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AAH
UTTAS
COMPETITION

UNITED STATES ARMY

MAY 1976

AVIATION DIGEST

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MAY 1976 VOLUME 22 NUMBER 5

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ABOUT THE COVER

The cover is a composite of the UTTAS and AAH contenders. The Army will be weighing the data obtained from comprehensive tests of these aircraft before selecting winners. This issue contains the points of view of the UTTAS and AAH contenders (see pages 2, 3, 4 and 5). Also see page 1 for GE's story on its T700 engine and the inside back cover for coverage of HELLFIRE. Cover art by Doug Carter

The mission of the *U.S. ARMY AVIATION DIGEST* is to provide information of an operational or functional nature concerning safety and aircraft accident prevention, training, maintenance, operations, research and development, aviation medicine and other related data.

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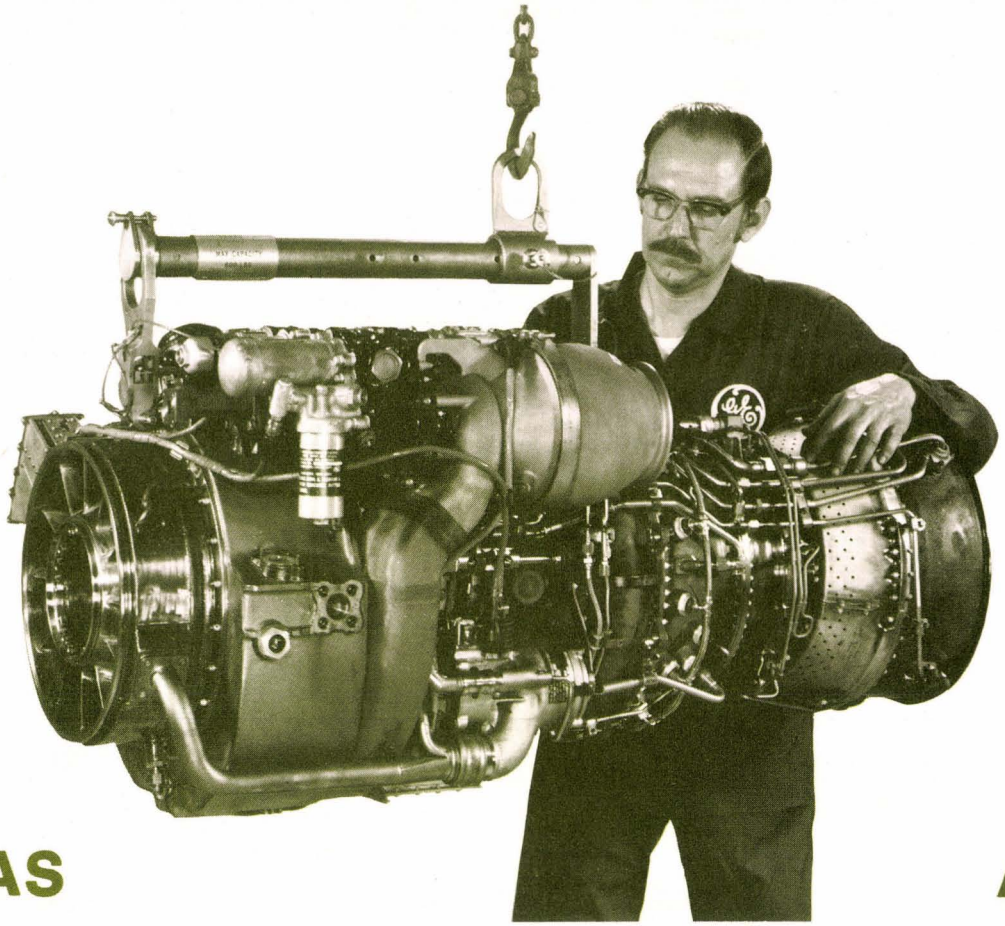

UTTAS **AAH**

T700

The Army's Engine of the 80s

Prepared By
General Electric Company

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ONE OF THE heroes of the Vietnam action was the UH-1 helicopter. The Huey, as it is usually called, made the combat Infantryman the most mobile fighting man in the world. The Huey did its job, and did it well. But times change and the Huey is being replaced by the more maneuverable, faster, more reliable Utility Tactical Transport Aircraft System, the twin engine UTTAS, and its complementary vehicle, the Advanced Attack Helicopter, AAH.

