved Plessey AN/ASN-157 Doppler navigation system and Honeywell AN/APN-209 radar altimeter have also been incorporated. AH-64D will have a dual embedded GPS and inertial navigation (EG1) fit plus AN/ARC-201D VHF/FM radios. EGI is being developed as a tri-service project. The improved navigation fit for the AH-64D gives it near all-weather capability compared to the adverse weather-capable AH-64A. Hamilton Standard has also developed an advanced lightweight PCS computer to take advantage of the 32-bit processor system. The larger volume of avionics in the AH-64D has forced the expansion of the Apache's cheek fairings, to become EFABs (Enhanced Forward Avionics Bays)

Communications revolution

Mission planning will be greatly eased by the AH-64D's data transfer module (DTM). The DTM allows key mission data such as flight routings (waypoints/hazards, FARP location, PLOT location), enemy/friendly forces dispositions, unit sectors, battle positions, priority fire zones and communications (callsigns, frequencies, secure codes) to be input directly to the AH-64D's mission computer on a single cartridge. The DTM will ease the battalion mission planning load, but the AH-64D's Improved Data Modem (IDM) will revolutionise the way the AH-64D flies and fights. The high-speed (16 KB/sec) IDM uses the newly developed variable message format (VMF) based on the 18820 protocol, which allows an AH-64D not only to talk to other AH-64Ds, OH-58Ds and RAH-66s but also to Rivet Joint (RC-135), J/STARS (E-8), airborne A^2C^2S (UH-60C 'C+CHawk'), the battalion TOG (Tactical Operations Center) and armoured manoeuvre units. IDM uses a communications standard that is tri-service (and still expanding in scope), digital, multi-channel, secure (using Have Quick and SINCGARS systems) and applicable to virtually any radio. The MMW/RFI system provides the Longbow commander with a digital picture of the battlefield where all targets are classified and prioritised using clear symbology. Targets can be classified as tracked,

wheeled, air defence, helicopter or fixed-wing aircraft. Once the radar has scanned the engagement area, automatic target handover to the fire control system takes place "faster than it takes to read this sentence", according to one Longbow programme official. The Longbow TADS/PNVS can be slaved to the MMW radar for visual ID, but in most cases the radar exceeds the FLIR's target recognition capability. In the words of a Longbow project officer, "The AH-64A finds the target and asks you what it is; the AH-64D finds it, then tells you." Target sort and handover can be accomplished with a few keystrokes.

More importantly, the engagement parameters can be changed with as little effort. Longbow Apache divides the battlefield using information transmitted in real-time to all the other members of the attack team. The prioritisation system allows targets to be clearly marked as 'shoot first', 'shoot second' or 'already shot at'. This minimises overkill and allows the battalion/company to make maximum use of its missiles. The Longbow can also minimise fratricide by setting up a 'no-fire zone' where it is impossible to engage targets, without man-in-the-loop override. The AH-64A is terrain-dependent, which limits the engagement areas and battle positions available to the attack force. AH-64As have to operate in relatively close formation to maintain LoS communications and station-keeping. The Longbow's C^3 capability allows it to conduct on-the-spot target handovers, without any of the intensive pre-briefing of the AH-64A mission - then find and kill virtually any targets regardless of conditions. The AH-64D has greater stand-off range and its digital communications fit enables aircraft to disperse widely. The rapid-fire, fire-and-forget AGM-114L can bring massive firepower to bear in a short time, during which the AH-64D is not exposed to enemy ADA fire.

Power for the AH-64D

The Apache's existing General Electric GE T700-GE-701 turboshafts are to be completely replaced by uprated 1,723-shp (1,285-kW) T700-GE-701C engines. The -701C has already been fitted to existing AH-64As from the 604th production aircraft (delivered in 1990). When the Longbow programme was initiated, the US Army planned to field a dual standard of upgrade. The full-upgrade AH-64Ds would be complemented by AH-64Cs which would not have the MMW radar or -701C engines. This designation was abandoned in 1993 with the decision to rebuild all aircraft to AH-64D standard, even though not all would be equipped with the Longbow radar. The AH-64C designation was an unnecessary complication (not least for the US Army's logistics system) and no longer exists. Apaches without the MMW radar will now be known simply as AH-64D Apaches while radar-equipped aircraft will be AH-64D Longbow Apaches.

The advent of the AH-64D will transform the composition of Army aviation battlefield units. However, the Longbow is not being fielded in isolation and is ultimately expected to work with the RAH-66A Comanche stealthy advanced scout. After intense uncertainty about the future of the Comanche, including its virtual cancellation, the RAH-66A now has a proposed first unit equipped (FUE) date of 2005. Current Army attack helicopter battalions comprise 24 AH-64s, divided among three companies, each with three AH-64A scouts and six attack-dedicated AH-64As. With the introduction of the AH-64D, battalions will graduate to nine Longbow aircraft and 15 baseline (AH-64D) aircraft. The objective for future battalions is to again have 24 aircraft, but divided between 15 Longbow AH-64Ds and nine Longbow-equipped RAH-66As.

The US Defense Acquisition Board authorised a 51-month AH-64D developmental programme in August 1990. In December this was extended to 70 months to incorporate AGM-114L missile development. On 11 March 1991 an AH-64A (82-23356) made its maiden flight as an aerodynamic testbed with a mast-mounted radar housing. The first of six actual AH-64D prototypes (89-0192) flew on 15 April 1992. A total of 232 full-standard Longbow Apaches will be fielded from a total of 758 examples in the current inventory. In June 1994 the Army demonstrated that is was capable of converting an AH-64D to Longbow AH-64D standard in four hours, as required. This involved the transfer of-701C engines, the Longbow radar and associated equipment from the first prototype AH-64D to the sixth, which was then flown for 30 minutes.

Full-scale production authorised by US Undcr-Secretary of Defense Paul Kaminsky on 13 October 1995 for 232

***Opposite page above:** The US Army has abandoned plans to field a dual-standard AH-64C/D, which originally called for the conversion of SOS AH-64Cs and 227 AH-64Ds. Now all 758 Apaches will be rebuilt to the full AH-64D standard. However, not all will be routinely equipped with the Longbow radar.*

***Above:** Initial MMW-guided Hell fire tests have been completed and proved to be largely successful. As in the original tests, some problems emerged, but they were far less*

***Top:** The first US Army unit to transition to the Longbow Apache will be 1-227 AVN, basedat Ft Hood, Texas. Instructor pilots from 1-227 will begin their training in July 1997 and the AH-64D will be active with the unit by December of that year.*

Right: In May 1995, Joint Project Optic Cobra '95 (JPOC '95) was integrated as an element of the regular Roving Sands joint air defence exercise, held at Ft Bliss/ White Sands missile range. JPOC '95 was a Theatre Missile Defence (TMD) exercise that integrated US Army, Navy, Air Force and Marine Corps (plus Dutch and German) units in the hunt for surface-to-surface missile threats during a regional conflict against Iran ('Dahib'). Responding to the 'Dahabian' invasion of 'Sabira' (New Mexico), in the 'West Gulfacia' region, allied forces had to defend the strategic port city of El Paso against attacks that included the use ofSS-2 'Scud-B' and SS-21 SSMs. AH-64As from the 3rd Battalion, 6th Cavalry were integrated into both sides, but the Apaches allocated to the allied (blue) forces were used on 'Scud'-hunting missions in conjunction with F-15Es. Future operations of this kind will increasingly involve unprecedented integration of sensor data from airborne, naval and ground-based systems. Optic Cobra '95, and other similar exercises, have paved the way for such complex military operations. The digital AH-64D will be ideally placed to act in unison with other systems in the hunt for small, mobile targets such as missile TELs.

Below: This AH-64D Longbow Apache in UK AAC configuration has (dummy) Starstreak box launchers on the wingtips.

aircraft. The complete US Army AH-64D contract also calls for 13,311 AGM-114L missiles, 227 fire control radars and 3,296 launchers. AH-64D remanufacture began at Mesa in November 1995, in advance of the December 1995 contract for the remanufacture of the first batch of 24 aircraft. Deliveries of the first AH-64Ds are due in March 1997. From start to finish it takes 15 months to convert an AH-64A into an AH-64D. The maximum remanufacture rate of eight per month will be reached in the last quarter of 2001. The first operational unit will be equipped by July 1998 and deliveries will continue until 2008.

The Longbow received spectacular validation in a series of field tests. Between 30 January and 9 February 1995, at China Lake, a team of AH-64As and AH-64Ds conducted preliminary gunnery trials against moving and static T-72s and static ZSU 23-4s. Eight gunnery 'events' were flown, half by day and half by night, and targets were protected by smoke (including IR obscurant smoke), decoys and camouflage netting. These Phase 1 trials paved the way for the 'all-out' force-on-force IOT&E (Initial Operational Test & Evaluation) trials, held at Ft Hunter-Liggett, California, between 6 and 31 March 1995. Two units ('A' Company and 'LT Company, 2-229th AVN) from Ft Rucker conducted a series of paired trials, AH-64A ('B' Co./eight aircraft) versus AH-64D ('A' Co./six aircraft). Twelve missions were flown at night — seven close attack and five deep attack - along with three daytime close attack missions. The Apaches were hunting an integrated threat force of US/Russian armour and mostly Russian ADA systems comprising 20 M1A1 MBTs, 10 M2/3 Bradley IFVs, six 2S6 Tunguskas, two SA-8B 'Geckos' (9K33 Osa), one SA-11 'Gadfly' (9M38 Buk), three SA-13 'Gophers' (9M37 Strela-10), one SA-15 'Gauntlet' (9M330 Tor), 10 SA-18s (9K38 Igla) and a Swedish-built Ericsson Giraffe radar. This 'red' force used smoke, RF/IR blankets, conformal RAM camouflage netting, decoys, corner reflectors and active jammers to further defend itself. No external SEAD, artillery support, or area weapons (rockets) were available to the Apaches. The tanks involved were advanced US Army M1A1 Abrams, with sophisticated reactive armour, active countermeasures and an anti-helicopter capability of their own. The parameters of the test were designed to isolate the attack helicopters and confront them with a 21st century threat. The AH-64Ds flew in a 'heavy Hellfire' configuration, with 12 AGM-114Ls and four

The AH-64A Apache - A Swedish perspective

Since 1988 the Swedish army has operated two companies of what it refers to as 'anti-tank' helicopters - 20 MBB BO 105CBs (local designation Hkp 9A) equipped with the Emerson Heli-TOW system. In March 1995 the Chief of the Army requested the Director of Army Aviation to undertake a technical demonstration programme of a dedicated attack helicopter. In 1996 Sweden was facing a major defence review and the army felt the time was at hand to evaluate its requirement for, and the benefits of, a modern multi-role attack helicopter.

