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AH-64A APACHE-BATTLE READY

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ABSTRACT

The AH-64A APACHE is now in production for the United States Army. This paper documents the APACHE system through detailed descriptions of the air vehicle's capability in terms of performance, survivability, crashworthiness, transportability and deployability. The subsystems of the AH-64A are described in detail with emphasis on the integrated capabilities of the visionics sensors, avionics, navigation and weapon systems. The reliability, availability and maintainability of APACHE are addressed and data gathered during the U.S. Army's operational evaluation of the aircraft is presented. Illustrations are provided to document highlights of the ballistic testing, laboratory evaluations and the extensive flight development program required to fully qualify APACHE.

INTRODUCTION

On the integrated battlefields of today and the future the AH-64A "APACHE" Advanced Attack Helicopter, is a valuable force multiplier and provides an added lethal dimension to the combined arms team. The AH-64A provides an immediate response to the needs of the ground commander. The first attack helicopter ever developed specifically for day, night and adverse weather anti-armor missions, it has the ability to fight and survive at the forward edge of the battle area. (Figure 1)

The AH-64A, a twin-engine four-bladed helicopter operated by a tandem-seated crew of two, delivers unprecedented firepower quickly and with deadly accuracy. The pilot is located in the rear cockpit, placing the copilot/gunner (CPG) in the forward position where he can concentrate on detecting, engaging and destroying enemy targets with an array of weaponry including: HELLFIRE® missiles, aerial rockets and the Hughes 30mm CHAIN GUN® Area Weapon System.

To enable the APACHE to fly and fight at night and during periods of reduced visibility, a unique Pilot Night Vision Sensor (PNVS) and Target Acquisition and Designation Sight (TADS) was developed and integrated to permit navigation and precision attacks under low visibility and night battlefield conditions. The APACHE's mission roles include anti-armor, covering force, flank security, economy of force and airmobile escort. The AH-64A provides:

- Performance that meets or exceeds the U.S. Army requirements
- Day, night and adverse weather operations
- Multiple firepower options
- Twin-engine performance and reliability
- Improved combat survivability
- Advanced crashworthy design features
- High reliability, availability and maintainability
- Rapid rearm and refuel capability

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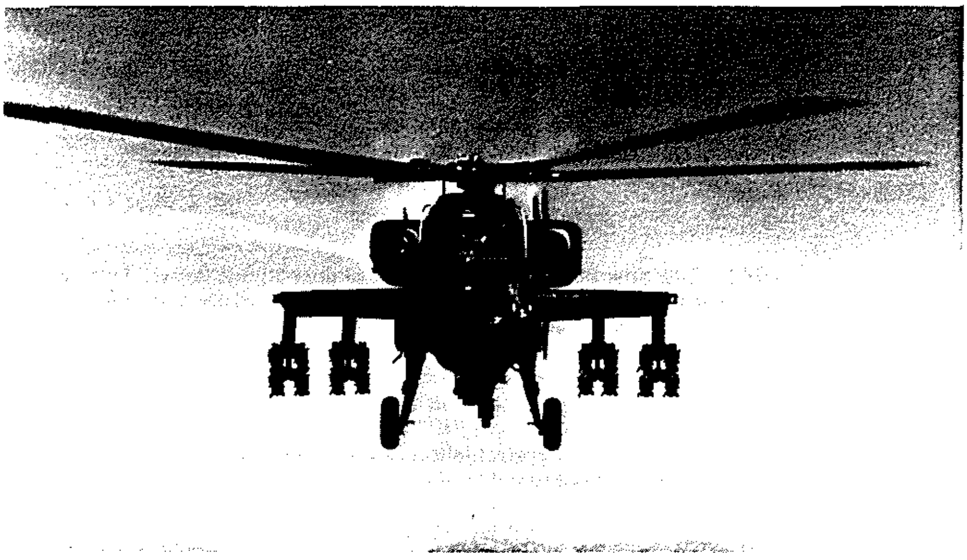


Fig. 1. APACHE in Flight

- Self-deployability
- Air transportability

The APACHE gives the ground force commanders the 24-hour tactical flexibility required to fight, survive and win on the modern battlefield.

In 1981, three YAH-64's participated in a 3-month exercise called OT-II (Operational Test II) in which all weapons and systems were field tested by the U.S. Army under operational conditions. The results of this exercise proved that the YAH-64 was ready for production. In July 1981, Mesa, Arizona was selected as the site for the company's new 240,000 square foot assembly plant for the AH-64. On 15 April 1982, a production contract was signed for the first 11 APACHEs, the first of which is scheduled for delivery in February 1984. The U.S. Army currently plans to procure 515 APACHEs with production peaking at a rate of 12 per month.

U.S. ARMY MISSIONS

ATTACK

The primary mission of the AH-64A requires engagement and defeat of enemy armor in day, night and adverse weather. The APACHE's rapid mobility, lethal firepower and ability to detect, recognize and engage multiple targets, and operate around-the-clock in adverse weather provides the responsiveness and flexibility required by today's battlefield commanders. It also denies enemy forces the normal advantage of night, adverse weather conditions and superiority of numbers. (Figures 2 and 3)

AIRMOBILE ESCORT AND AREA SUPPRESSION

These missions include: covering force, flank security, economy of force, airmobile escort and area suppression. The covering force mission is to detect, impede and disrupt enemy forces approaching the main battle area. In the flank security mission a group of

Fig. 2. Adverse Weather Attack

Fig. 3. Night Attack

AH-64As protects the flanks of the main body forces from surprise attacks. The economy of force mission employs small, mobile forces in strategic areas so ground forces can be massed at the decisive time and place elsewhere on the battlefield. Airmobile escort is another important mission alternative offered to the ground commander by the mission flexibility of the APACHE. The airmobile escort mission entails the destruction or suppression of enemy personnel, material and air defense in support of hellborne operations.

In a typical area suppression mission, infantry is transported by tactical transport helicopters to seize or control terrain. The AH-64A's ability to suppress enemy air defenses will help ensure mission success. An added advantage for the combined arms team is the APACHE's ability to penetrate enemy defenses along a controlled corridor and neutralize river crossings or other strategic locations ahead of a rapidly moving armored column.

TACTICS

As the world's most advanced attack helicopter, the APACHE is able to improve upon the special tactics used in a high threat combat environment, thus enhancing its effectiveness and survivability. In this environment the APACHE utilizes the surrounding terrain to mask itself while preparing to engage and defeat enemy threats. The inherent agility and large maneuver envelope allows superior nap-of-the-earth flight, minimizing exposure to enemy weapon systems. Rapid masking and unmasking during attacks is provided by exceptional hover performance and engine power availability.

The AH-64A expolits the tactical advantages of terrain masking and nap-of-the-earth flight at night and during weather that stops most helicopters. The ability to designate targets cooperatively with other attack helicopters or scout forces and the utilization of weapons that provide maximum stand-off ranges makes the APACHE a superior tactical weapons system. (Figure 4)

The AH-64A can engage autonomously or work as a team member. As many as 10 target locations can be passed to the AH-64A, which are then entered into the navigation system computer. The fire control computer can then pre-position weapon systems and display steering information, providing rapid target engagement. The AH-64A provides effective suppression of primary threat air defenses and enhances survivability of the combined arms team.