In its charge to the competing airframers (Boeing-Vertol and

Continued on page 6

UTTAS —— UTILITY TACTICAL YUH-60A

Prepared By
Sikorsky Aircraft

This article represents the manufacturer's concept of its product and in no way reflects on the status of evaluation or on a final decision concerning the choice of the UTTAS contenders. A decision on the winner will be made after a comprehensive program of evaluation directed by the U. S. Army

FOR THE FIRST time in its history, the U.S. Army is going to have a helicopter — the UTTAS — that has been designed from the first line on a blank piece of paper to be truly an Army combat vehicle, with all the performance, ruggedness, crashworthiness, ballistic survivability and general suitability for the ground battlefield environment that this connotes. Until now, our airmobile troopers have had to develop their revolutionary concepts and fight a long, vicious war using off-the-shelf vehicles that were designed for logistics purposes or meant to be flown well back of the FEBA.

The airmobile concept was proven with live ammunition, however, and the lesson was learned. As a result the Army now is testing the first combat assault squad carrier that makes it possible for that key team, the Infantry squad, to enter combat in a single helicopter and thus retain vital tactical integrity.

Furthermore, the UTTAS will offer this capability even under the demanding conditions of the Army hot day (4,000 feet density altitude and 95 degrees Fahrenheit) and it will greatly enhance the tactical capability for medical evacuation, tactical lift or direct support artillery, command and control, and combat resupply.

Sikorsky's UTTAS candidate, the YUH-60A, not only meets, but in many cases exceeds the Army's demanding requirements for the UTTAS mission.

In its UTTAS Request for Proposal, the Army

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TRANSPORT AIRCRAFT SYSTEM YUH-61A

Prepared By
Boeing-Vertol Company

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ABOVE THE BEST truly reflects the spirit of the dedicated men and women who have contributed to Army aviation and nurtured it from its humble beginnings on 6 June 1942 up to its honored place today as a full member of the Army team.

While "Above The Best" signifies Army aviation's contribution in providing support to the ground Soldier it could also signify the objective of constantly striving to give the Army better, more effective equipment than has been provided in the past. Each new generation of equipment is naturally required to be better than the equipment preceding it. In furtherance of this philosophy the United States Army has embarked on one of the most exciting and effective new aviation system development programs in its long illustrious history. This program is the Utility Tactical Transport Aircraft System.

The UTTAS is unique in its development antecedents because it is the first new helicopter to be developed by the Army since the early 1960s. This fact is significant because no previous helicopter has been developed with the advantage of the millions of hours of flight operations and intensive combat experience the helicopter gained as a design basis during hostilities in the Replublic of Vietnam. While valuable improvements have been made to current helicopters these are essentially modifications to the basic technology of the 1950s or earlier. The Army judiciously concluded that with our vast increase in

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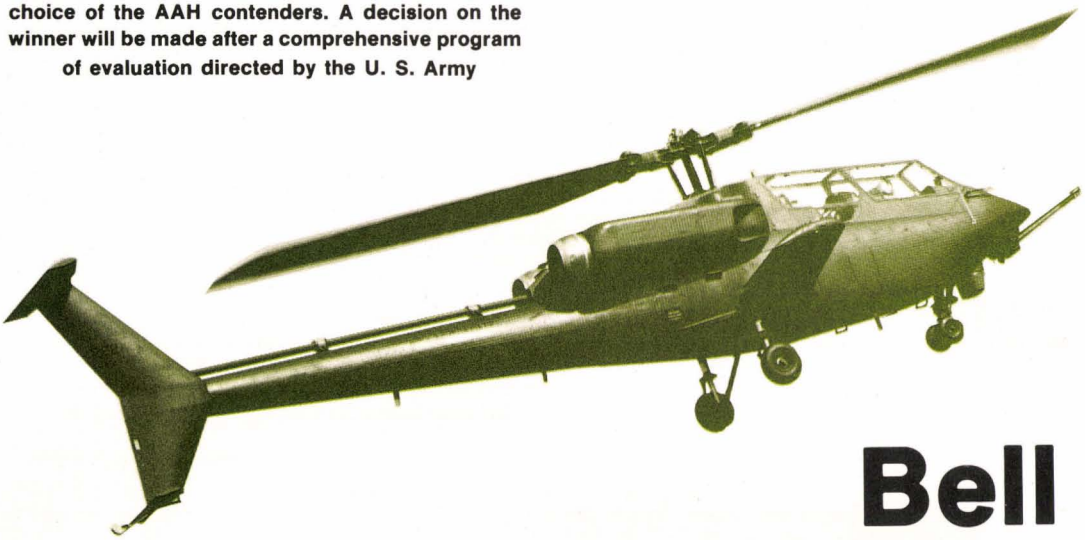
This article represents the manufacturer's concept of its product and in no way reflects on the status of evaluation or on a final decision concerning the choice of the AAH contenders. A decision on the winner will be made after a comprehensive program of evaluation directed by the U. S. Army



Bell YAH-63

Prepared By
Bell Helicopter Textron

THE YAH-63, Bell Helicopter's Advanced Attack Helicopter (AAH), is the latest in a long line of company-designed gunships which spans more than 15 years. One primary fact sets this gunship apart from those that have preceded it: it can operate and survive in a multi-intensity [high threat] combat environment. This survivability requirement—more than any other—affected the entire design and is responsible for the way the ship looks today.