A list of potential types was drawn up for evaluation, including the MDH AH-64A Apache, Bell AH-1W Super Cobra, Agusta A 129 Mangusta, Eurocopter Tiger, Atlas/Denel CSH-2 Rooivalk, Mil Mi-28 'Havoc' and Kamov Ka-50 'Hokum'. The primary purpose of the evaluation was to determine how aircraft would perform in a Swedish environment, so the army insisted that its pilots be trained to fly each type under evaluation, and act as systems operators/gunners. Aircraft had to be available for evaluation in mid-1995, undertake live weapons firings and require a minimum of operating/ support costs. The choice was narrowed to the AH-64A and Mi-28. The Swedes recognised that one was a mature system and the other still in the early stages of development, but were interested in examining the two completely different design philosophies and doctrines behind the Apache and the 'Havoc'.

Planning for the four-week evaluation began in April/May 1995. Upon arrival in Sweden the aircraft would self-deploy to the Northern Military District to undertake tactical missions and live-firing exercises. This would be followed by air-to-air target firing and tactical missions in the Central and Southern Military Districts. As a result, each aircraft would be exposed to the full range of Swedish geography and climate.

The Swedish Defence Material Administration (FMV) and the United States Army Security Command, with the support of the Swedish Army Aviation Centre and McDonnell Douglas Helicopters, agreed to supply two USAREUR AH-64As, then stationed in Hanau. A Swedish crew was trained by MDH at Mesa to fly the Apache and operate its systems. A team of Swedish tactical advisors travelled to Ft Rucker to undertake detailed mission planning. The two Apaches (86-9029/86-9033) were flown from Germany by a mixed US/Swedish crew, arriving at the 2nd Army Aviation Battalion in Linkoping on 12 August 1995.

The Apaches were scheduled to undertake a range of tactical scenarios, including operational redeployment between military districts, avoiding enemy fighter aircraft, engagement of enveloping forces, deep strike operations, operations in the Swedish archipelago, engagement of enemy air assault forces, delaying operations against mechanised forces, and supporting attacking armoured forces.

Swedish terrain, tactics and military posture mean that standard US operational procedures, such as artillery and air support, were impossible. The Swedes learned that the Apache had the flexibility to operate throughout the country and could be redeployed over substantial distances while still carrying an effective weapons load. Even without the use of EW systems, the Apaches avoided the JA 37 Viggens of F21 Wing, which were hunting them during their redeployments. In the event, missions were not flown at night, although the Swedes recognise that night operations are preferable, indeed essential, in their Arctic environments (in northern Sweden six months of the year are spent in almost permanent darkness). The autonomous nature of AH-64A operations stretched Sweden's (substantial) C^3 network and highlighted the need for an improved communications fit on the aircraft. The Apache's radios are not compatible with Swedish radio systems. Two days of maritime operations with navy and marine units in the archipelago proved that the Apache was very vulnerable on the outer coastline and needed the shelter of the inner archipelago to protect it from hostile fire. However, the Marines were impressed by the AH-64A and thought that the Apache could play an important role in supporting (or repelling) amphibious attacks. Furthermore, the Hellfire missile (Rb 17) is already in service as a coastal defence weapon in Sweden and is compatible with the Apache's own weapons.

During a simulated air drop by an air force Hercules, the Apaches 'shot down' the aircraft using Hellfire. During anti-armour missions the Apache proved to be far superior to Sweden's existing Hkp 9As. Air-to-air trials were conducted against towed targets at the Swedish Anti-Aircraft School, Vaddo. The targets were 'cold' (with no IR signature, perhaps not the most realistic simulation) and the FLIR and DVO were unable to acquire them within the prevailing safety limits. When the gun did lock-up a target the autotracking system failed and no direct hits were ever made on any target. Live-firing trials were limited to the Apache's rocket system, as Sweden already has the Hellfire in service (as a coastal defence missile) and is familiar with its performance. There were also cost and safety factors in this decision. A manual rocket firing was made and the rockets missed the target area by several hundred meters.

A total of 99 hours was flown by the two aircraft during the four-week evaluation. During that time, there were periods when one or both AH-64As were unserviceable. The Apaches suffered from software problems in the FCC and badly maintained rocket pods; an APU clutch had to be changed, a TV camera had to be replaced, a laser unit had to be replaced, several bulbs had to be changed, one gun suffered a hardware failure and rotors needed repairing. As a result, five of the planned 20 missions were cancelled due to technical problems. Additional missions were also cancelled to allow ground crews more time to prepare for weapons tests. The Apache's navigation and fire control systems suffered several problems. Co-ordinates in latitudes higher than 65°N could not be entered and, as a result, planned night attack missions were not flown.

A single Mi-28 was supplied by Rosvoorouzhenie to the FMV under a contract signed in August 1995. The evaluation helicopter (Mi-28 prototype 042) was airlifted by Il-76 to Lulea on 7 October 1995. Using Mi-24s and Mi-28s in Moscow, the Swedes had trained one test pilot and two service pilots to fly the Mi-28. Swedish personnel ultimately flew as weapons systems operators during the evaluation, and not as command pilots (the Mi-28 does not have dual controls). Since the Russian pilot was not a fluent English speaker, all operational missions were tightly pre-briefed and flown with a translator airborne in another aircraft. The Mi-28 flew a number of tactical missions that mirrored the Apache programme. The Swedish evaluation found that the sighting system worked well and was easy to use, even in the hands of an inexperienced crew. The Mi-28 was rated as highly survivable, with good ballistic protection for the crew and with an extensive onboard RWR and ECM system. The MMI (Man Machine Interface/ergonomics) of the Mi-28 was generally good and will be improved. The aircraft handled well, although crews had some reservations about their early production standard aircraft in this area. Current production Mi-28s are completely lacking in any night-fighting capability. Mil is working to remedy this problem with the much improved Mi-28N, which has been compared (perhaps over-optimistically) to the AH-64D.

The official Swedish Army Aviation Centre report on the evaluation stated that the Mi-28's weapons accuracy was "good and astonishingly repeatable," particularly taking into account the range of firing parameters and poor weather conditions. Both 9M1154Shturmand 9M120 Ataka guided missiles were fired against stationary targets (to a maximum range of 4680 m/15,354 ft, with the Mi-28 flying at 200 km/h, 124 mph IAS), with 1-m (3.3-ft) accuracy. Rockets were found to be accurate up to a range of 4000m (13,123ft), with 35 hits registered from 40 firings. Four unexploded rockets were later found and questions were raised about the production quality and safety standards of Russian ammunition. Gun firings were unsuccessful due to bad boresighting.

The Mi-28 was flown for a total of 30 hours, never failed to undertake a mission, and experienced the minimum of technical snags. On one occasion an engine automatically throttled back after plume ingestion from a rocket firing. This was a safety measure which performed as expected, and the aircraft was ready for flight within an hour, to resume firing tests. The aircraft also experienced a failure of the flare dispenser. The Swedish opinion of the Mi-28 was that it was a robust and reliable helicopter well-suited to field conditions. Reservations were expressed about the classification and standards of its electrical system and some design features. Integration of the required modern avionics would require additional electronic shielding and filtering. Availability of the necessary specifications, airworthiness certification, technical manuals and maintenance documentation was an unknown.

The evaluation of the AH-64A concluded that it was a highly-complex aircraft, requiring a well-trained and co-ordinated crew. Successful missions demanded an intensive level of mission planning. Its onboard systems allowed detection of targets, by day and night, at ranges meeting all Swedish requirements. A large proportion of Swedish wartime personnel are drawn from a (trained) conscript force, who were deemed to be capable of supporting Apache operations. The attack helicopter demonstration programme to date has provided much first-hand experience and broadened the Swedish understanding of modern attack helicopter operations. The programme will continue through to 1999/2000, with a view to presenting a final proposal, prior to the next major Parliamentary defence review in 2001. An AH-64D Longbow Apache evaluation will take place during that timeframe. A Eurocopter Tiger evaluation was scheduled for February 1997.

Robert Hewson

The AH-64A maintained its reputation as an complex and effective aircraft during the Swedish army aviation evaluation.

The Mi-28 'Havoc' prototype deployed to Sweden surprised many with its good performance.

The UK MoD is studying a 'marinised' version of its WAH-64D Longbow Apaches for operations in support of the Royal Marine Commandos. At present, the UK's 3rd Commando Brigade, based at Dishforth, relies on TOW-armed Lynx AH.Mk 7s, and eight of the Army Air Corps' new WAH-64DS have been 'set aside' as their replacements. These aircraft could conceivably be modified with folding tails and blades for use on Royal Navy vessels, placing the UK in a unique position as an Apache operator. Any allocation of Apaches to the Marines will diminish the already small number of WAH-64Ds available to the Army and is bound to lead to inter-service controversy between the Army and Navy. The Marines' (Army-standard) Lynxes are currently flown by Navy pilots. In the meantime, the Army's own introduction of the Longbow Apache is bound to reawaken debate between the AAC and the RAF, which currently operates the Army-dedicated support helicopter force. As the Army exercises its new-found attack helicopter capability some Air Corps insiders believe that the AH will ultimately force a change in the relationship of the AAC and RAF, and their mutual helicopter forces.

AGM-114Ks, plus 330 30-mm rounds. The AH-64As flew with an all-AGM-1 14K loadout.

The results of the test were staggering. The AH-64Ds achieved 300 confirmed kills, the AH-64As notched up just 75. Four AH-64Ds were shot down while the AH-64A force lost 28 aircraft. Most importantly, in the eyes of many, the Longbows failed to make a single blue-on-blue kill; the AH-64As made 34. One test official stated, "In all my years of testing, I have never seen a tested system so dominate the system it is intended to replace." An opposing 'red' force member paid a more succinct tribute when he said, "We always knew when it was the Longbow Apache attacking. Everybody died with no warning." In fact, so successful were the tests that the Pentagon's OT&E office cancelled the final two elements in the programme. According to the AAH Program Manager Colonel Robert Atwell, "In a very, very short time frame we figured out that the A model would be incapable of operating on what we consider the modern battlefield. It's time to move on to the next generation."