FLIGHT PERFORMANCE

The U.S. Army's primary mission performance for the AH-64A requires a minimum vertical rate of climb of 450 feet per minute and a cruise speed of 145 knots with eight HELLFIRE missiles, 320 rounds of 30mm ammunition and fuel for a 1.83-hour mision at the standard Army hot day of 4,000 feet, 95° F. The AH-64A, equipped with two General Electric T700-GE-701 engines, has demonstrated flight performance which exceeds these demanding Army requirements and exceeds the capabilities of all current attack helicopters. (See Figure 5) The AH-64A features:

- Superior nap-of-the-earth flight capability
- Low vibration
- Forward speed in level flight of 164 knots
- Sideward and rearward speed of 45 knots
- Sustained rates of climb in excess of 3,000 feet per minute
- Maximum gross weights up to 18,500 pounds
- High maneuverability from +3.0 to -0.5g

Fig. 4. Terrain Masking and Nap-of-the-Earth

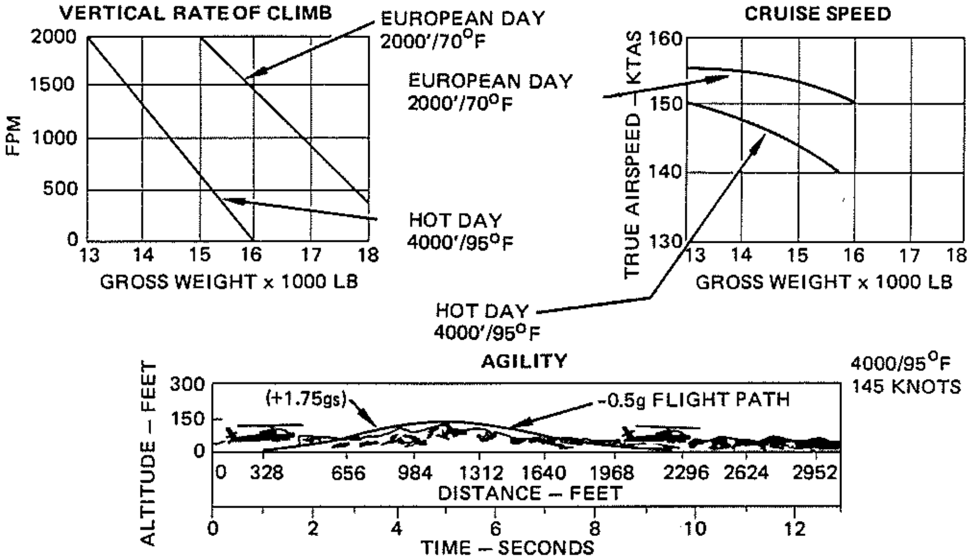


Fig. 5. Flight Performance

Designed specifically for the attack helicopter role, the APACHE's performance capabilities and ability to carry various combinations of ordnance provides the battlefield commander total mission flexibility, without sacrificing aircraft performance.

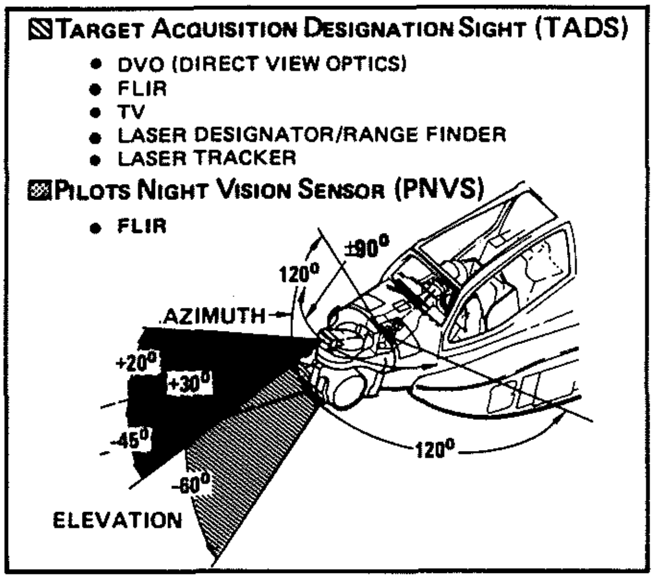
The APACHE, which requires no vibration reduction absorbers or equipment, is one of the smoothest flying helicopters ever built. Low-vibration levels are the result of comprehensive engineering development efforts and are attributable to the fully articulated four-bladed main-rotor, static mast, "scissor" tail rotor and a rugged tuned airframe. Pilots may operate the AH-64A throughout the flight envelope over extended time periods without vibration-induced fatigue, maximizing the full potential of this high performance attack helicopter.

Enhanced nap-of-the-earth flying is provided by an exceptionally responsive rotor system and substantial control power margins. The AH-64A has a high degree of controllability, remarkable low-speed stability and excellent performance. The APACHE can execute all critical maneuvers required to fight . . . and survive.

VISIONICS SENSORS AND AVIONICS SYSTEMS

TADS/PNVS

The TADS provides the APACHE copilot/gunner with day, night, and adverse weather target acquisition (search, detection, and recognition) capability by means of direct view optics, day television, or forward looking infrared (FLIR) sighting subsystems. Each subsystem may be used singly or in combination depending on tactical, weather, or visibility conditions. The TADS includes a stabilized platform for the sighting sensors which provides a steady image in the presence of the helicopter's flight environment. Once acquired, targets can be tracked manually or automatically for attack with the 30mm gun, rockets, or HELLFIRE missiles. For the HELLFIRE missile, the TADS provides a laser designator which illuminates the target with laser energy. This energy is detected by the HELLFIRE missile seeker and is used to guide the missile to the target. The designator can also be used to guide HELLFIRE missiles launched from other APACHEs, Copperhead projectiles launched by artillery units, and other laser guided weapons. The designator also includes a laser receiver which provides the range to the target for fire control computations. Automatic target tracking is available in any sensor mode and is accomplished by processing the day television or FLIR video signal and commanding the turret to maintain the target within the selected sensor field-of-view. Linear motion compensation allows pointing of the turret to a fixed position regardless of helicopter motion. (Figure 6)



▧ **TARGET ACQUISITION DESIGNATION SIGHT (TADS)**
- DVO (DIRECT VIEW OPTICS)
- FLIR
- TV
- LASER DESIGNATOR/RANGE FINDER
- LASER TRACKER

▩ **PILOTS NIGHT VISION SENSOR (PNVS)**
- FLIR

Fig. 6. TADS and PNVS

A laser tracker incorporated in the TADS provides the copilot/gunner with the capability to rapidly acquire targets designated by other ground or airorne designator systems.

An optical relay tube (ORT) provides the TADS controls and displays necessary for the copilot/gunner to operate the system. In the head-down mode, the copilot/gunner can view the two field-of-view direct view optics or a cathode ray tube which displays either the two field-of-view day television or three field-of-view FLIR video. Additionally, the head-down mode allows him to view symbology for target engagement and an alphanumeric display which provides fire control system status information. In the heads-out mode, he can view a panel mounted CRT which also displays day television or FLIR video.

Controls on the handgrips and the ORT allows him to utilize the system in all of its modes of operation and to select and fire weapons. Critical to the proper functioning of the TADS is the boresight alignment of the various sensors to the laser. The boresight module allows rapid alignment both on the ground and in flight.

The PNVS allows the pilot to fly the AH-64 in the hostile night environment using terrain flying techniques. A real-time, passive "thermal image" of the "world" outside the cockpit window is displayed on a helmet mounted display (HMD) which the pilot views with one eye. The TV-like image is generated by the common module FLIR sensor integrated within the PNVS turret. The FLIR instantaneous FOV is 30 × 40 degrees but the pilot has the capability, through the Integrated Helmet and Display Sight System (IHADSS) to slew the turret-mounted FLIR in both azimuth and elevation to increase the field-of-regard (FOR). This concept approaches the normal daylight "out-of-the-window" flying by allowing the pilot to see FLIR imagery of the scene in the direction he turns his head. The high resolution FLIR imagery allows the pilot to execute low level, contour, and nap-of-the-earth (NOE) flight to enhance survivability. In addition, the PNVS allow a night confined terminal area capability to execute maneuvers such as hover, bob-up, remask, sideward flight, takeoff, landing, etc., with confidence. (Figure 7)

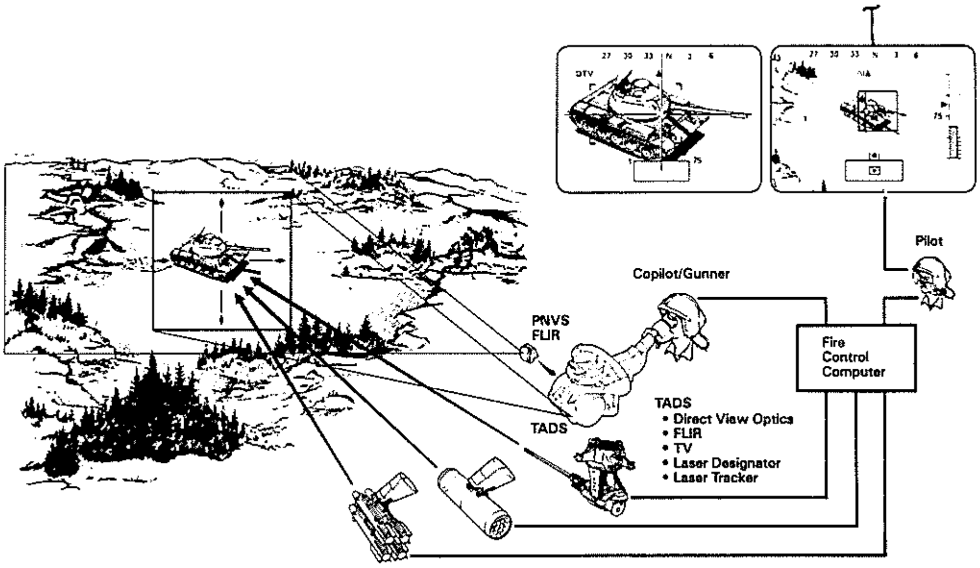


Fig. 7. Visionics Sensors and Avionics Systems

The PNVS turret is mounted above the TADS. TADS and PNVS operate independently, and a malfunction in one does not affect the other. In the event a malfunction occurs, the pilot may, at the push of a switch on the collective, instantaneously select the TADS wide field-of-view FLIR. This independent TADS FLIR backup provides an added safety feature during NOE operation.