The YAH-63 has two-bladed rotors: a wide-chord, dual-spar main rotor to survive a 23 mm HEI explosive impact and a high-thrust tail rotor for sideward flight. Mast moment springs permit zero "G" flight and further improve aircraft agility. The high main rotor allows full field of fire and maximum range for all weapons but can be retracted for air transportability.

The pilot up front permits safe day/night NOE operation. The flat-plate canopy minimizes the area on the ground where sun glint can be detected. Widely spaced twin T700 engines reduce the possibility of both engines being damaged by a single hit; infrared suppressors lessen the chance of lock-on by heat-seeking missiles.

The circular cross-section tailboom tolerates internal blast of a 23 mm HEI projectile. The entire drive train survives a 12.7 mm hit without parasitic armor. The 30 mm ammunition storage container, located underneath the aircraft, is jettisonable along with wing stores. A tricycle landing gear provides excellent ground handling and uses space-age technology to absorb crash impacts.

To develop the YAH-63, Bell management formed a self-contained project team, including engineering, design-to-cost, system engineering management, integrated logistic support and contract administration personnel. This team blended all of the design concepts into an optimized weapon system that could be developed on schedule, procured within cost restraints, meet performance specifications and have the lowest possible operating cost.

MISSION REQUIREMENTS: The YAH-63 is designed to provide direct aerial fire support as an integral part of the land combat force with the primary task of defeating armor during day, night and varying weather conditions. Operating in all intensities of conflict, this aircraft can tolerate a single hit by a 12.7 mm API projectile; furthermore, the design minimizes damage effects to all critical systems from a 23 mm HEI projectile and considers the infrared-homing missile threat along with other API and HEI projectiles. No aircraft, regardless of its maneuverability, can hope to avoid all projectile impacts. That is why the YAH-63 has been built to withstand battle damage and continue to operate.

Recognizing the importance of the mission and

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This article represents the manufacturer's concept of its product and in no way reflects on the status of evaluation or on a final decision concerning the choice of the AAH contenders. A decision on the winner will be made after a comprehensive program of evaluation directed by the U. S. Army

Hughes YAH-64

Prepared By Hughes Aircraft Company

WHEN THE U.S. Army announced the Advanced Attack Helicopter competition in late 1972, Hughes Helicopters was in a position to make a significant contribution to the program. As a result of the OH-6A Kiowa success in extensive combat nap-of-the-earth operations, we had a full appreciation of the significance of aircraft agility (i.e. lightweight).

Our research work and design of the New Initiatives Aerial Scout program had provided us with firsthand experience in the design, system integration and operation of day/night advanced visionics and avionics. We also had designed and installed a TOW missile system for the OH-6A and demonstrated successful firings. Optic IV, a Hughes developed night scout helicopter, had successfully demonstrated outstanding capabilities during day and night operations of more than 1,200 hours. Optic IV systems include both target acquisition and navigation capabilities for 24-hour operation.

The Hughes Helicopters Ordnance Division, under the same roof as the Helicopter Division, with extensive expertise in installing gun and missile systems in aircraft had just created in late 1973 a unique machinegun that showed tremendous potential as a very lightweight, highly reliable and low-cost aircraft cannon. Designated the "Chaingun," this concept was ready for the AAH system.

Previous company supported research and design work on a twin-engined helicopter provided the engineering staff considerable exposure to the detail design of dynamic components in the size range that would be required for the AAH. Following the cancellation of NIAS, our team was ready to give undivided attention to the AAH program. Hughes Helicopters was prepared to offer the Army an advanced attack helicopter of unusual merit.

The Hughes design philosophy is to create the smallest, lightest and most agile helicopter to meet and/or exceed the specifications laid down for an aircraft system. In following this philosophy, the OH-6A was developed for the Army to what, at that time, seemed to be an almost impossible specification. History has verified that the OH-6A, holder of 23 world records, proved beyond a doubt to be the most effective scout aircraft under the rigorous demands of the combat duty in the Republic of Vietnam. Its record of agility for NOE missions, crash survivability, maintainability and system reliability is unparalleled.

This same design philosophy is being applied to the development of the AAH. Utmost simplicity of the structural configuration, maximum accessibility for easy maintenance and servicing, low vulnerability and the greatest degree of crashworthiness, all incorporated into the smallest low-cost package, were the goals set for the development.