Before that happens, some problems remain to be corrected. The AH-64D's communications fit is not perfect and the existing TADS/PNVS is now starting to show its age, particularly when used alongside the Longbow radar. Longbow itself has some difficulty in acquiring stationary targets, and AGM-114K's ability to deal with multiple countenneasures has not been 100 per cent proven. A US General Accounting Office report stated that after evaluation it became clear that there were instances where the radar failed to detect and identify targets. Some missile engagements failed against multiple countenneasures such as smoke/jammers. The pilot's greatest wish is for a radio system that is truly independent of terrain. The AH-64D's digital communications suite is far better than that of the AH-64A, but can still be improved.

To date, the six Longbow Apaches have amassed over 5,000 flying hours. This handful of aircraft has achieved a 92 per cent availability figure and a 96 per cent successful launch rate with the Longbow Hellfire. Operational testing of the Longbow is complete and the AH-64D test fleet has begun to look forward to the next century and Task Force XXI. In early March 1997 the US Army initiated its Task Force XXI exercise at the NTC, Ft Irwin, California. Two Longbow Apaches are integrated into this advanced warfighting skills/technology exercise. Task Force XXI will be the first operational fielding of the AH-64D's IDM in conjunction with the US Army's entire combat force. It also marks the US Army's continued advance into the digital battlefield.

The Korean theatre

The armoured threat in Europe, the Apache's *raisoti d'etre,* has all but disappeared. However, with the end of Cold War Superpower tension, attention has returned to the Korean peninsula where hostilities have simmered for nearly 50 years. The Democratic People's Republic of Korea (North Korea) is an isolated, heavily-militarised Communist dictatorship that claims the territory of its southern neighbour and is gripped by a worsening domestic situation fuelled by floods, famine and the indifference of its former political allies. Crews based in Korea during Desert

Storm remember standing armed alerts while the world's attention was focused on Iraq,- As one put it, "we reckoned the North Koreans just had to do something, our forces there were so depleted. They missed their best chance."

During rising tension in 1996, the Apache force stationed in Korea was quietly boosted. The North Korean army has some T-72-class MBTs, but most of its armoured forces are far less sophisticated and well-protected, including Soviet-supplied T-54/55s and Chinese copies. Nevertheless, as one experienced observer pointed out, "Kim Chong Il's generals have 2,600 tanks; that's substantially more than Hitler needed to overrun Poland or France - and it's only 37 miles from the DMZ to Seoul." Any armoured thrust towards Seoul, the Republic of Korea's capital, is a 'straight shot' down what is called the Uijonbu corridor, and the conventional wisdom today is that friendly forces would not have time to regroup if the city were lost, as they did in 1950. The central avenue of approach is the central Chorwon Valley (Korea's Fulda Gap). It is here that the Apache battalions based in South Korea train to bottle-up advancing North Korean armour. Any heavy attack is anticipated in the winter, when the paddy fields are frozen. Summer brings with it the monsoon and much unpredictable weather. Korea offers a good flying environment for the Apache pilot. Operating temperatures and air density allow an aircraft with weapons and auxiliary fuel to hold five hours on station. Far more than West Germany ever was, Korea is 'Apache country'.

Universal Apache

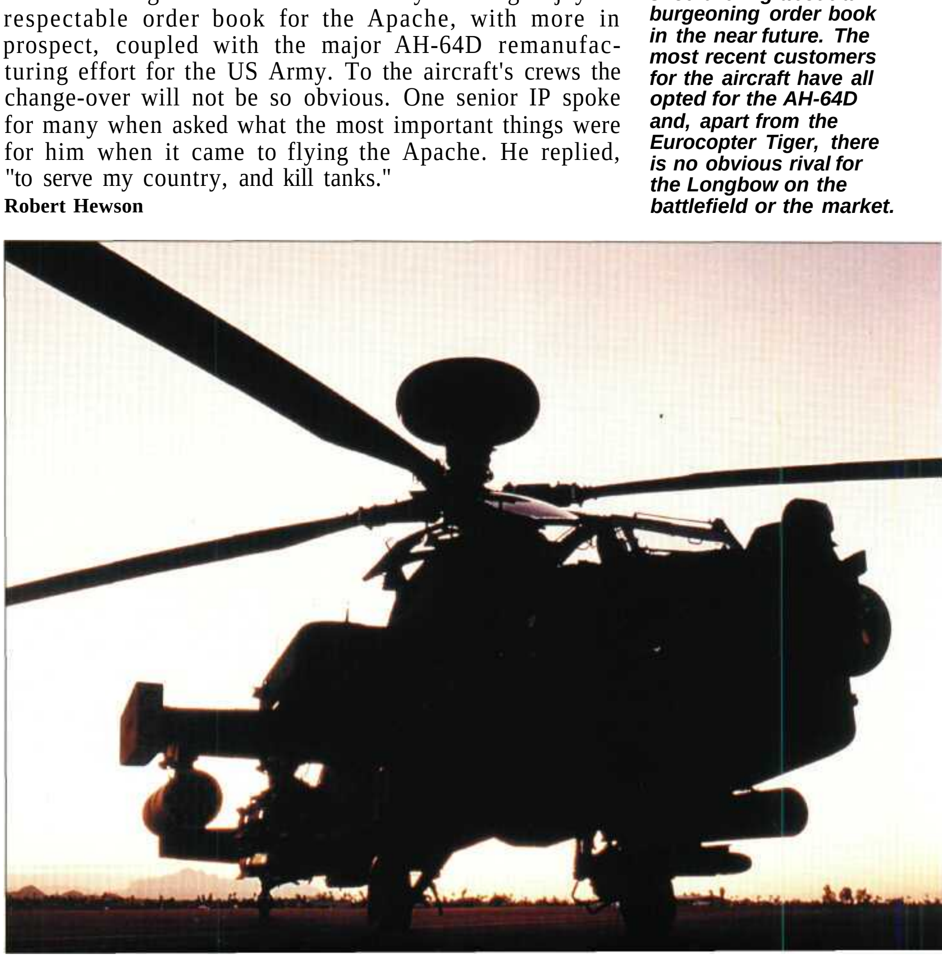
The end of Desert Storm brought with it a clamour for the Apache from customers worldwide, but particularly in the Middle East. Countries that had been toying with the idea of acquiring the Apache began to sign on the dotted line, and many others, like the UK and Holland, at last drew up serious requirements for an attack helicopter. A flood of new orders was answered with deliveries to Saudi Arabia and a batch to the UAE in 1993. In 1994 Egypt took delivery of its first batch of AH-64As, and in the following year so did Greece. The second batch for the UAE was handed over in 1996 and Egypt's second batch will be delivered in 1997. Dutch and British aircraft will follow.

While McDonnell Douglas's salesmen were busy with the Apache, its crews were back in action again. In December 1995 USAREUR AH-64As were deployed to Bosnia as part of NATO's determined IFOR (Implementation FORce) contingent monitoring the Dayton peace agreement. It is a testament to the Apache's reputation that the AH-64 force was never fired upon.

The Apache and its crews have shown that they are more than capable of dealing with any existing armoured threat. Intensive training, absolute dominance in combat and complete faith in their aircraft mean that US Army aviation Apache crews are still the masters of the modern battlefield. Future threats belong to the realm of the AH-64D, and people involved in the Longbow programme admit they have only begun to scratch the surface of the Longbow Apache's capabilities. One senior British officer, transitioning to the AH-64 at Ft Rucker in 1996, reflected that "the step up from AH-64A to AH-64D is even more profound than the gap between Lynx and AH-64A. There is just no comparison."

As this article was being compiled, the news emerged that McDonnell Douglas had been acquired by the Boeing Company in a $13.3 billion deal ($63 per share). As a result, Boeing will inherit and expand McDonnell Douglas's mantle as the world's leading producer of combat aircraft. Boeing-Vertol has substantial helicopter experience of its own, and the company has a 50 per cent stake in the Bell/Boeing V-22 Osprey and Boeing/Sikorsky RAH-66A Comanche programmes. With the acquisition of the Apache, only the AH-1W and UH-60 helicopters lie outside Boeing's sphere of influence in the United States. During 1997 all of McDonnell Douglas's divisions, including McDonnell Douglas Helicopters, will operate under the name of the Boeing Company. The Apache will undergo its third major change of title, and the emergence of the 'Boeing AH-64' is not far away. Boeing enjoys a respectable order book for the Apache, with more in prospect, coupled with the major AH-64D remanufacturing effort for the US Army. To the aircraft's crews the change-over will not be so obvious. One senior IP spoke for many when asked what the most important things were for him when it came to flying the Apache. He replied, "to serve my country, and kill tanks."

Robert Hewson



Above and below. The advent of the AH-64D Longbow Apache heralds the rejuvenation of the Apache and should bring about a burgeoning order book in the near future. The most recent customers for the aircraft have all opted for the AH-64D and, apart from the Eurocopter Tiger, there is no obvious rival for the Longbow on the battlefield or the market.

AH-64 Apache Production

US Army

Fiscal Year funding	Production total
FY73	3
FY79	3
FY82	11
FY1!3	48
FY84	112
FY85	138
FY!!0	116
FY87	101
FY88	//
IY89	54
FY90	154
FY95	10

Export Customers

Country	Total ordered	First delivery date
Israel	18	September 1990
Saudi Arabia	12	April 1993
UAE	20	October 1993
Egypt	24	February 1994
Greece	20	February 1995
UAE	10	1996
Egypt	12	1997
Netherlands	30	1<)<]}!
United Kingdom	67	1999
Total deliveries to US Army		827
Total export orders/deliveries		213

United States of America
US Army Aviation

Forces Command (FORSCOM) HQ Ft McPhearson, Atlanta, GA

The US Army Forces Command (FORSCOM) is the major Army command responsible for the combat readiness, sustainment and training of active component (AC) and reserve component (RC) Apache units based in the Continental US (ConUS).

I Corps (ICORPS), HQ Ft Lewis, WA

The corps, known as 'Eye Corps', is based at Ft Lewis, WA and is composed primarily of light infantry combat units, the vast majority of them RC units, dispersed to over 20 states including Alaska and Hawaii. Several light infantry AC divisions were assigned to I Corps in the 1980s, none with AH-64As assigned, but they were inactivated or reassigned by the early 1990s.

The corps aviation brigade is the 66th Aviation Brigade at Camp Murray, WA, a Washington Army National Guard (WA ArNG) command that will complete transition of its assigned units by FY98. It had two AC Apache units, 4-501 AVN (ATK) and 5-501 AVN (ATK), that were forward-deployed from 1993 with the Eighth US Army (EUSA/8ARMY) in the Republic of Korea, but these units were refiagged and reassigned in 1996. The UT ArNG-assigned 211th Aviation Group, or regiment, has been assigned two ArNG Apache battalions, and with recent realignments a third has been added, 1-285 AVN of the Arizona ArNG. AVIM (aviation intermediate maintenance) and combat support capability for the AH-64A fleet is provided by elements of the 103rd Corps Support Command (103 COSCOM), a USARC-assigned unit based in Des Moines, IA.