The PNVS output video signal is routed to the symbol generator and to the IHADSS. Within the symbol generator, flight symbology necessary for NOE and terminal area maneuvers is superimposed on the FLIR video and presented to the pilot. In the event of symbol generator failure, PNVS video is directly provided to the display. Whenever the pilot desires to fire the gun, rockets, or HELLFIRE, weapon symbology can also be presented on the display such that the IHADSS becomes a true "heads-out display" for flying and target engagement.

IHADSS

The IHADSS replaces the standard Army Aviator's flight helmet. It provides the same crash protection and communication functions but at a lower weight and with more stability on the head in order to maintain the pilot's eye alignment with the helmet mounted display (HMD). It provides electrical head line-of-sight position signals such that head motions of the pilot direct the PNVS sensor line-of-sight and 30mm gun in one-to-one angular correspondence. Finally, it allows presentation of PNVS or TADS video imagery with unity magnification with or without flight and/or weapon symbology to be displayed on the 1-inch CRT for either eye. (Figure 8)

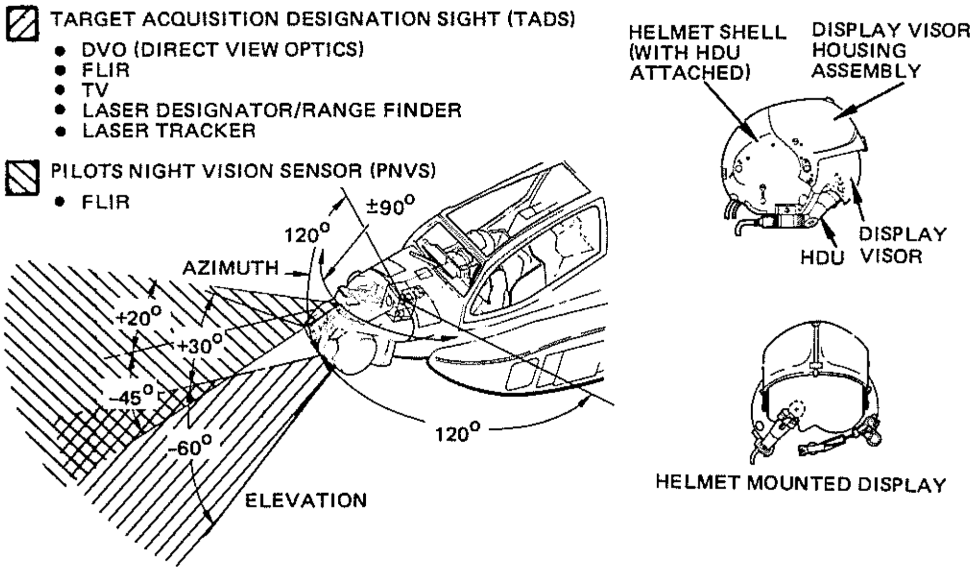


Fig. 8. Target Acquisition

AVIONICS

An advanced lightweight avionics equipment package has been utilized to provide secure UHF, VHF, AM and FM radio communications. The Lightweight Doppler Navigation System, with the Heading Attitude Reference System (HARS), permits accurate nap-of-the-earth navigation and provides for storing target locations. The navigation suite includes an automatic direction finder, VHF-FM homing and a lightweight IFF transponder, with secure encoding feature.

NAVIGATION

The AAH navigation system plays a major role in fire control and weapon delivery. It is used to precisely prepoint TADS to known target locations for rapid acquisition and weapon engagement. It is also tied into the fire control system for indirect launches of the HELLFIRE missile and can be used to fire the gun.

The principal elements of the navigation system are the AN/ASN-128 Doppler, a strapped down inertial heading and attitude reference system (HARS) and an air data sensor. Aircraft and target position are provided in both universal transverse mercator (UTM) and latitude-longitude coordinates. Output signals are provided for magnetic bearing, helicopter pitch, roll and heading, ground speed and drift corrected steering data.

Since the basic Doppler system is a "dead reckoning" navigator, it is necessary to periodically update the system by inputting position fixes at known geographic points in order to truncate the growth in system error. This can be accomplished either by overflying a known reference point stored in the fire control computer or alternatively using the TADS to get range and angular coordinates to the reference point. This latter mode is referred to as offset updating since the updating can be performed from a distance eliminating the need to overfly the reference point.

A two axis air data sensor mounted at the top of the rotor mast provides lateral and longitudinal airspeed, side-slip and air density ratios. This information is utilized by the fire control computer in the solution of both navigation and weapon's delivery equations. The HARS is used to determine the gravity vector for drop compensation in correcting weapon aimpoint. Linear motion compensation is used to correct gun aim and TADS target tracking by automatically producing a line-of-sight rate proportional to helicopter velocity.

FIREPOWER

Firepower options include up to 16 HELLFIRE missiles, 76 2.75-inch aerial rockets and 1,200 rounds of 30mm ammunition. A mix of HELLFIRE and rockets or external fuel tanks can be accommodated based on the commander's tactical requirements. (Figure 9)

The HELLFIRE laser guided missile subsystem is the primary armament, capable of defeating all currently known armored vehicles at significant stand-off ranges. This missile system minimizes engagement time and permits missile launching from concealed positions. HELLFIRE is employed using direct or indirect firing modes with single fire, rapid and/or ripple-fire missile engagement. Normally, direct and rapid fire modes are fired autonomously by using the onboard laser to designate the target. Ripple and indirect fire modules are used in cooperative attacks with designation by other attack helicopters, laser equipped scouts, RPVs, or remote ground designators. The indirect mode allows the APACHE to destroy threat armor while remaining masked and at extended stand-off ranges, enhancing effectiveness and survivability. In the ripple mode, 16 missiles can be fired in one minute. (Figure 10)

The 30mm CHAIN GUN® automatic cannon is the primary area weapon subsystem, providing suppressive firepower and for the destruction of lightly armored vehicles. This weapon system is normally operated by the copilot/gunner using the TADS but may also be directed by either crewmember utilizing the helmet mounted sight. The 30mm cannon has a normal rate of fire of 625 rounds/minute of Aden/DEFA 30mm rounds or Honeywell TP, HE and HEDP ammunition. Maximum ammunition load is 1200 rounds. (Figure 11)

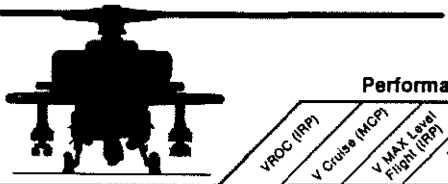
Another firepower option consists of 2.75-inch Folding-Fin Aerial Rockets (FFAR) which have been a standard U.S. Army and NATO munition for many years. However, new development for the 2.75-inch FFAR — such as the Mark 66 motor, the Multipurpose Submunition Warhead, and articulating pylons — have significantly enhanced the effectiveness of this system. The aerial rocket subsystem may be fired by either crewmember with aiming and steering commands shown on the helmet display, or in conjunction with the TADS for increased accuracy. The crew can select fuse ranges or tree heights to control detonation, as well as launching mode (singles, pairs or quads), launching rate, quantity launched and zone launching.

All weapons systems are directed through a fire control computer which significantly enhances target kill probability. By prepointing weapons and computing precise ballistic trajectories, the fire control computer reduces time to acquire targets and provides the best weapons system performance ever achieved in an attack helicopter.