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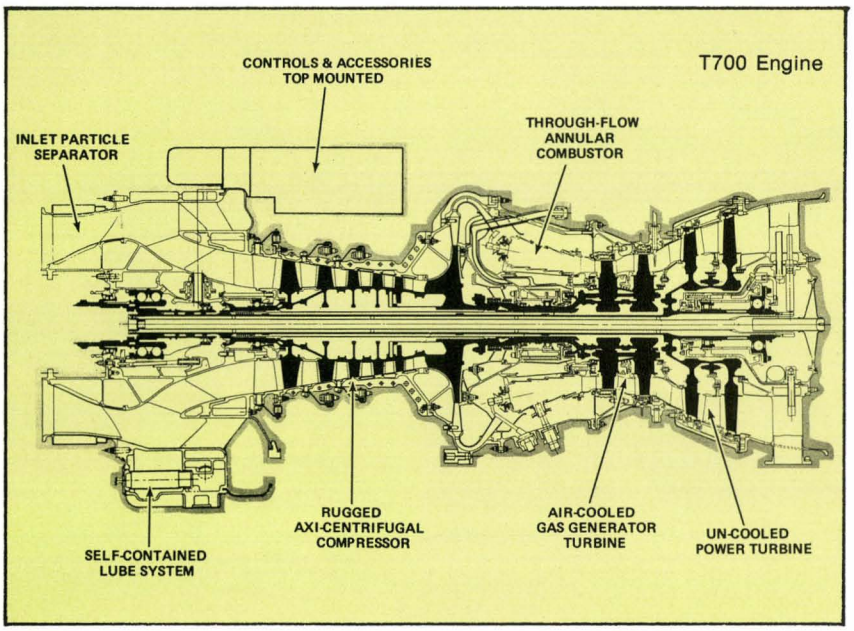


T700

Continued from page 1

Sikorsky for UTTAS; and Bell and Hughes for AAH), the Army specifically spelled out its requirements. The UTTAS has to be capable of lifting and carrying a combat-equipped infantry squad of 11 men and a three-man crew from a 4,000-foot high takeoff point on a 95 degrees Fahrenheit day with secondary tasks which include logistics support, aerial command post and ambulance service.

As for the AAH vehicle, which was initiated nearly a year later, the Army defined its mission responsibilities calling for quick, responsive, direct aerial fire as an integral element of ground forces during the day and in adverse weather. Designed to use terrain cover for fighting and survival in mid-intensity [high threat] conflict, the AAH helicopter is to be operated by a two-man crew.

Traditionally, the development of a new engine design requires longer lead times than the airframe. So even before the mission parameters had been firmed for the two new helicopter designs, the Army had set in motion its requirements for the engine that would power them. Since one of the prime objectives for the new helicopters was cost effectiveness, the Army decided at the outset that both systems would use the same engine model. The use of a common engine model for both aircraft helps achieve cost effectiveness by providing a 30 percent savings in spares and logistics cost. Other stipulated engine goals were a 40 percent decrease in engine weight and a 20 percent to 30 percent reduction in fuel consumption with improved survivability, reliability, durability and maintenance characteristics over existing engines.

In 1967, the Army issued competitive technology contracts to Pratt & Whitney and General Electric to design and build 1,500 horsepower prototype engines to demonstrate the feasibility of building an advanced technology engine for the UTTAS. By September 1971, General Electric had successfully demonstrated all of the major objectives with its GE12, demonstrator engine, and in March 1972, GE was awarded the Army's development/production contract following another competition with the AVCO-Lycoming

ENGINE SPECIFICATIONS

Maximum Diameter 15.5 In (394 mm) **Length 46.5 In (1181 mm)**

Ratings	Sea Level 59°F (15°C)	4,000 Ft (1220m) 95°F (35°C)
Intermediate Ship (Takeoff)	1543	1168
SFC	.469 (.213*)	.483 (.219)
Maximum Continuous SHP	1251	869
SFC	.477 (.217)	.513 (.233)
75 Percent Max Continuous SHP	900	652
SFC	.520 (.236)	.563 (.256)
Weight	415 Lb (188 kg)	

Shaft Speeds
Gas Generator 44,720 RPM (Rated)
Output/Shaft 20,000 RPM (Rated)
Allowed (17,000—21,000 RPM)