66th Aviation Brigade, Camp Murray, WA; 66AVNBDE
WA ArNG-assigned

211th Aviation Group (Regiment), West Jordan, UT; 211AVNGRP
UT ArNG-assigned unit commands the following units:

1-183 AVN (ATK) (ID ArNG)	AH-64A	Boise Air Terminal, ID
1-211 AVN (ATK) (UT ArNG)	AH-64A	West Jordan AP, UT
1-285 AVN (ATK) (AZ ArNG)	AH-64A	Final AP, Marana, AZ

Above: The insignia of Idaho ArNG Apache unit 1-183 AVN (ATK).

Above left: The badge of Utah ArNG AH-64A unit 1-211 AVN (ATK).

Left:'€'Company, 1-227 AVN ('Vampires') has applied this bat marking to its AH-64As.

III Corps (IIICORPS), HQ Ft Hood, Texas

Tracing its combat history to 1918, when it was first activated in France, III Corps gained the nickname 'Phantom Corps' during the Battle of the Bulge in 1944. Since 1954 it has been based at Ft Hood, TX and is composed primarily of heavy armour units with a sustainment mission for the European theatre. The corps achieved peak strength in the late 1980s with five AC armour and mechanised infantry divisions, and numerous brigades, commands and groups. Several RC divisions are aligned with III Corps for training and readiness. In the late 1980s the corps was responsible for eight combat Apache battalions and squadrons. By 1997, III Corps was down to five AH-64 battalions and squadrons, a force level that is expected to be maintained through the turn of the century. AVIM and corps sustainment is provided by units of the 13th Corps Support Command (13 COSCOM), also based at Ft Hood.

The extensive facilities and live-fire ranges at Ft Hood led the Army to decide to field the first Apache units here in 1984, forming a task force to plan the introduction of the AH-64 into the force structure. The Apache Training Brigade (ATB) was activated in 1985 to develop the Single Station Unit Fielding and Training Program (SSUFTP), later shortened to UTP, and the brigade was responsible for fielding all AC and RC Apache units, 31 in all. In 1992 the brigade was redesignated as the Combat Aviation Training Brigade (CATB), reflecting the addition of the OH-58D(I) Kiowa Warrior fielding responsibility. In 1996 it was redesignated as the 21st Cavalry Brigade (21 CAV BDE) to reflect preparations for the fielding of AH-64D Longbow Apache units from 1997.

21st Cavalry Brigade (Aviation), Hood AAF, Ft Hood, TX
21 CAV BDE AH-64A (AH-64D to be gained 1997)

6th Cavalry Brigade

The 6th Cavalry Brigade (Air Combat) is III Corps' aviation brigade with heraldry and lineage that dates back to the Civil War. The brigade has pioneered many of the tactics and organisational advancements in Army aviation since its most recent activation in 1975. It was the first aviation brigade to become operational and combat-ready with the Apache. The first three Apache battalions were fielded to the brigade from April 1986 to 1988. In early 1988, one of the units, 2-6 CAV, was deployed to Germany for the Reforger '88 exercises and remained in-country, being assigned to the 11th Aviation Brigade; this marked the first overseas deployment of the type. The brigade has also deployed Apaches since 1991 to support Joint Task Force SIX in the war on drugs, operating from remote locations along the southwest US border. 6th CAV operated one RC and three AC Apache units until 1996, when it was reduced to one AC and one RC unit of the type. In the summer of 1996, the 6th ACCB headquarters and its remaining AC Apache unit were forward-deployed to Korea, reporting to the 8th Army. The brigade gained a second AC Apache squadron, redesignated from an attack battalion previously deployed there. While 6 ACCB is on deployment, the 385th Aviation Group of the Arizona ArNG commands the single USARC squadron.

6th Cavalry Brigade (6 CAV BDE/6 ACCB), Hood AAF, Ft Hood, TX
Command forward-deployed to Korea, 1996

385th Aviation Group (Regiment) (385 AVN GRP), Final Airpark, Marana, AZ
AZ ArNG-assigned unit commands the following unit:

7-6 CAV (AC)	AH-64A	Montgomery County AP, Conroe, TX

The 7-6 CAV, a USARC unit, has trained to augment the 1st Cavalry Division for contingency operations but is attached to 6 CAV BDE in peacetime. AVIM support for the 'First Team' Apaches is by C Co./227th Aviation Regiment.

1st Cavalry Division

The 1st Cavalry Division Aviation Brigade is based at Ft Hood, TX and is assigned a single AC Apache battalion, 1-227 AVN. This unit transitioned from AH-1 Cobras in 1988-89 and was deployed with the division to Saudi Arabia in 1990 for Operation Desert Shield/Storm. The unit has recently transitioned to the ARI force structure and it is in line to become one of the first operators of the Longbow Apache in 1997.

1st Cavalry Division Aviation Brigade (4th Brigade) (1 CD AVN BDE), Ft Hood, TX

1-227 AVN (ATK)	AH-64A (AH-64D in 1997)	Robert Gray AAF, W. Ft Hood, TX

1st Infantry Division

The 1st Infantry Division (Mechanized) was assigned to III Corps after its return from the Vietnam War in the early 1970s. The division, known as The Big Red One', gained the Apache in the late 1980s, operating it with 1-1 AVN from Marshall AAF at Ft Riley, KS until the battalion was inactivated in 1995. The division flag was reassigned to reflag the 3rd Infantry Division assigned to V Corps in Germany in 1996.

2nd Armored Division

The 2nd Armored Division, 'Hell on Wheels', was based at Ft Hood from 1946 until it was refiagged as the 4th Infantry Division (M) in 1996. The command's aviation brigade operated 1-3 AVN from 1988 to 1991 when the battalion was inactivated. The 5th Infantry Division (M) was refiagged as the 2nd AD in 1993, with the 1-502 AVN from the 5th's aviation brigade becoming the division's attack battalion, based at Hood AAF. The battalion was refiagged as 1-4AVN in 1996, assigned to the 4th Infantry Division.

4th Infantry Division

The III Corps-assigned 4th Infantry Division has been located at Ft Carson, CO since its return from Vietnam in the early 1970s. Its 1-4 AVN began to field its Apaches in 1990 and operated them until the battalion was inactivated at Butts AAF, Ft Carson, CO in late 1995. The 'Ivy Division' flag was relocated to Ft Hood, TX by early 1996 to reflag the assets of the 2nd Armored Division, and 1-4 AVN reflagged the 1-502 AVN at Hood AAF in early 1996. The unit remains there today and is an important element in the Force XXI experiments that will shape the force structure and future of Army warfighting systems. The 404th ASB provides AVIM capability to the division.

4th Infantry Division (Mechanized) Aviation Brigade (4ID A VNBDE), Ft Hood, TX

1.4 AVN (ATK)	AH-64A/D	Hood AAF, Ft Hood, TX

5th Infantry Division

The 5th Infantry Division was located at Ft Polk, LA from 1975 to 1993, assigned to III Corps. The 1-5 AVN transitioned to AH-64As in 1991 and by 1993 the battalion was reflagged as 1-502 AVN. The 'Red Diamond Division' was relocated to Ft Hood, TX and was reflagged as the 2nd Armored Division in 1993 with the 1-502 AVN.

49th Armored Division

The 49th Armored Division, the 'Lone Star Division', is the only ArNG division equipped with AH-64A Apaches. The battalion began to transition from AH-1S Cobras at its base at Ellington Field, Houston, TX in late 1991, becoming combat-certified in 1994. The Texas ArNG division remains an element of the strategic reserve force but its proximity to III Corps at Ft Hood gives it a reinforcement mission to that corps. The battalion remains in the AOE structure, and is not expected to transition to ARI until FY98.

49th Armored Division Aviation Brigade (49 AVN BDE), Mueller AP, Austin, TX
TXArNG-assigned

1-149 AVN (ATK)	AH-64A	Ellington Field, Houston, TX

XVIII Airborne Corps (XVIIIABIMCORPS) HQ Ft Bragg, North Carolina

The XVIII Airborne Corps has been headquartered at Ft Bragg, NC since 1951 and the 'Dragon Corps' has been the Army's contingency corps for strategic, rapid-reaction land warfare since 1958. The corps routinely trains its force to deploy worldwide. Since the 1980s it has been assigned from four to five AC divisions, along with numerous brigades, commands and groups from all the combat branches. In the early 1990s the 18th Airborne Corps operated as many as 12 Apache battalions with 216 combat-coded aircraft, and by 1997 it was down to a force level of 10 AC and RC units with an increased aircraft strength of 240 AH-64As. Major support and AVIM is provided by the 1st Corps Support Command (1 COSCOM).

The aviation brigade for the corps is the 18th Aviation Brigade (Corps) (Airborne). The first Apaches had been assigned by 1988 when the North Carolina ArNG had begun to train with the aircraft. The brigade wa"s one of the first Army commands deployed to Saudi Arabia in 1990. No Apache units were directly assigned to the brigade, and units with the Florida, North Carolina and South Carolina ArNGs continued to train, but never deployed. 18th AVN BDE gained its first organic Apache units after returning from duty in Operation Desert Storm in 1991 when the 229th Attack Regiment (Group) was activated with two AH-64A units. The FL and SC ArNG units train with and are supported by the group, and at least one of these units has a European reinforcement mission.

229th Aviation Group (Regiment) (229 AVNGRP), Simmons AAF, Ft Bragg, NC
Group commands the following units:

1-229 AVN (ATK)	AH-64A	Simmons AAF, Ft Bragg, NC
3-229 AVN (ATK)	AH-64A	Simmons AAF, Ft Bragg, NC
1-130 AVN (ATK) (NC ArNG)	AH-64A	Raleigh-Durham AP, NC
1-151 AVN (ATK) (SC ArNG)	AH-64A	McEntireANGB.SC

3rd Infantry Division

The 3rd Infantry Division (Mechanized) flag was relocated from Germany to reflag the 24th Infantry Division (M) at Ft Stewart, GA in 1996. The 'Marne Division' is the primary armour force assigned to XVIIIABNCORPS and is the only division in the corps equipped with two Apache battalions. The 1-111 AVN, belonging to the Florida ArNG, relocated from Craig Field to NAS Cecil Field, FL in early 1997. The 603rd ASB provides AVIM support to the AH-64As.