Weapon Control System

APACHE features an all-digital integrated fire control system. A network of subsystem imbedded mini/microcomputers are interconnected through a closed loop multiplex system to take advantage of the cost and simplicity benefits achieved from a distribution of digital capacity and to exploit the latest state-of-the-art advances in computer technology. The Fire Control Computer, which is the heart of the fire control network, is the executive controller of

AAH ARMAMENT OPTIONS = MISSION FLEXIBILITY



Performance

Mission				VROC (IRP)	V Cruise (MCP)	V MAX Level Flight (IRP)	Mission Duration
Anti-Armor Mid-East Primary Mission 4000'/95°F	4 HF	320 RDS	4 HF	1300 FPM	145 KTS	157 KTS	1.83 HRS
Europe Alternate 2000'/70°F	8 HF	1200 RDS	8 HF	770 FPM	147 KTS	151 KTS	2.5 HRS
Covering Force Mid-East Alternate 4000'/95°F	4 HF	1200 RDS	4 HF	715 FPM	143 KTS	154 KTS	1.83 HRS
Europe Alternate 2000'/70°F	4 HF 19 RKTS	1200 RDS	4 HF 19 RKTS	1330 FPM	150 KTS	153 KTS	2.6 HRS
Airmobile Escort Mid-East Alternate 4000'/95°F	19 RKTS	953 RDS	19 RKTS	695 FPM	144 KTS	155 KTS	1.83 HRS
Europe Alternate 2000'/70°F	38 RKTS	1200 RDS	38 RKTS	445 FPM	148 KTS	151 KTS	2.5 HRS

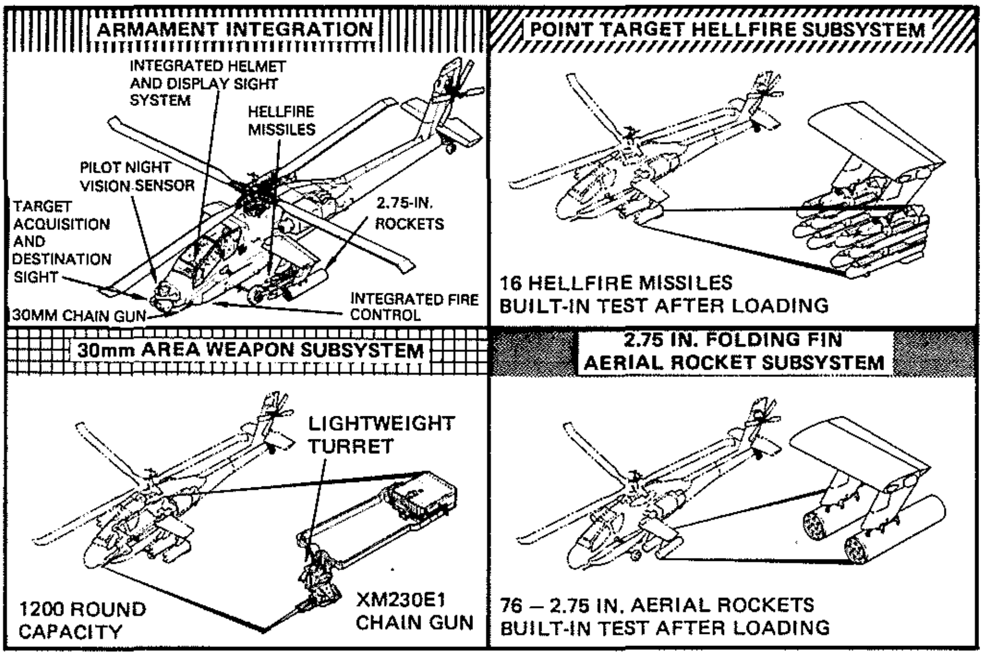


Fig. 9. Firepower Options

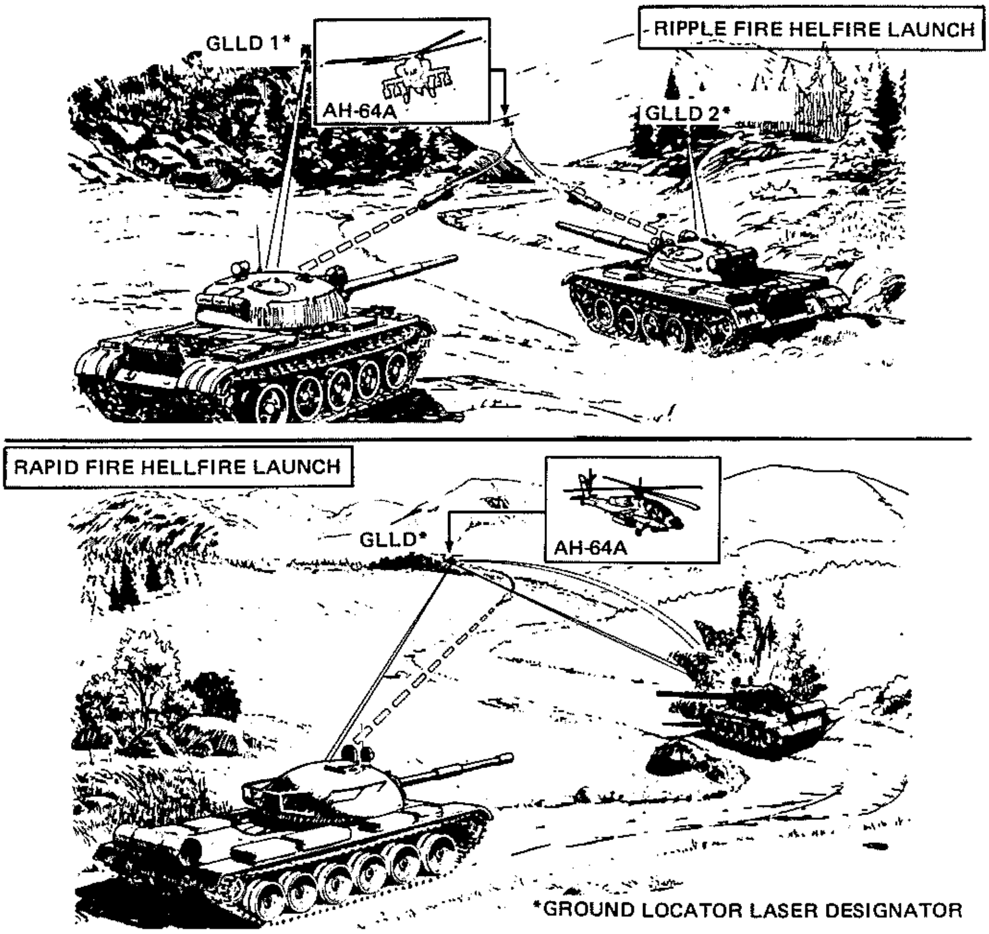


Fig. 10. Missile Launching

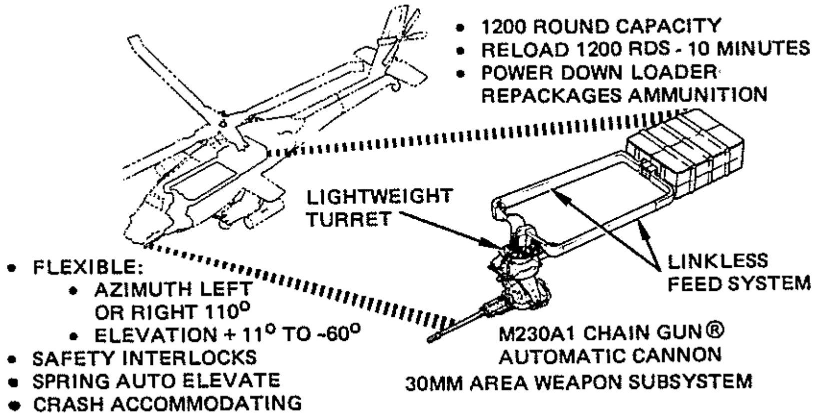


Fig. 11. Area Weapon Subsystem

all other imbedded microcomputers. This approach allows each subsystem developer maximum software and interface flexibility by only requiring rigid software interface specification controls for the higher order interface message traffic which must flow between subsystems. (Figure 12)