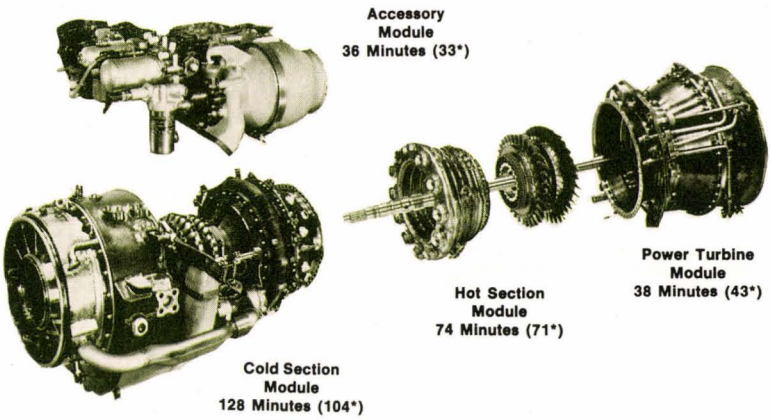
(*Values in kg/shp/hr)

and Pratt & Whitney designs.

Designated T700-GE-700 by the Army, GE's demonstrator engine aerodynamic design was retained with improvements added to reflect the needs identified by combat experience in Southeast Asia and to meet the survivability, reliability and maintainability goals set for the production engine. Since contract award, T700 engine development has gone very well. Program objectives have been achieved. The program has been consistently on schedule and costs are within acceptable margins. To date 86 engines have been shipped for Army UTTAS and AAH ground and flight aircraft.

Reliability enabled the Army to increase The inspection interval to 400 hours

In the field, three T700 engines have exceeded 600 hours of operation and a fourth engine has achieved more than 1,000 hours of operation without unscheduled removal. This demonstrated reliability and durability has enabled the Army to increase the inspection interval on the prototype flight engines to 400 hours of operation, an extremely high interval for this early in an engine program. Another achievement—one which the Army finds very gratifying—is the assurance that a single T700 engine configuration will indeed satisfy the needs of all the aircraft applications.



- Four Basic Modules
- Complete Module Interchangeability
- Module Removal/Replacement With 10 Common Tools
- No Critical Dimension/Calibration Checks At Field Level Modular Maintainability

*Assessment-August 1974 By U.S. Army Maintenance Team

Fast Economical User Maintenance
(Tasks-Elapsed Time)

What, then, is this GE T700 engine that has proved itself more than worthy of the Army's trust and confidence? The T700 weighs about 415 pounds. Although the Army specs call for 1,543 shp, the T700 has regularly exceeded 1,600 shp. Its SFC is 25 percent to 30 percent better than comparable current turboshaft engines, as required by the Army. Here again, the T700 also has bettered the Army specs. At 900 shp, which is about 60 percent of full power, the T700's SFC is 0.52 lb/hr/lb—roughly 69 gallons per hour. That's the best SFC achieved on any helicopter engine—including commercial engines currently in service, where fuel consumption is absolutely essential to profits earned.

The T700 itself is a rugged axial/centrifugal flow turboshaft engine. The gas generator is comprised of a five-axial, one-centrifugal stage compressor, annular combustor with central fuel injectors, and a two-stage gas generator turbine. Power is extracted by a two-stage free turbine, which coaxially drives a shaft at the front of the engine.

Everything about the T700's basic design is targeted to satisfy three basic requirements: cost, survivability and reliability. But they do not break off into three separate entities. All three are interrelated. For example, cost is reflected in engine commonality for many aircraft; modular construction for ease-of-maintenance; better engine reliability and so on. Survivability is one of the highest priority considerations—both of the engine and the combat personnel. The designed-in survivability characteristics also impact on cost.

The mounting of engine controls and accessories on top of the engine, for instance, makes them completely self-contained along with the lube system, which includes the tank and oil cooler. Dual lube jets in the bearings ensure reliability. The T700 control system enhances survivability by reducing pilot workload so that he may give his undivided attention to flying the mission. The control features include constant output speed control, automatic load sharing and automatic temperature limiting for

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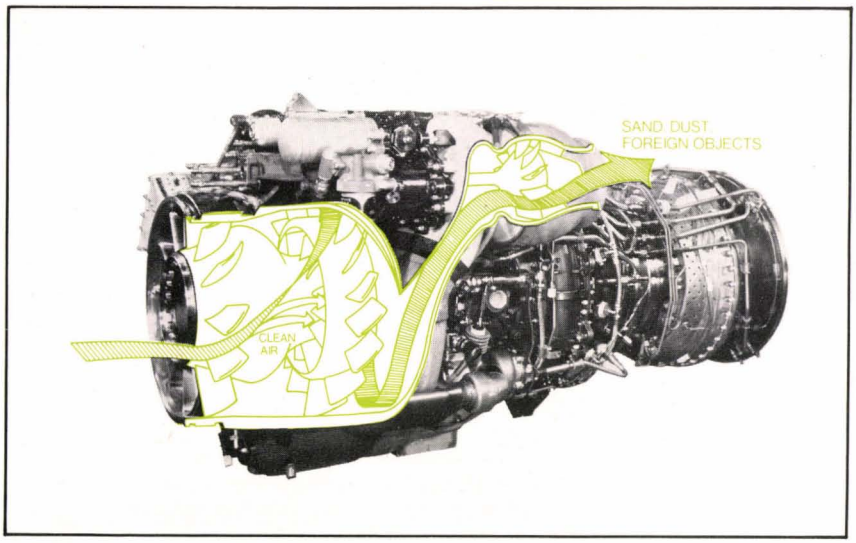