3rd Infantry Division (Mechanized) Aviation Bde (3ID AVNBDE), Hunter AAF, GA

1-3 AVN (ATK)	AH-64A	Hunter AAF, Savannah, GA
1-111 AVN (ATK)	AH-64A	NAS Cecil Field, FL

24th Infantry Division

The 24th Infantry Division (Mechanized) was located at Ft Stewart, GA from 1975 until 1996 when it was reflagged as the 3rd ID(M). The division's attack battalion, 1-24 AVN, transitioned from AH-1s in 1989. The battalion was reflagged as 1-3 AVN in 1996.

82nd Airborne Division

The 'All Americans' of the 82nd Airborne Division are a light infantry division that is completely airmobile and parachute-deployable, based at Ft Bragg, NC. The division's attack battalion, 1-82 AVN, received its first Apache in 1987, becoming operational with the type at Simmons AAF in 1988. They deployed with the division to participate in Operation Desert Shield/Storm and the battalion operated the AH-64A until 1994, when it transitioned to the OH-58D(I) Kiowa Warrior. The unit was augmented from 1991 by 'E' Company, a USARC company that was assigned to enhance the battalion during combat operations.

101st Airborne Division

The 101st Airborne Division (Air Assault) is the Army's only air assault division based at Ft Campbell, KY. The aviation brigade gained its first Apache battalion in 1988, a second in 1989 and the third converted from HueyCobras in 1991. The unit was deployed with XVIIIABNCORPS, seeing extensive combat in Operation Desert Storm. The 2-229 AVN, based at Guthrie AAF, Ft Rucker, AL was assigned to the 101st during Desert Storm. It is the only Army division with three AH-64A attack units. The assigned AC unit 3-101 AVN was inactivated in 1995 and replaced by the RC battalion 8-229 AVN, the first unit to complete the transition to the ARI structure.

101st Airborne Division (Air Assault), Aviation Bde, 101 AD(AASLT), Ft Campbell, KY

1-101 AVN (ATK)	AH-64A	Campbell AAF
2-101 AVN (ATK)	AH-64A	Campbell AAF
8-229 AVN (ATK) (USARC)	AH-64A	Goodman AAF, Ft Knox, KY

Above: This AH-64A carries the markings of 5-6 CAV, one of the former spearhead Apache units in Germany.

Below: The uniquely sharkmouthed Apaches of 1-229 and 3-229 AVN highlight the fact that the 229th Regiment is the (only) official inheritor of the 'Flying Tigers' heritage.

Above: The badge of FL ArNG's 1-111 AVN (ATK), based at Cecil Field.

Above left: The insignia of 3-229 AVN, the famous 'Flying Tigers'.

Left: This 'death's head' badge is worn by Apaches of 'B' Company, 1-227 AVN ('Reapers'), at Ft Hood.

3rd US Army (THREEUSA/3rd Army), Ft McPherson, GA

The 3rd US Army is the theatre Army assigned to the US Central Command (USCENTCOM). During peacetime no Apache units are assigned but units would be drawn from other commands, including the contingency corps, XVIII Airborne Corps. During Operation Desert Shield/Storm, approximately 300 Apaches were deployed to the theatre.

US Army Europe/7th Army (USAREUR/7A) HQ Campbell Barracks, Heidelberg, Germany

The US Army Europe/7th Army is the command that provides the land warfare force for the US European Command (USEUCOM) and represents just a fraction of the combat power available to NATO's Supreme Allied Commander, Europe/Supreme Headquarters Allied Powers (SACEUR/ SHAPE). The command has been based in Germany since 1950 and during the Cold War it was sustained by several corps of US Army soldiers; through most of the 1980s and into the early 1990s it was sustained by V Corps at Frankfurt, Germany and VII Corps at Stuttgart. Three divisions were to equip with the Apache in-theatre and were assigned two battalions each of the type. A total of five Apache units was assigned directly to V Corps and VII Corps by 1991. The 11th Aviation Brigade was assigned 2-6 and 6-6 CAV along with 4-229 and 5-229 AVN (the latter battalion being redesignated as 2-3 AVN in 1991), while the 12th Aviation Bde gained the 5-6 CAV in 1990. The theatre army would have been reinforced by III Corps and XVIII Airborne Corps in a contingency, and at its peak in 1991 it had a paper force of over 500 AH-64As that could be expected to be deployed to Europe within 60 days of an emergency.

Force reductions have been dramatic and VII Corps was inactivated in March 1992. VII Corps' aviation brigade, the 11th Aviation Brigade, was reassigned to V Corps at that time, replacing the 12th Aviation Brigade, which became a group assigned to the 11th. By 1995, 2-3 ATK, 3-4 ATK and 4-229 were inactivated. In 1997 V Corps continued to be equipped with 11th AVN BDE, 1 ID(M) and 1AD, operating a total cadre of 96 Apaches. The 3rd Corps Support Command (3 COSCOM) provides AVIM services.

AH-64 Apache Operators

***M* Corps, HQ, Heidelberg, Germany; VCORPS**

12th Aviation Brigade (12 AVNBDE), Illesheim AAF, Ansbach, Germany;

11th Aviation (Group) Regiment, Illesheim AAF, Ansbach, Germany; 11 AVN GRP
Group commands the following battalions:

2-6CAV(AC)	AH-64A	Illesheim AAF, Ansbach
6-6 CAV (AC)	AH-64A	Illesheim AAF, Ansbach

1st Armored Division

The 1st Armored Division, traditionally known as 'Old Ironsides', is based at Bad Krueznach, Germany having reflagged the assets of the former 8th Infantry Division (M) and relocated its headquarters from Ansbach, Germany. Its aviation brigade was originally equipped with 2-1 AVN and 3-1 AVN, which transitioned from AH-1 Fs in 1989-90. These units were replaced by 2-227 and 3-227 in late 1991, undergoing conversion to the API structure in 1994.

In late 1995 Apaches of 2-227 AVN were deployed to Bosnia to support the 1 st AD Task Force Eagle and NATO forces of the Implementation Force (IFOR), while involved in Operation Joint Endeavor. 3-227 AVN has been inactivated. The 127th ASB provides AVIM support to the division's Apaches.

1st Armored Division Aviation Brigade/ 4th Brigade (IAD AVN BDE), Hanau, Germany

1st Infantry Division

The 1st Infantry Division (Mechanized) flag was moved from Ft Riley, KS in early 1996 to reflag the assets of the former 3rd Infantry Division. The attack battalion of the 'Big Red One' was redesignated as 1-1 AVN from 3-1 AVN at that time. The Wurzburg, Germany-based division is a heavy unit.

A reinforced brigade-sized task force was to replace the 1st AD in Bosnia in late 1996-97, augmented by Apaches from 2-6 CAV. The 603rd ASB is the brigade's AVIM component.

Aviation Brigade/4th Brigade (1ID AVNBDE), Katterbach AHP, Ansbach, Germany

3rd Armored Division

The 'Spearhead Division' was based in Germany from the 1950s until 1992. Its aviation brigade fielded AH-64As with two battalions in 1989, 2-227 and 3-227 AVN. SAD deployed with VII Corps to fight in Operation Desert Storm (3-227 AVN deployed with the 12th Aviation Brigade). Within a year after its return, the aviation brigade of the division was reassigned to the 1 st Armored Division, with the two Apache battalions and the other division assets inactivated.

3rd Infantry Division

The 3rd Infantry Division (Mechanized) was headquartered at Wurzburg, Germany, and was subordinate to VII Corps. The two assigned attack battalions transitioned to the Apache in 1990. 2-3 AVN was deployed to Saudi Arabia and was assigned to support VII Corps in the Gulf War. 3-3 AVN did not deploy, remaining in Europe with most division assets until called to deploy a task force in support of Operation Provide Comfort in turkey and Iraq from April 1991. In early 1992 the 3rd Infantry Division flag was relocated to Ansbach, Germany to reflag the assets of the 1st Armored Division. Its aviation brigade was inactivated but its structure stayed intact, becoming the 159th Aviation Group at Ft Bragg, NC. 2-3 AVN and 3-3 AVN were inactivated in 1992, its aircraft and aircrews reassigned to the ConUS. The 3rd Infantry Division was itself reflagged as the 1st Infantry Division in 1996 and its flag was reassigned to Ft Stewart, GA to reflag the former 24th Infantry Division.

Eighth US Army (EUSA/8th Army) HQ, Yongsan, Seoul, Republic of Korea

The Eighth Army is the theatre US Army responsible for the land defence of the Korean peninsula, allied with the forces of the Republic of Korea (RoK). The four-star commander of EUSA is also the commander of the UN Command (UNC), US Forces Korea (USFK), and the RoK-US Combined Forces Command (RoK/US CFC, or just CFC). American and Korean forces operate together in the CFC Ground Component Command (CFC-GCC). Only a few major US units are assigned to 8th Army and in any contingency they would be heavily reinforced by ConUS units.

The theatre aviation brigade is the 17th Aviation Brigade. It operated two attack battalions forward-deployed from I Corps, 4-501 and 5-501 AVN, which transitioned from AH-1 Fs in 1993-94. From May 1996 the 6th Cavalry Brigade (Air Combat) was deployed to Korea from Ft Hood, TX with 3-6 CAV. The 5-501 AVN battalion was redesignated as the 1-6CAV and was reassigned to the 6 ACCB. The other battalion, 4-501 AVN, was reflagged as 1-2 AVN.

6th Cavalry Brigade (Air Combat), 6 ACCB/6 AVN BDE, Desiderio AAF, Camp Humphreys, RoK
Brigade forward-deployed from Ft Hood, TX, 1996

1-6 CAV (Air Combat)	AH-64A	Camp Eagle, Hoengsong
3-6 CAV (Air Combat)	AH-64A	Camp Humphreys, Pyongteak

2nd Infantry Division

The 2nd Infantry Division (Mechanized) is the largest US combat formation based in Korea. The 'Indianhead Division' is based at Camp Casey, Tongduchon, Korea and has recently deployed one of its manoeuvre brigades to Ft Lewis, WA. The division's attack battalion operated AH-1 HueyCobras until the summer of 1996, when 4-501 AVN was reflagged as 1-2 AVN.

2nd Infantry Division Aviation Brigade (2ID AVN BDE), Camp Stanley, Uijongbu, RoK

1 -2 AVN (ATK)	AH-G4A	Camp Pago, Chunchon

The substantial number ofApaches allocated to the Ft Rucker-based 1-14 AVN (Training) are all based at HancheyAAF.