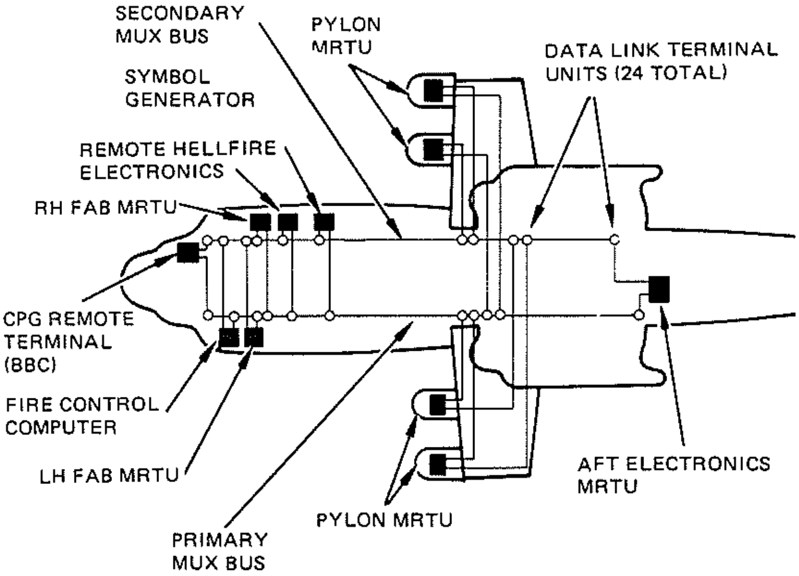


Fig. 12. Multiplex System

The AH-64 multiplex system, which ties together the computer network, is a distributed time division multiplex system consisting of 13 units, interfacing directly to redundant data busses. Nine of the units are Remote Terminals specifically designed to adapt off-bus subsystems to the multiplex data bus. Functionally, the YAH-64 multiplex system replaces much of the signal and control wire and relay logic required in conventional aircraft configurations. The system can be expanded to meet future requirements.

Figure 13 is the block diagram of the present multiplex system. The primary data bus and controller is on the left side of the aircraft, while the secondary data bus and controller is on the right side. This isolation between the busses increases survivability. Critical signals can be routed into remote terminal units by providing separate signal paths, precluding the loss of that function with a remote terminal failure. The active bus controller collects data from all boxes on the bus (via transmit commands), performs the required logic processing and computations, and outputs the revised data to all boxes on the data bus (via receive commands). During normal operation, sole control of information transmission on the bus resides with the active bus controller, within the Fire Control Computer (FCC) while backup control resides in the Backup Bus Controller (BBC).

The fire control computer is the executive controller of all other on-board computers. It integrates the AAH operations associated with delivery of all weapons as well as performs certain specific computational functions such as gun and rocket ballistics, navigation updating and Kalman filtering. In addition to controlling the multiplex bus, the computer performs a Fault Detection/Location System (FD/LS) housekeeping function. The BBC also is capable of performing all of the moding and some of the computational and housekeeping functions of the FCC when it has control of the bus.

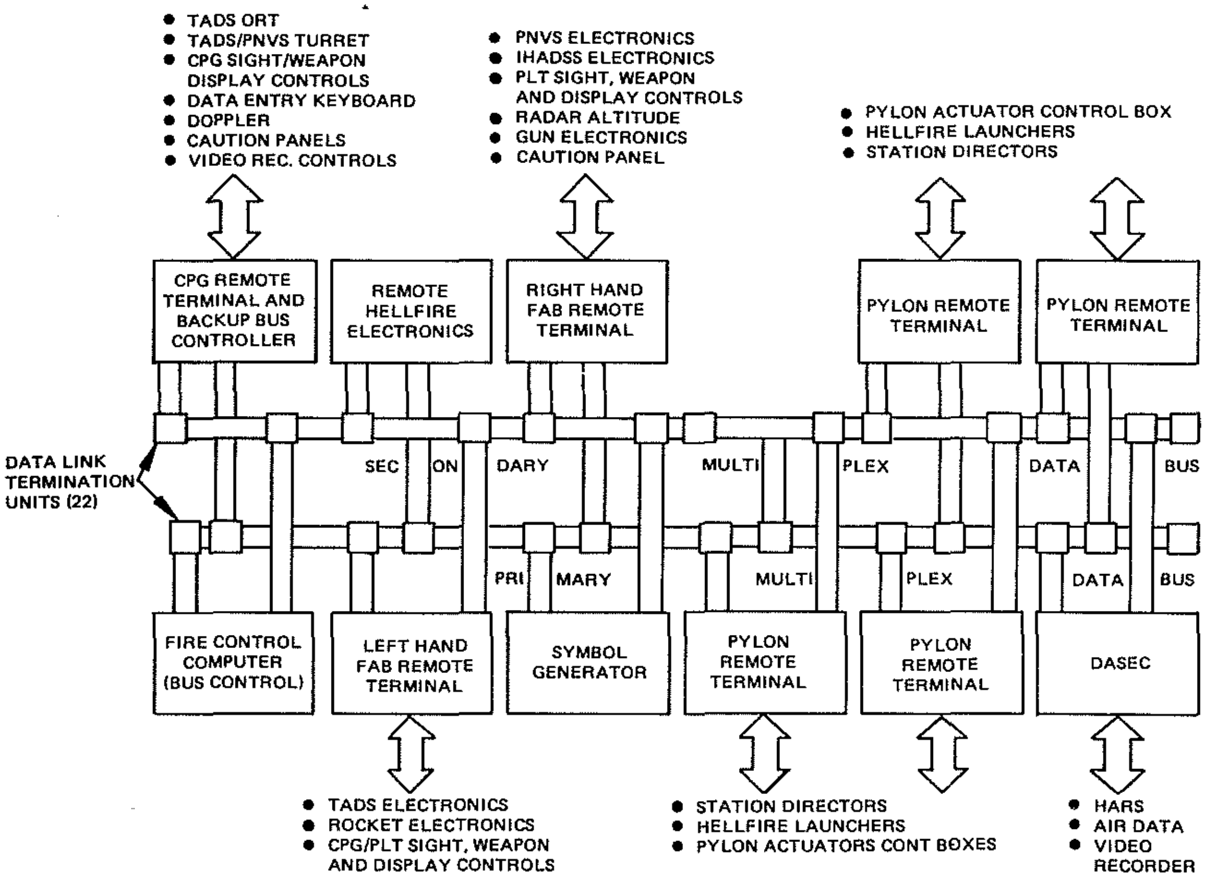


Fig. 13. AH-64 Multiplex System Block Diagram

The distributed digital control system has several advantages over the single (or central) computer approach. It allowed subsystem contractors maximum flexibility to autonomously work out individual organic software design. In a system where numerous companies provide hardware, this approach presented a lower risk development by alleviating significant scheduling problems emanating from the rigid software design interfaces which must be established at the outset of development when all subsystems share one central computer.

During development, many of the embedded computers were in a programmable state in order to maintain the flexibility for design updating. In production they have been converted to read-only-memory to eliminate field management of software tapes.

To assure that the hardware and software design and integration was accomplished with a minimum of risk, HHI developed a Mission Equipment Development Laboratory (MEDL) which was dedicated to hardware and software integration, test, and evaluation prior to air vehicle integration and flight tests. The MEDL includes a complement of bench test capabilities and a Mission System Simulator (MSS) which is, in essence, a hot mockup of the AH-64 used to exercise total system capabilities. Additional features of the MEDL include: non-real time data generation, real-time data simulation, scenario programs and sensor models employed through a host computer system. All subsystems are evaluated and software interfaces resolved in the MEDL prior to integration into the prototype aircraft.

In summary, the APACHE armament subsystems are integrated through a full solution digital fire control system. The design philosophy is predicated on distribution of digital capacity with imbedded subsystem microcomputers to simplify system design and provide maximum flexibility for future growth. The principal subsystems contributing to the fire control system include the TADS and IHADSS for sighting and weapon control, a high-speed hybridized fire control computer, a lightweight Doppler navigator, a strap-down inertial heading and attitude reference unit, a three-axis air data sensor and mode control electronics for the HELLFIRE missile. These subsystems communicate through a dual redundant multiplex bus. Kalman algorithms have been developed to improve accuracy of ballistic weapons, to reduce navigation errors and to improve targeting response time.

These design features along with the aircraft's performance, survivability mission flexibility and growth capability will provide the U.S. Army with a total weapon system designed for the '80's and beyond.

SURVIVABILITY

Battlefield survivability will be a challenge to all aircraft in the high threat environment. The AH-64A is the most survivable helicopter ever built. This survivability is achieved through the use of advanced technology, high strength materials, optimized weapons lethality, maximum stand-off ranges, and doctrine and tactics designed for the modern battlefield. The demanding design requirements for flight maneuverability and agility, ballistic tolerance, system redundancy, crashworthiness and reduced detectability give the APACHE the ability to support the ground commander under the most demanding combat conditions.