GEs inlet particle separator removes up to 95 percent of sand, dust, ice and other foreign objects

both UTTAS and AAH. Except for the dual gauges, the pilot will be able to fly the UTTAS as though he were flying a single engine aircraft. The T700 will operate with no visible smoke and low noise levels. External lines and leads have been greatly reduced and grouped to improve survivability and maintainability.

One of the great lessons learned in Southeast Asia was that something had to be done about sand and foreign object damage. They were responsible for nearly 60 percent of all unscheduled engine removals. Sand erosion was the biggest culprit. We went to work on this problem and came up with the integral inlet particle separator. It is expected to achieve up to 95 percent particle separation. The separator is fully anti-iced and contains no moving parts. All of this results in increased operational durability, reliability and survivability.

In the aircraft engine business, we are apt to talk "too easily" about one of the most important aspects of a new engine design—maintainability. Not so on the T700 program. The Army has set extremely tough goals and standards and we were able to successfully demonstrate most of the objectives in our very first test. Central to this objective is the new Army Field Maintenance Concept—a three tier maintenance program in which work is performed at (1) organizational unit, (2) intermediate and (3) depot/overhaul sites.

At the organizational level, one man can perform maintenance on all T700 engine accessories or LRUs as they are called. Only 10 of the 150 tools carried in the Army's A07 toolbox are required to accomplish them. In a typical field operation, one mechanic can perform a fuel control change in just 12 minutes. And once its changed, that's it! No adjustments, rigging, trimming or lockwiring are ever necessary.

At the intermediate level of field maintenance, the hot section can be changed in 71 minutes. In fact, all of the engine's four major modules can be changed at intermediate if necessary; the accessory module (in 36 minutes), cold section (128 minutes), power turbine (38 minutes). And the modules too all can be replaced with the 10 simple handtools.

The third level of the new Army Maintenance Concept—the Depot—handles module overhaul and repair. The payoff of T700 engine design effort is that it significantly reduces maintenance time—and, of course, costs.

Nobody sets out to build anything that's expensive to fix, but traditionally, it quite often happens anyway. That's why the Army set out to effectively reduce maintenance costs and monitored them during development to keep them at the lowest possible level. And, system reliability becomes an essential ingredient to the achievement of that goal. The attention devoted to the maintainability aspects of the T700 design results in a significant reduction in engine maintenance. By this and similar advances in the airframe, a net 54 percent reduction in maintenance manpower for UTTAS has been achieved.

Impacting most on life cycle cost is the T700's reliability. Contemporary helicopters in the UTTAS/AAH size average about 500 hours MTBFDR resulting from all scheduled and engine caused unscheduled maintenance. Removal caused by inherent component characteristics such as bearing failures, seal leakages, inspection, lubrications, replenishment and replacement of parts are chargeable to the engine. Removals due to external causes such as accidents, battle damage, operational stresses beyond design limits, crew induced maintenance, cannibalization or modification are not chargeable. On a comparable basis, the new T700 powered UTTAS/AAH vehicles will have a 1,500 MTBFDR. This translates into approximately one full year between depot maintenance actions on a typical twin engine helicopter operating 50 hours a month.

Durability of the T700 has been abundantly demonstrated in factory and field testing, which already has reached an impressive 21,000 engine hours and exceeds 170,000

component test hours. One result of the intensive development program is combustor reliability. A current generation engine combustor requires inspection, repair or replacement every 300 to 600 hours, which further results in an expenditure of 50 to 100 manhours of labor in addition to the loss of the equipment during that time. A T700 combustor already has demonstrated a life in excess of 1,000 hours In fact, every combustor built since the start of the program is still serviceable.

The T700 development program includes a high concentration of abusive and durability testing which substantiates engine maturity in advance of production. Comprehensive factory testing of critical engine and airframe supplied components was conducted to assure successful aircraft propulsion systems in advance of flight. Operation of the T700 in UTTAS/AAH ground and flight test vehicles has been excellent. Twelve flight test helicopters and four ground test vehicles have achieved more than 10,000 engine hours since field programs began in 1974. More than 2,200 UTTAS and AAH flights have been accomplished since October 1974 with an accumulated time in excess of 3,300 engine flight hours.