Training and Doctrine Command (TRADOC) HQ Ft Monroe, VA

The US Army Training and Doctrine Command manages weapon system training and doctrinal implementation, including basic, combat, technical and warfighting skills for all aviators. The principal aviation training centre for the Aviation Branch is the US Army Aviation Center, headquartered at Ft Rucker, Alabama. After an aviator completes initial entry rotary-wing (IERW) training, he advances to 1-14 AVN (Training), assigned to the Aviation Training Brigade (ATB) for type qualification and combat skills training on the Apache. The battalion was formerly designated as the 7th Aviation Training Battalion (7 ATB). Upon completion of training with ATB, aviators are assigned to the 21st Cavalry Brigade, assigned to III Corps/FORSCOM at Ft Hood, TX where they enter unit training or a sustainment programme and will report to a combat Apache battalion for additional training. The assigned 1st Aviation Brigade conducts advanced combat skills and leadership training for US Army and international officers, with the FORSCOM-assigned 2-229 AVN assigned to the brigade in peacetime, performing as a combat laboratory and development support unit.

US Army Aviation Center (USAAVNC) HQ Ft Rucker, AL

Aviation Training Brigade, AL; ATB

1-14 AVN (Training)	AH-B4A(AH-64D in 1997)	HancheyAAF, Ft Rucker

1st Aviation Brigade (Air Assault), AL; 1 AVN BDE

2-229 AVN (Attack)	AH-64A	Guthrie AAF, Ft Rucker

US Army Aviation Logistics School

A major component of the USAAVNC is the Army Aviation Logistics School (USAALS) at Ft Eustis, VA, which trains most maintenance personnel for Army aviation platforms. The school is assigned grounded airframes for the maintenance instruction role, and it should receive its first GAH-64Ds in 1997. USAALS has acquired a number of Apache systems trainers, modified from AH-64A airframes that were written off due to accidents.

US Army Aviation Logistics School (USAALS) Ft Eustis, VA

Department of Aviation Trades Training	GAH-64A (GAH-64Dm1997)

Army Material Command (AMC), HQ Alexandria, VA

The Army Material Command (USAMC/AMC) is the major command responsible for acquisition, depot-level maintenance, research and development, and systems test of Army aviation assets. The AH-64D programme and Apache modernisation efforts are a critical AMC task. The aircraft listed here are contractor-operated are maintained at company facilities at Falcon Field, Mesa, AZ.

Program Executive Office, Aviation (PEO-AVN) St Louis, MO

Apache Attack Helicopter Project Manager's Office fAAH PMO)
(Y)AH-64D
Apache Modernization Project Manager's Office (AM PMO)
AH-64A

Several AMC major subordinate commands are focused on aviation activity, including the **Aviation & Missile Command** (AMCOM) activated in late 1996 and consolidating throughout 1997. The Redstone Arsenal, Huntsville, AL, will become the headquarters for AMCOM.

The command's **Aviation, Research, Development & Engineering Center** (AVRDEC) is focused on aviation technology and systems. One of its principal activities is the **Aviation Applied Technology Directorate** (AATD) at Ft Eustis, VA, which is involved in several Apache product improvement programmes including the joint cockpit air bag system (JCABS). Several AH-64A Apaches are involved in the programme.

Communications-Electronics Command (CECOM), headquartered at Ft Monmouth, NJ, is the major subordinate command that develops and acquires Army systems for command, control, communications, computer and intelligence/electronic warfare (C^4IEW), CECOM is responsible for those systems mounted in airframes, tying them into the service's data and voice networks. The **Command's Research, Development and Engineering Center** (RDEC) manages new systems integration through its **Command/Control & Systems Integration Directorate** (CCSID), at Ft Monmouth. Aviation-related projects are tested by the **Electronic Systems Division's Airborne Engineering Evaluation Support Branch** (AEESB) at the Naval Air Warfare Center Aircraft Division (NAWC/AD) at Lakehurst, NJ. That test unit was formerly known as the Aviation R&D Activity (AVRADA). It utilises a number of AH-64A/JAH-64A Apaches.

Depot maintenance is the responsibility of the **Industrial Operations Command** (IOC), HQ Rock Island Arsenal, IL The **Corpus Christi Army Depot** (CCAD), NAS Corpus Christi, TX, is the only one of more than a dozen depots that conducts helicopter repair. Apaches from around the world are flown to CCAD when they require overhaul and updating.

The **Test and Evaluation Command** (TECOM) is the major subordinate command responsible for material testing. From its headquarters at Aberdeen Proving Ground, MD it operates a number of diverse test facilities and ranges to support its objectives.

The **Aviation Technical Test Center** (ATTC), located at Ft Rucker, AL, is the organisation responsible for testing aviation systems. It was formerly known as the Aviation Development Test Activity (ADTA) and supports numerous customer requirements including those of AMCOM and PEO Aviation. ATTC's **Airworthiness Qualification Test Directorate** (AQTD), previously known as the Aviation Engineering Test Activity (AETA) and assigned to the former AVSCOM, operated at Edwards AFB, CA until 1996 when the unit relocated to Ft Rucker, AL. ATTC provides a wide variety of testing including lead-the-fleet, flight and performance data, and weapons testing and trials, utilising about half a dozen Apaches.

This AH-64A is one of those detached from the 1-14 AVN to the Aviation Technical Test Center, based at Cairns AAF, Ft Rucker.

Test and Evaluation Command (TECOM) HQ Aberdeen Proving Grounds, MD

Aviation Technical Test Center (ATTC) Cairns AAF, Ft Pucker, AL
AH-64A/JAH-64A

Israel

Tsvah Haganah Le Israel/Heyl Ha'Avir (Israeli Defence Force/Air Force)

Israel's Apaches are allocated to 113 Sqn and 127 Sqn, based at Ramon (Canaf **25),** and 190 Sqn based at Ramat David (Canaf 1). An initial order for 19 was placed in 1990, and delivered by 1991, and at least 40 (in total) have been delivered since.

No. 113 Sqn was formed in October 1955, as the IDF/AF's first Dassault Ouragan fighter-bomber unit. Its squadron badge bears a remarkable similarity to that of the AA's2[e] Escadrille, EC1/12-from whom some of the Israeli aircraft were delivered. No. 113 Sqn later transitioned to the Mystere IVA, IAI Nesherand became the first IDF/AF Kfir squadron in 1976. As the Kfir was phased out of service No. 113 Sqn was disbanded in 1987, only to be reformed on 12 September 1990 after the delivery of the first AH-64As.

In August/September 1993 Israel took delivery of 24 AH-64As (plus two UH-60A) from surplus US Army Europe stocks, as a 'thank you' for support during Operation Desert Storm. The first batch of 18 Apaches was drawn from units at Giebelstadt, Hanau and Illesheim, and comprised 84-24235, 84-24252, 84-24258, 84-24263, 84-24288, 84-24291, 84-24292, 84-24294, 84-24298, 84-24302, 85-25351, 85-25422, 85-25444, 85-25447, 85-25451, 84-25452 and 85-25462. All were delivered by C-5A from Ramstein AFB. The arrival of these aircraft in September led to the establishment of the IDF/AF's second AH-64 squadron. The additional six aircraft are believed to have been delivered in September 1993.

The Apache is known as the Peten (cobra) in IDF/AF service. Israel became the first, and so far only, foreign operatror to use its aircraft in combat during November 1991. Following a Hizbollah ambush on an Israeli patrol in southern Lebanon, Apaches undertook a night attack with Hellfires against a 'Hizbollah base'. This attack was part of a much larger offensive in the area involving TOW-armed Bell AH-1S Cobras, Hughes 500MD Defenders and RPVs.

Apaches were active during Operation Grapes of Wrath - Israel's 1996 retaliatory incursion into Lebanon following Hizbollah rocket attacks on Israeli border settlements. Apaches initiated the operation, attacking a Hizbollah HO in southern Beirut, on 11 April 1996. A total of 550 combat missions was flown by all types involved in the two weeks of attack and counter-attack.

Late in 1996 Israel became the first export customer for the improved AGM-114K Hellfire II missile, which is now in IDF/AF service.

Even in Israeli terms the IDF/AF's Apache fleet is publicity shy. Despite the substantial number of aircraft that have been delivered over the years only one squadron has been publically acknowledged, though not officially identified. This is No. 113 'Wasp' Squadron, whose badge is seen opposite.

United Arab Emirates

United Arab Emirates Air Force

On 23 January 1992 MDH announced that confirmation had been reached in December 1991 with the UAE for the purchase of 20 AH-64As. The first of these aircraft was handed over in a ceremony in Abu Dhabi on 3 October 1993, and deliveries continued into the following year. The AH-64As are assigned to the Apache Squadron, part of Western Air Command headquartered in Abu Dhabi. The Apaches are based at Al Dhafra. An additional 10 aircraft are currently on order. The UAE has submitted an application to the US DoD to acquire 30 Advanced Threat Radar Jammers for its AH-64 fleet, worth $82 million.

The United Arab Emirates became the second export customer for the AH-64A when it ordered an initial batch of 20 aircraft in 1991.

Saudi Arabia

Royal Saudi Land Forces

Twelve AH-64As were delivered in 1993 to Army Aviation Command, based at King Khalid Military City. Saudi Arabia is not known to have taken delivery of AGM-114, but they are certain to have been included in the deal. The AH-64s operate in conjunction with Bell 406CS Combat Scouts.

Saudi Arabia was refused delivery of full-spec OH-58D Kiowa Warriors, and instead was given TOW-armed Bell Combat Scouts. The Saudi AAC now has 12 Hell fire-capable AH-64As.

Egypt

Al Quwwat Al Jawwiya II Misriya (Arab Republic of Egypt Air Force)

Egypt first ordered a batch of 24 AH-64As for delivery from 1995. In December 1994 the Pentagon offered Egypt an additional batch of 12 AH-64As, four spare Hellfire launchers, 34 rocket pods, six additional T700 engines and one spare TADS/PNVS system in a $318 million package. This order was confirmed during the Dubai IDEX show of March 1995, and a Letter of Intent for another 12 AH-64As was also signed. All aircraft in question would be of the latest US Army standard with imbedded GPS, but with a localised radio fit.

This deal was an important one for McDonnell Douglas as it bridged the six-month gap from July 1996 between the last AH-64A delivery and the first AH-64D. The aircraft in service are believed to be allocated to the air force's single attack helicopter regiment.