The AH-64A has very low detectability because of reduced aural, visual, radar and infrared (IR) signatures. Low flicker main and tail-rotors, low-glint canopy, compact design, IR suppression, and special infrared paint result in low signatures across the spectrum. (Figure 14)

The Aircraft Survivability Equipment (ASE) suite consists of a passive radar warning receiver, IR jammer, chaff dispensers, and a radar jammer and laser detector. The ASE enables the APACHE to stand and fight while rendering threat sytems ineffective.

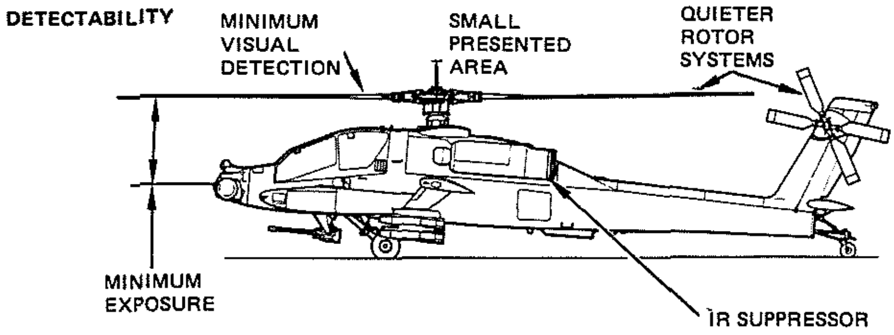


Fig. 14. Detectability

The AH-64A is ballistically tolerant as a result of twin engines, redundant flight controls, armor protection, ballistically tolerant components, self-sealing fuel cells and a blast shield separating the crew compartments.

The fuselage is a conventional semi-monocoque aluminum strucure designed to survive hits by 12.7mm and 23mm ammunition. All components of the drive system can operate for at least 30 minutes after taking a 12.7mm hit. (Figures 15, 16, 17, 18) In laboratory tests, most components have been shown to have the capability to operate for much longer periods. The main rotor is designed to operate for at least 30 minutes after taking a 12.7mm hit. In a laboratory test, one rotor blade operated for 5 hours after such a hit. Figure 19 depicts damage from a 23mm HEI round. Despite the damage, sufficient life remains to permit continued flight and a safe landing. Combat damage to either of the redundant lubrication systems of the main gearbox can be accepted and flight continued. In addition, the main gearbox has been operated for 1 hour following complete loss of oil. The intermediate and tail gearboxes are grease lubricated to provide continued lubrication and operation following impact by a 12.7mm round. The main rotor hydraulic actuators have a dual tandem configuration consistent with the APACHE's dual hydraulic system. In addition, these actuators are invulnerable to a 12.7mm round.

The crew of two is seated in tandem with the pilot aft and the copilot/gunner in front. Lightweight boron carbide/Kevlar armor shields are provided on the cockpit floors and sides. The cockpits are separated by armor plating and a transparent blast shield offering protection against 23mm fragmentation particles. (Figure 20) The fuel tanks are designed to survive 23mm projectiles. The primary hydraulic control system is ballistic tolerant to 12.7mm hits and, in the event of primary control system failure, the system switches to the secondary fly by wire control system.

CRASHWORTHINESS

Crashworthiness is designed into the APACHE to protect both the crew and aircraft in the event of an accident and ensures crew survival of a 42 feet-per-second vertical crash impact. The rugged construction and innovative design features that contribute greatly to an expected low attrition rate also help to assure that both crew and helicopter can reenter combat, promoting overall fleet survivability and life cycle cost savings. (Figure 21)

Tested and proven design features include high strength, armored, energy absorbing crew seats; a redundantly supported static mast and main transmission; a crashworthy fuel system; and a trailing-arm, energy-absorbing main landing gear. The chain gun turret is designed to safely collapse in the event of a crash-landing.

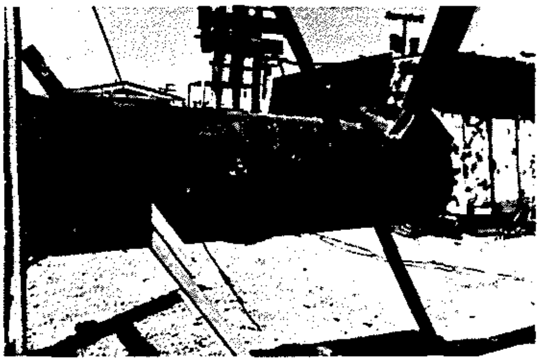


Fig. 15. 23mm Hit on Tailboom

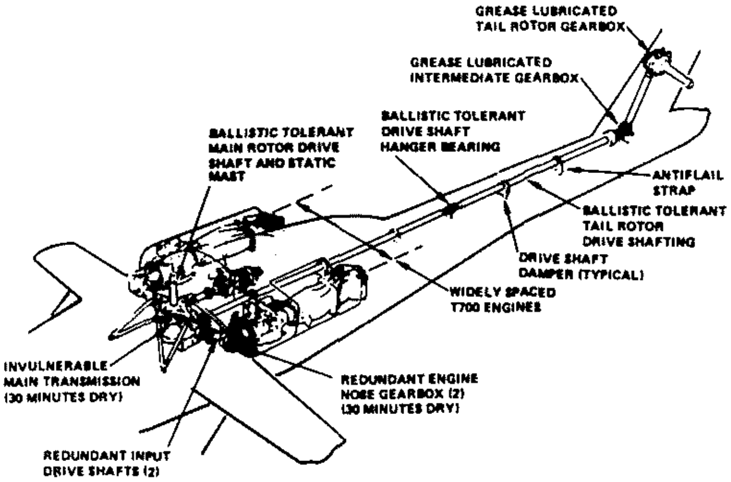


Fig. 16. Drive System Schematic

In a 42 ft/sec crash, the landing gear and fuselage crushing attenuate the crash to 37g at the fuselage floor. The crew seats then attenuate the 37g at the fuselage floor to a livable 13g acceleration of the crew seat occupant.

RELIABILITY, AVAILABILITY, MAINTAINABILITY

The APACHE, the most reliable and maintainable attack helicopter ever developed, meets the Army defined requirements, resulting in increased combat mission availability. Close attention was given to RAM during the design and development of the AH-64A. Maintenance requirements have been significantly reduced over current attack helicopters. (Figure 22)

Reliability was a major objective in the design of the AH-64A. As a result of that effort it has a greater than 95 percent probability of successfully completing its assigned mission. High component reliability is reflected in the low maintenance requirements of the system. Despite the increased capability and number of sytems on board, maintenance requirements have been reduced to less than half that of present attack helicopters.

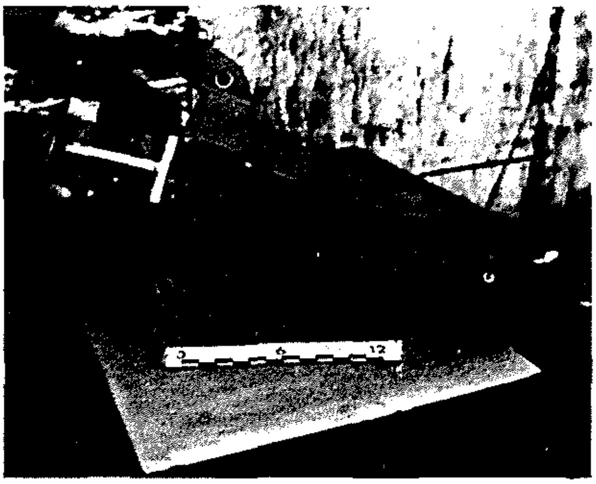


Fig. 17. 12.7mm Hit on Pitch Housing

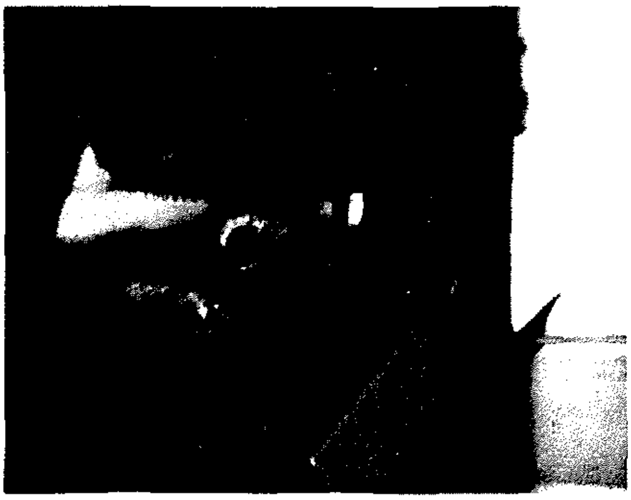


Fig. 18. 12.7mm Hit on Tail Rotor Hub

Maintainability in the combat environment was considered during the design of components for the AH-64A. The fixed rotor-mast design permits main transmission or drive shaft removal without affecting the main-rotor installation. Built-in maintenance platforms, quick removal fairings and large removable panels provide access to components. Maintenance requirements are further reduced by using grease lubricated intermediate and tail-rotor gearboxes, and elastomerics in the rotor head. The low mean-time-to-repair is supported by using the built-in fault detection equipment which rapidly identifies and isolates any system problems to a Line Replaceable Unit for replacement or repair.