Accessories can be maintained Using only 10 of the 150 tools

In February the Army completed the inspection of the two T700 MQT endurance engines. Each engine had completed a required 150-hour run—a test which is 6 to 10 times more demanding than flight operations. The Army team which judged the engines performance stated that they were in "excellent condition." These two endurance tests required for model qualification are the most demanding of a series of 20 production qualification tests. The combined test series is the most rigorous helicopter engine qualification test program ever conducted. They represent a major milestone that must be completed to clear the way for the engine production phase for both the UTTAS and AAH helicopter systems.

In addition to the endurance tests, the qualification test phase included a low cycle fatigue test which simulated typical long term Army flight service; a series of severe environmental tests, including hot and cold starting; sand, ice and bird ingestion; salt corrosion and overtemperature/overspeed requirements.

Another achievement of the T700 program was the retention of a single engine configuration for all applications. The T700 remains interchangeable in all four UTTAS and AAH aircraft systems.

To ensure maximum engine reliability before full production begins, the Army has contracted with General Electric to conduct accelerated testing programs beyond MQT. Purpose of the tests is to identify possible improvements before engine production begins and aircraft are deployed. This maturity program will significantly increase early operational reliability and reduce the risk of unexpected hardware changes.

All in all, the General Electric T700 powerplant is performing to every standard set for it. And we at General Electric take pride in the fact that we have been able to deliver everything that is expected of us and more.

GLOSSARY

AAH	Advanced Attack Helicopter
AP	ammunition point
API	armor-piercing incendiary
APU	auxiliary power unit
ARCS	Aerial Rocket Control System
ASE	automatic stabilization equipment
ATE	Advanced Technology Engine
BIM	blade inspection method
CLGP	cannon-launched guided projectile
DSARC	Department of Defense Systems Acquisition Council
DTC	design-to-cost
ESR	electro slag remelt
FEBA	forward edge of the battle area
FLIR	forward looking infrared
GCT	Government Competitive Test
GLLD	ground laser locator designator
GTV	ground test vehicle
HEI	high explosive incendiary
HELLFIRE	Helicopter Launched Fire and Forget
HMMS	HELLFIRE Modular Missile System
IFR	instrument flight rules
IR	infrared
LCC	life-cycle cost
LOAL	lock-on after launch
LRUs	line replaceable units
MAVERICK	TV guided air-to-surface missile
Medevac	medical evacuation
MQT	model qualification test
MTBFDR	mean time between failure for depot repair
MTBR	mean time between repair
NIAS	New Initiative Aerial Scout
NOE	nap-of-the earth
psi	pounds per square inch
R-C	remote control
R&M	reliability and maintainability
RF/IR	Radar frequency/infrared seeker
rpm	revolutions per minute
SFC	specific fuel consumption
shp	shaft horsepower
STA	structural test article
TADS	Target Acquisition Designation System
TLS	Tactical Landing System
TOW	tube-launched, optically-tracked, wire-guided
UTTAS	Utility Tactical Transport Aircraft System
VASCO X-2	type of high-hot hardness steel, originally used for tool steel

YUH-60A

Continued from page 2

wisely established bands of performance, as well as specific points of performance to be met. At Army hot day conditions — 4,000 feet, 95 degrees Fahrenheit—the vertical rate of climb band using 95 percent of power is 450 to 550 feet per minute. The YUH-60A will achieve 470 feet per minute. The mission cruise speed band is 145 to 175 knots. The YUH-60A cruises at 148 knots and has a dash speed of 165 knots.