Greece

Elliniki Aeroporia Stratou (Hellenic Army Aviation)

Greece was the first European export customer for the AH-64. The Hellenic Ministry of Defence signed a Letter of Offer and Acceptance with the US Army on 24 December 1991 finalising the purchase of 12 AH-64As, with a option for eight (which could be increased by another four), and deliveries began by sea in June 1995. Twenty Apaches are now in service with 1 Lokos (company), 1 Tagma Epidolkon Elikopteron (attack helicopter battalion), based at Stefanovikion. In April 1995 US sources announced that a follow-on contract for 24 aircraft was expected to be signed that year. The status of this contract is unknown.

The Creek army's acquisition of 12 AH-64As in 1995 will no doubt influence neighbouring Turkey's plans to expand and improve its own attack helicopter fleet.

AH-64 Apache Operators

The Dutch Apaches will be AH-64Ds, but without the Longbow radar. This is one of the AH-64D prototypes, wearing a Dutch roundel.

The Netherlands

Royal Netherlands Air Force

The Dutch requirement for an attack helicopter was officially a search for a multi-role armed helicopter that could undertake escort, reconnaissance, protection and fire-support missions. In that respect they did not clearly target the Apache, even though Apache was what the Dutch military was seeking. The performance criteria for the new helicopter were clearly influenced by the AH-64. It had to be night/adverse-weather capable, have a maximum speed of 150 kt (277 km/h, 172 mph), an unrefuelled range of at least 285 miles (489 km) and a mission endurance of 2.5 hours, plus missile rocket and gun armament.

The helicopter programme was governed by Holland's unique democracy-driven Defence Material Procurement Process (DMP). DMP involves rigorous Parliamentary checks on virtually every military acquisition effort, no matter how small. The Dutch evaluated the Bell AH-1W and Agusta A 129 before opting for a choice between the Eurocopter Tiger and the AH-64D Apache. The AH-1 W was deemed by the Dutch authorities to be the only Cobra variant actually available, and no (proposed) improved versions were evaluated. Even though the allocated budget would buy 40 AH-1 Ws, the type was considered to be lacking in performance and operational capability. Agusta offered 36 upgraded A 129 Internationals, but the developmental status of this helicopter counted against it.

McDonnell Douglas offered 30 AH-64Ds for a nominal $962 million, while Eurocopter offered 34 Tigers for $1.09 billion. The US offered AH-64As for initial training, while Germany offered BO 105s. The DMP led to disagreement between the RNLAF, which publicly advocated the Apache, and the Ministry of Economic Affairs (MEZ), which preferred the Tiger. Dutch industry also supported the Eurocopter bid on the grounds of future Dutch participation in the Tiger/Tigre project. This tension between the RNLAF and MEZ led to the postponement of the cabinet decision from December 1994 to January 1995 to an indeterminate date in the future. Industrial offsets were crucial to the Netherland's 1993 selection of the Eurocopter Cougar in preference to the Sikorsky Blackhawk, and so the pressure was obviously on MDH if it was to win the (adjusted) DFL1.553 billion ($890 million contract). Both the German Chancellor Helmut Kohl and the French Minister for Foreign Affairs Alain Juppe visited the Dutch Prime Minister Wim Kok to lobby on behalf of Eurocopter.

In April a 21-page Apache Decision Memorandum was submitted by the government to Parliament, in favour of acquisition of the AH-64D. It reiterated the fact that at the time the Apache had an operational record of over 700,000 flying hours while Tiger had 720. The slide in the value of the dollar was also a persuasive factor, for the deal would now cost only DFL1.1 billion ($710 million) - although this weakness would also affect industrial offsets. The US bid was $12 million less than Eurocopter's bid for 34 Tigers, although Dutch officials said that was not a significant factor.

At the time Eurocopter stated that it "accepted" the Dutch decision. By early May 1995, however, a special hearing had been arranged for Eurocopter Chairman Jean-Francois Bigay before the Dutch Defence Committee to restate the case for Tiger. Intense political pressure was brought to bear from France and Germany to change the decision and there were many who agreed that the immediate military requirement was less important than the long-term implications for European industry and security co-operation. Eurocopter strongly disputed the results of the AH-64D/Tiger performance evaluation and MDH's estimates of life-cycle costs. Dutch military officials declined to stage a head-to-head fly-off between the two helicopters.

On 24 May 1995 the Netherlands became the third NATO nation to select the AH-64 and the first export customer for the AH-64D. Prime Minister Kok stated that the Apache was chosen because of its "proven high quality and timely availability" coupled with the "lateness and technical risk of the Tiger." A Letter of Offer and Acceptance signed on that day specified 30 AH-64D-standard aircraft for delivery in early 1998. For an order of 30 helicopters the Dutch received a 100 per cent off-set deal plus a long-term industrial co-operation deal, to include AH-64A/D remanufacturing, AH-64D component manufacture, F-15, F/A-18, C-17 and other engine component work, Phillips CD-I technology, and Akzo Nobel Twaron fibre (body armour) technology.

The RNLAF AH-64Ds will not be delivered with the Longbow's MMW radar, but do have the facility to add the radar in the future (six sets may initially be acquired). Likewise, they are compatible with the radar-guided Longbow Hellfire, even though only laser-guided weapons have been ordered. They retain all the fully-digital mission fit of the AH-64D allied with the glass cockpit, Improved Data Modem and embedded GPS/INS. The 30 AH-64Ds will be built at Mesa as part of Apache Production Lot P13 and will be delivered over a five-year period.

The new helicopters will form the centrepiece of the newly-evolving Dutch rapid-deployment Air Mobile Brigade which will become operational in 1998. The Dutch 11th Air Mobile Brigade will have three infantry battalions and an aviation battalion, comprising two transport squadrons (one with 13 CH-47D Chinooks, one with 17 AS 532 Cougars) and two Apache attack squadrons. The Apaches will form a tactical helicopter group at Gilze-Rijen AFB with armed BO 105s. The transport helicopters will be based at Soesterberg AFB. The 11th AMB is attached to NATO's ACE Rapid Reaction Corps and its mission will be to deploy within 15 days for combat operations to any location, worldwide. The RNLAF has adopted US attack helicopter training and undertaken the bulk of its pilot and maintenance training in the USA.

The first Apache squadron is 301 Sqn 'Redskins' (motto: 'Per Sapientiam Efficens et Immortalis'). On 17 December 1996 the '301 st Tactical Helicopter Squadron' completed its training with the Ft Hood-based 21st Cavalry Aviation Brigade, becoming the first allied unit to graduate from the US Army's helicopter collective training programme. The second Dutch Apache unit, 302 Squadron, will follow in 1997. In advance of its own aircraft the RNLAF agreed to accept 12 US Army AH-64As for initial training, in a nominal FMS loan of $1 each.

On 13 November 1996 12 AH-64As were handed over to the RNLAF at a ceremony held at Gilze-Rijen AFB. The aircraft, which had flown from Hanau, were 85-25430, 85-25465, 85-25471, 85-25472, 85-25474, 85-25480, 85-25482, 85-25485, 86-8970 86-8983, 86-9029 and 86-9033. The lease did not become active until 17 January 1997 and any flying conducted before then was undertaken by US Army pilots.

In November 1996 12 US Army AH-64As were leased to the Dutch air force to allow crews to begin initial type training before the delivery of their AH-64Ds in 1997/98.

United Kingdom

Army Air Corps

Since 1980 the spearhead of the British Army Air Corps had been its TOW-armed Westland Lynx AH.Mk 1/7s. The addition of TOW missiles to the Lynx made it an excellent 'armed helicopter', but it was obviously no match for a dedicated battlefield attack helicopter (AH). Acquisition of an AH had been a long-standing UK requirement but one which was not pursued until after the Gulf War. As early as 1988 a senior British Army Air Corps officer, Lieutenant General Sir David Ramsbottom, had expressed his preference for the AH-64.

The Apache sales effort in Europe had begun in 1982 but it was only in the late 1980s that the more experienced stewardship of McDonnell Douglas, coupled with several years of practical operational experience, allowed serious marketing efforts to began. European NATO members had long been debating the acquisition of a new anti-armour helicopter and MDH squarely targeted the UK/Italian/Spanish/Dutch Tonal Light Attack Helicopter (LAH) programme. Germany and France were perceived as by then being too deeply involved in their joint PAH-2/HAC-3G/HAP project, which was further advanced than that the LAH group. LAH studies were centred around a growth version of Italy's Agusta A 129 Mangusta, which was ultimately considered to be too small, and the partnership fell into abeyance.

The UK's search for an AH was renewed in the mid-1980s, with approximately 127 aircraft being sought. From this point a formal UK requirement, Staff Target (Air) Cardinal Point Specification 428 (previously GSR 3971), was finally endorsed in June 1991. A competitive tendering/assessment phase was initiated by MOD(PE) for an 'off-the-shelf helicopter, followed by an invitation to tender (ITT) for the supply of aircraft, munitions and support systems. The ITT was issued in February 1993 and by the following November had attracted five bids: the Agusta A 129, the Boeing/Sikorsky RAH-66A Comanche, the BAe/Eurocopter Tiger, the GEC-Marconi Avionics Cobra Venom and the Westland/McDonnell Douglas WAH-64D Longbow Apache. A final sixth bid came late, in September 1994, from the Marshall/Denel Kestrel (Rooivalk). The Kamov Ka-50 was also touted as an outside, and unlikely, competitor. The A 129 and the RAH-66A soon dropped out of the race, leaving the others chasing a potential order of over 90 helicopters. The definitive bids were made by 20 February 1995. Each set of tender documentation comprised 10 or more copies and typically weighed two to three tons.

This retouched photograph shows an AH-64D Longbow Apache with notional Helstreak missiles, the UK's 'preferred' weapons choice.

The AH Target Operational Characteristics (AHTOC) document specified the essential AH performance points. The new helicopter must have night/adverse-weather capability, be highly survivable, boast a substantial payload/range combination and high weapons Pk factor. In total, 678 individual AHTOCs were included in SKA) CPS 428. From the outset, the Apache's bid was a strong one. Not only was it the Army's preferred choice (if not in official terms), but McDonnell Douglas's

In addition to being the first exported full-standard Longbow AH-64Ds, AAC WAH-64Ds will be uniquely powered by RTM322 engines - in common with the RAF's and RN's EH101 Merlins.

teaming with Yeovil-based GKN Westland would secure jobs at the UK's only helicopter manufacturing firm while providing invaluable technical experience and future co-production possibilities. Important technology transfer issues, such as the MMW radar, RF seekers and laser guidance systems, would also be involved.