Fig. 19. APACHE Main Rotor Blade

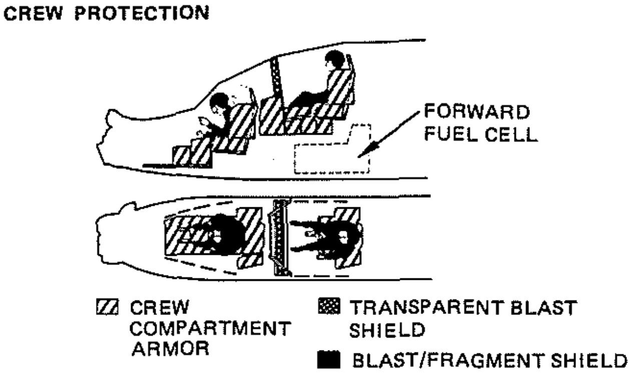


Fig. 20. Crew Protection

The onboard Fault Detection/Location System (FD/LS) capability has been integrated into the multiplex system to detect and isolate electrical and electronic failures. Fault processing, control and data storage are performed by the active bus controller while the remote terminals are used for signal conditioning and data transfer. By means of keyboard entries, flight or maintenance personnel can command a particular subsystem checkout or run a complete end-to-end aircraft checkout. Failed units are identified alphanumerically on the TADS display. The present system fault detects and isolates 69 aircraft replaceable units.

The TADS and PNVS reliability and maintainability are key design criteria. Subsystem reliability is enhanced by utilizing designs based on previously proven engineering prototypes or field systems. Solid state electronics and microprocessors are used to the maximum extent possible to increase subsystem reliability. The systems include built-in-test equipment (BITE) to allow system go/no-go verification and to fault isolate the failed line replaceable unit on board the aircraft without the necessity for ground support equipment (GSE). In

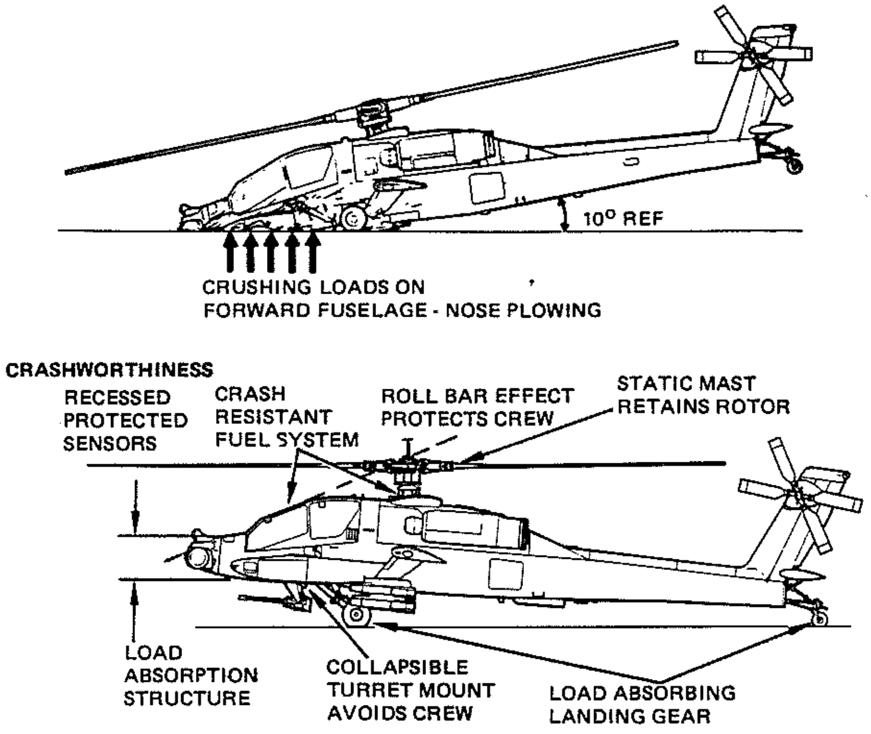


Fig. 21. Crashworthiness

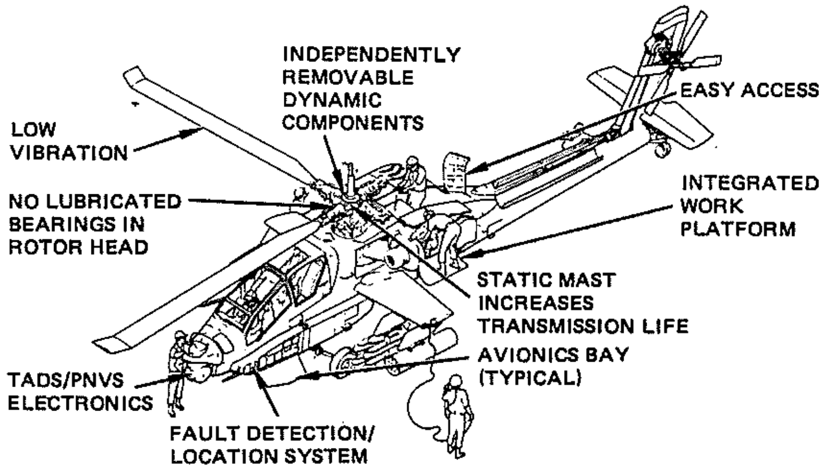


Fig. 22. Easy Maintainability

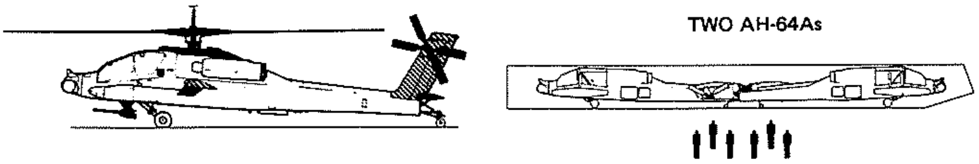
addition, provisions have been incorporated to allow further fault isolation once the unit is in the repair shop. These features will ensure that the systems can be supported in the field.

In keeping with Army Material Maintenance Concept and Policies, the on-condition maintenance concept is used extensively throughout the AH-64A. Parts will be replaced when condition or wear indicates, thereby providing full life utilization of components and eliminating unnecessary maintenance. The end result is greater aircraft availability at lower cost. The APACHE has a high degree of self-supportability provided by rapid access to systems, functional equipment grouping and an on-board APU power source. The on-board APU provides power for engine starts and maintenance checks, reducing ground support equipment requirements.

TRANSPORTABILITY

The AH-64A is capable of rapid strategic deployment worldwide and is air transportable in C-130, C-141 and C-5 aircraft. One APACHE can be carried in a C-130, two in a C-141 and six in the C-5A. Air transport preparation time varies with the lift aircraft involved. For maximum transportability the main rotor blades, rotor mast and hub, tail rotor, stabilator, weapons platforms and 30mm weapon, may be readily removed. Six APACHEs may be prepared for C-5A transport in 6 hours. All the preparations for air transport can be accomplished within the Army's elapsed time requirements. Preparation for flight is a simple reversal of the process. (Figure 23)

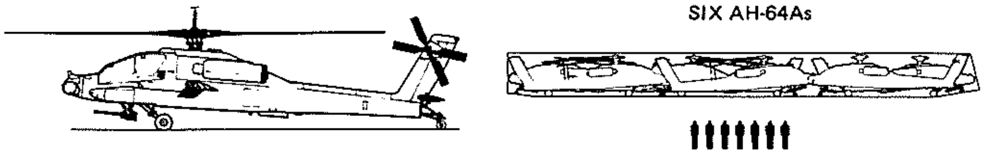
AH-64A TRANSPORTABILITY IN C-141B



■ ITEMS REMOVED
▨ ITEMS STOWED

● TOTAL ELAPSED TIME – 3 HOURS/AC
● TOTAL MANHOURS – 36

AH-64A TRANSPORTABILITY IN C-5A



■ ITEMS REMOVED
▨ ITEMS STOWED

● TOTAL ELAPSED TIME – 1 HOUR/AC
● TOTAL MANHOURS – 42

Fig. 23. Transportability

SELF-DEPLOYABLE

Auxiliary fuel tanks provide self-deployment for the APACHE for an 800 + nautical mile ferry range in a 20-knot headwind with a 45-minute fuel reserve at maximum flight speeds.

Within a theater of operation, the APACHE is easily deployable on internal fuel only. Rapid deployment, whether by Air Force transport or self-deployment, makes the APACHE an important element of our strategic forces worldwide.

ENGINEERING FLIGHT TEST

The development and qualification of the AH-64A required an extensive flight test program as illustrated in the chart below. As of 27 June 1983, a total of 4386 flight hours were logged on five prototype air vehicles by Hughes Helicopters, Inc. and the U.S. Army. The chart shows flight time devoted to each major development task as well as a breakdown of flight hours by air vehicle (AV02, AV03, etc.). AV02 and AV03 were the original prototypes fabricated during Phase 1 of the development program. The remaining three aircraft were fabricated following the award of the Phase II development contract to Hughes Helicopters, Inc. in December 1976. (Figure 24)

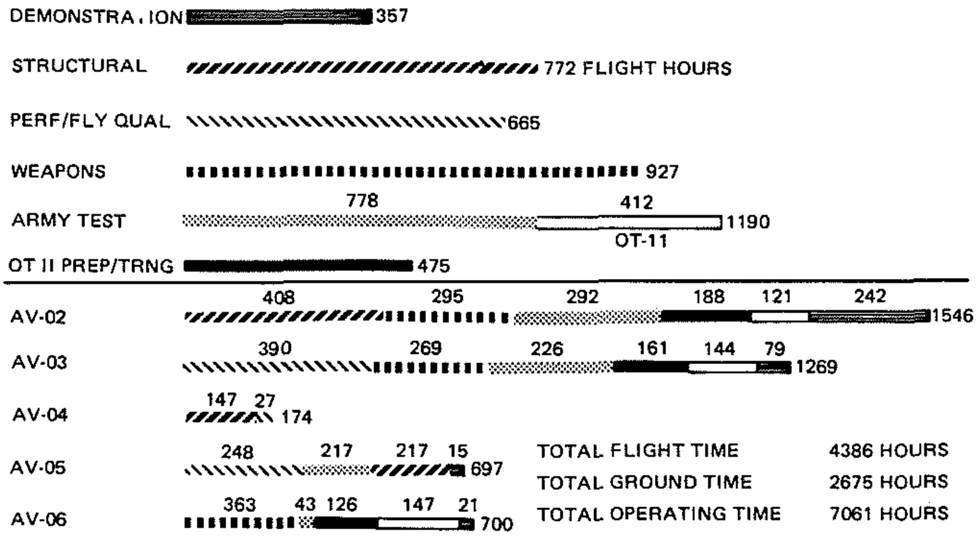


Fig. 24. YAH-64 Flight Testing

OPERATIONAL TEST

The purpose of Operational Test II (OT-II) was to prove the operational capability of APACHE in a combat environment while being maintained and flown by Army personnel. System specification requirements were to have three air vehicles flying for a total of 360 hours over a 3-month period (31 May 1981 through 28 August 1981). The prime objective of OT-II was to asertain if the reliability, availability, and maintainability (RAM) parameters of the Army decision coordinating paper (DCP) requirements could be achieved. Table I gives some insight to the activity of each aircraft during this operational evaluation.

TABLE I. OPERATIONAL TESTS — AIRCRAFT UTILIZATION

AIRCRAFT	FLIGHT HOURS	ORDNANCE EXPENDED		
		30MM	2.75 ROCKETS	HELLFIRE
AV02	121.4	10	7	4
AV03	144.4	300	0	2
AV06	146.6	35	26	6
TOTAL	412.4	345	33	12

The RAM data represents the systems as tested in an environment which was the most representative of the operational test environment and provides insight as to the level of expected YAH-64 reliability, availability and maintainability.

RAM data was collected for a period of 3 months commencing 31 May through 28 August 1981. Initial actions were in preparation for the flight from Castle Dome, Arizona to Fort Hunter-Liggett, California, with final actions occurring at the end of OT-II. A total of 412 flight hours was accumulated during OT-II on the three aircraft. Appropriate RAM incident reports were merged to form the scored data base on 513 scheduled and unscheduled RAM incidents (505 unscheduled, 8 scheduled). The Army scoring conferences concluded that 445 of the unscheduled maintenance actions were chargeable maintenance time against the systems. Of the total unscheduled maintenance actions, 149 were scored as changeable system failures. Maintenance was performed by Army crew personnel, unit (AVUM), intermediate (AVIM) and contractor depot level personnel during the test.

Although AV02 and AV03 were not of the latest YAH-64 airframe development configuration, AV06 was, and closely approximated the production design. Since AV06 more closely approximated the production configuration, it exceeded the combined RAM results of AV02 and AV03 by up to 57% (the highest being in the areas of mission reliability and maintenance manhours per flight hour).

Table II depicts a comparison of RAM results (after the initial assessment conference) between the AV02-AV03 and AV06 configurations.

PRODUCTION

The AH-64A APACHE is a fully qualified system in production for the United States Army. The development and qualification program which resulted in the production program is the most thorough ever conducted for a helicopter weapon system. The production contract for the first 11 APACHEs was signed on 15 April 1982 with the first aircraft scheduled for delivery to the U.S. Army in February 1984. The following figure shows the delivery schedule for the currently planned 515 APACHE. (Figure 25)

TABLE II. OT-II RAM STATUS AFTER ASSESSMENT

	MN REQUIREMENT	OT-II (412.03) STATUS
MISSION RELIABILITY (MTBF)	19.5	
AV02 and AV03		24.00
AV06		37.50
SYSTEM RELIABILITY (MTBF)	–	
AV02 and AV03		2.69
AV06		2.90
MAINTENANCE MAN-HOURS/FLT HOURS (AVUM AND AVIM)	8.0 - 13.0	
AV02 and AV03		4.818
AV06		3.061
MEANTIME TO REPAIR (ARS)	0.9	
AV02 and AV03		1.386
AV06		1.340
OPERATIONAL AVAILABILITY	0.75 - 0.80	
AV02 and AV03		73.35%
AV06		83.2%

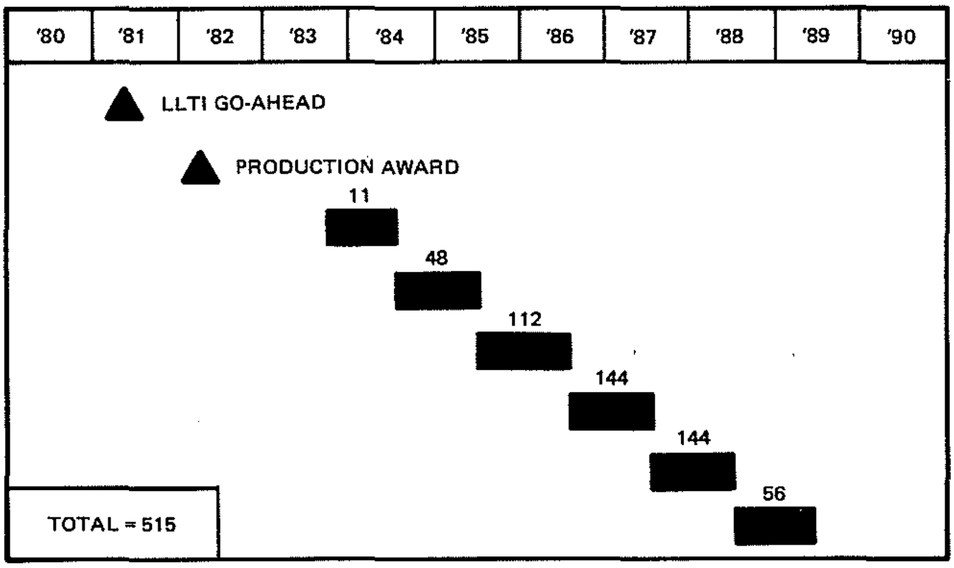


Fig. 25. Calendar Years