The AH-64D on offer to the Army Air Corps, always referred to as the Westland Attack Helicopter (WAH-64D) Apache, was a full-standard Longbow aircraft with MMW radar and digital systems. The WAH-64D was offered with baseline T700 engines, or more powerful Rolls-Royce/Turborneca RTM322 turboshafts. The latter would provide commonality with the RAF/RN EH101 helicopter and, it was maintained, could be fitted at little additional cost. Primary armament for the WAH-64D would be the RF-homing AGM-114L Longbow Hellfire, although standard AGM-114K Hellfire Us were also on offer. Rocket armament would be provided by the Bristol Aerospace CRV 7 70-mm system, already in UK service. An air-to-air armament was specified for the British Apaches from the outset and the weapons of choice included the air-to-air Stinger and a version of the Shorts Starstreak high-speed anti-aircraft missile, the Helstreak. An 18-month Helstreak development programme, in conjunction with the US Army, was underway by mid-1995.

In a competition that became increasingly politicised and fractious, the Eurocopter Tiger (Tigre) team played the 'European' card heavily, particularly in the light of the UK's C-130J and CH-47 acquisitions. Eurocopter firmly believed it offered a risk-free option to the UK (as development costs were already underwritten by the French and German governments), with the promise of a 20 per cent stake in the project if the Eurocopter bid was successful. Eurocopter teamed with British Aerospace's Defence Dynamics division, considering it a full partner and offering a 100 per cent offset deal. The UK was already involved in the development of the Trigat missile (intended as the primary armament for anti-tank UHU/HAC Tiger/Tigre versions), and as Trigat's future was closely linked to that of the Tiger a closer British involvement in either project would be welcome. A UK Tiger buy would also be a pointer to closer European defence ties between the UK, France and Germany.

GEC-Marconi mounted a vigorous campaign in support of its Cobra Venom proposal, based on the Bell AH-1W SuperCobra. The Cobra Venom would be TOW/Hellfire compatible (with a newly designed four-station pylon wing), but its primary armament was the GEC-Marconi Brimstone, an RF-homing anti-tank missile based on the chassis and motor of the Hellfire with a UK-designed and -built seeker head. Cobra Venom featured an advanced, purpose-designed avionics suite that GEC-Marconi was also offering for the US Marine Corps' proposed AH-1W Integrated Weapons System (IWS) upgrade. The cockpit boasted impressive colour MFDs and a colour moving map display - and was the only avionics/software fit in the competition to be developed in the UK. Its T700 engines would also be built in the UK by EGT. In June 1995, GEC-Marconi also added the Marines' proposed four-bladed rotor system for the AH-1 W (4BW) to its Cobra Venom specification.

The dark horse in the competition was the Denel (Atlas) Rooivalk which, like the Tiger, was still in development. Favourable pilots' opinions coupled with the 'x-factor' of a *quid pro quo* deal with the SAAF involving a purchase of BAe Hawk trainers meant the Rooivalk was a stronger competitor than some believed. The Rooivalk's good standing may not have been unconnected with the US blocking GEC from offering the full Brimstone armament, which uses the chassis and motor of Hellfire, on the Rooivalk. In 1994 Rockwell was prohibited from supplying any missile components due to allegations that Armscor had broken UN arms embargoes. This left Atlas able to offer only the South African-developed Kentron ZT35 Swift as the Rooivalk's primary armament, with perhaps a Brimstone MMW seeker or even an all new Somchem motor from the SAHV SAM. The US opposition was seen to be wholly political in nature and was smoothed over soon after the competition ended.

The Army Air Corps did not undertake an evaluation of the AH types on offer, although several AAC pilots did fly in the various aircraft. Their experiences were unconnected with the formal evaluation that was conducted by the MoD AH Project Office, using Boscombe Down's test pilots.

Firm prices were submitted on 30 September 1994 and final bids for the £2 billion ($3.2 billion) contract were submitted on 20 February 1995. A huge emphasis was placed on the amount of technology transfer and industrial offsets on offer to British industry. The Dutch selection of the AH-64D in May 1995 only increased the standing of the Westland/MDH team, but the impending UK decision was still seen by most manufacturers as the one that would set the seal on all future markets. In April 1995 the UK MoD selected the Northrop/Grumman Nemesis DIRCM system for its future attack helicopter in a deal worth £193 million ($271 million). The Dutch decision to buy the Apache prompted discussions between MDH and Westland to explore the possibility of setting up a European support centre in the UK for all Europe-based AH-64s. The Dutch have also proposed the possibility of establishing a pan-European AH training centre.

On 13 July 1995, in an announcement rushed through before the summer Parliamentary recess, the Westland WAH-64D was announced as the winner of the UK's attack helicopter competition. UK Defence Secretary Michael Portillo, who had to overcome intense Treasury opposition to the early announcement, approved a £2.5 billion project for 67 WAH-64Ds, saying it was "the equipment that best does the job." The actual WAH-64D contract award was made to Westland in March 1996. The aircraft will (presumably) be known as the Apache AH.Mk 1. Although the total involved was lower than the Army had hoped, each aircraft would be equipped with the Longbow MMW radar. The initial UK order comprises 68 Longbow radars, 980 AGM-114L missiles and 204 missile launchers. Westland estimated that its workshare would be £800 million ($352 million). A Eurocopter statement read, "Eurocopter can only deeply regret this sovereign decision and deplore this (lost) opportunity to set up a new co-operation with Great Britain." BAe said that the decision would cost the jobs of 200 people involved in the LR Trigat project. By August 1995 the US Army had awarded a $3.2 million contract to Shorts, in association with McDonnell Douglas and Lockheed Martin, for Starstreak/Helstreak trials. The primary benefit, not appreciated by many, of an all-Longbow fleet for the UK derives from the heavy emphasis that will be placed on the Apache's air-to-air mission in British service. Helstreak is an essential element of this emerging doctrine.

The British army's 300 helicopters are currently organised into two divisional regiments (supporting the UK's armoured divisions), two regiments attached to the 24 Airmobile Brigade, a regiment stationed in Northern Ireland and a Territorial Army (reserve) regiment. The Apache will replace the armed Lynx in the combat role, and the 'de-TOWed' Lynxes will become Light Utility Helicopters (LUH), joining the Lynx AH.Mk 9 Light Battlefield Helicopter (LBH) in restructured AAC regiments. Once the transition to WAH-64D is complete, no armed Lynxes will remain in AAC service, although the TOW thermal sight will be retained. Under current plans (not yet finalised), Nos 3 and 4 Regiments AAC, based at Wattisham, will comprise two squadrons each of eight WAH-64Ds and four LUHs, plus a single squadron of 11 LBHs. No. 9 Regiment, AAC (currently based at Dishforth) will have two squadrons of eight WAH-64Ds with an amphibious assault tasking, plus a single squadron of 10 LUHs. The Army anticipates having a total of 48 Longbow Apaches active in the field. This new fleet of combat helicopters will require a new fleet of support vehicles (fuel tankers, ammunition carriers, mobile command/mission planning stations), all rugged and air-transportable.

Initial crew training ('conversion to type') will be undertaken on AH-64As with the US Army at Ft Rucker. These early crews will make their AH-64D conversion at Mesa. The AAC has not yet made a decision on where its unit-level 'conversion to role' training - as undertaken by the US Army's 21st Cavalry Aviation Brigade (formerly CAT-B) at Ft Hood - will take place. A variety of training options and training sites is still under evaluation. The target in-service date (ISO) has slipped from December 1998 to December 2000. The ISO relates to the formation of the WAH-64D OCU, which will be No. 671 Sqn at Middle Wallop. The OCU will establish with an initial complement of eight aircraft. The first WAH-64D will arrive in the UK in April 2000. This aircraft will be dedicated to type Military Aircraft Release (MAR) certification procedures at Boscombe Down. Two aircraft for the Project Office will follow in April, with an additional pair arriving in May. Deliveries will then continue at the (approximate) rate of one per month until January 2004.

Potential Apache Customers

Kuwait

The Kuwaiti requirement for *a* new attack helicopter to replace its TOW-armed Gazelles was generated immediately after Operation Desert Storm. An imminent order for the Apache was then expected but never materialised. By early 1995 the AH-64A was believed to have been selected once more and a $700 million order for 16 aircraft was announced but never formalised.

This deal would be crucial in helping MDH bridge the gap between the last AH-64A deliveries and the first AH-64Ds. Press reports suggested that Kuwait was pushing to acquire AH-64D Apaches, though the Longbow radar is not yet cleared for export. The sale of AH-64s to Kuwat has stalled, however, reportedly becuase McDonnell Douglas was having difficulties in disposing of the Kuwait Air Force's withdrawn fleet of A-4KU Skyhawks. McDonnell Douglas had agreed to handle the sale of the Skyhawks, before the Iraqi invasion, as part of the Kuwaiti F/A-18 deal. The intervening conflict left the aircraft, and their spares stock, in a less than desirable condition, and despite strenuous efforts McDD has failed to interest a buyer.

Chances of an Apache sale may be dashed by Kuwait's 1996 decision to acquire 16 Hellfire-capable Sikorsky UH-60L Blackhawks (with 500 Hellfires and 38 launchers). The UH-60Qs are believed to have been offered instead of AH-64Ds and are fitted with a FLIR system downgraded from that in use with similar US Army special operations MH-60 DAP (Defensive Armed Penetration) helicopters. Confirmation of this deal has yet to be announced, however.

Bahrain

In 1991, after the cessation of hostilities in the Gulf, it was announced that Bahrain had ordered six AH-64As. This deal was never completed.

Republic of Korea

MDH chose the Farnborough air show to announce on 9 September 1992 an FMS deal with the Republic of Korea for 37 AH-64As, which was then the largest export order for the Apache. This deal subsequently fell through but in October 1996 Korean interest in a new attack helicopter was revived.

An initial Army requirement for 18 helicopters has been proposed, to enter service after 2000, and the Army hopes to acquire between 38 and 48 aircraft to replace its AH-1S fleet. The Apache is the front-runner, though the Eurocopter Tiger is also a potential candidate. If Korea does opt for an Apache acquistion, it may also consider re-engining them with RTM322 turboshafts, as fitted to the WAH-64D. A procurement decision is anticipated in 1997.

Other near- and mid-term future customers for the Apache may include **Malaysia, Singapore, Qatar and Japan**

US Army operator details supplied by
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