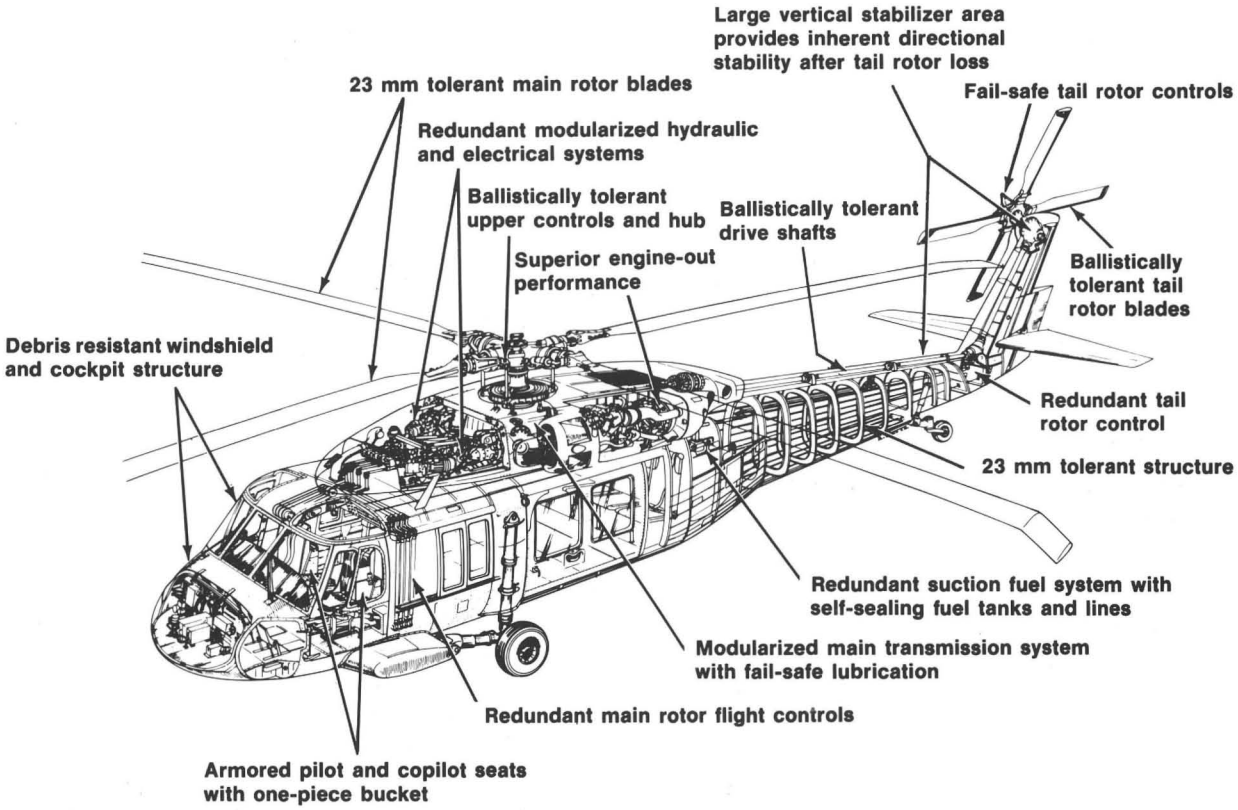
The dash speed is achieved at the expense of endurance, but the YUH-60A still has the additional fuel capacity to meet the key performance requirement of 2.3 hours of endurance at design gross weight, even at high speeds by reducing the payload or taking advantage of the allowable overload gross weight. These are tradeoffs, of course, but Sikorsky has chosen to design its YUH-60A to emphasize those characteristics that contribute most to the operationally important performance parameters for nap-of-the-earth flight while keeping others inside the bands.

The YUH-60A has repeatedly demonstrated its maneuverability and control response in nap-of-the-earth flights that have included 90-degree bank angles and 3.0 "G" loads.

Other achievements of our test program, which involved a total of 603 hours and 823 flights, have been similarly impressive.

The YUH-60A has flown at speeds of 147 knots in level flight at a gross weight of 20,000 pounds, 172 knots at sea level, standard conditions and up to 195 knots in a slight descent. It has flown at a gross weight of 21,400 pounds (mission gross weight is 16,580) and reached a service ceiling of 19,800 feet, exceeding the Army requirement of 17,500 feet. Speeds of 40 knots have been attained in right, left and rearward flight and external loads up to 7,000 pounds, the book rating, have been carried. Power off autorotative landings and landings on slopes with angles ranging up to 17 degrees have been demonstrated, and the airborne and ground elements of the TLS have been successfully evaluated.

From the outset, our design philosophy has been simple — give the Army what it needs, a combat helicopter that can perform its missions safely and efficiently under any atmospheric conditions, altitudes



Sikorsky Aircraft's YUH-60A is designed to survive a 42 foot-per-second vertical crash. Diagram shows some of the safety features included in the YUH-60A

Refer to Glossary on page 9

and temperatures likely to be encountered anywhere in the world.

We believe we have succeeded.

By taking maximum advantage of the latest advances in rotary wing technology and combining them with our own experience as a designer and manufacturer, we have developed a simple, easy to produce helicopter that offers high performance, increased reliability, reduced maintenance and high survivability all in one package.

There are no warmed over components in the YUH-60A, yet all are laboratory and flight proven.

Designing and building the YUH-60A also gave Sikorsky an excellent opportunity to take advantage of the great progress made during the last decade toward improving the reliability and maintainability of components and systems. This new R&M technology has been integrated in the YUH-60A.

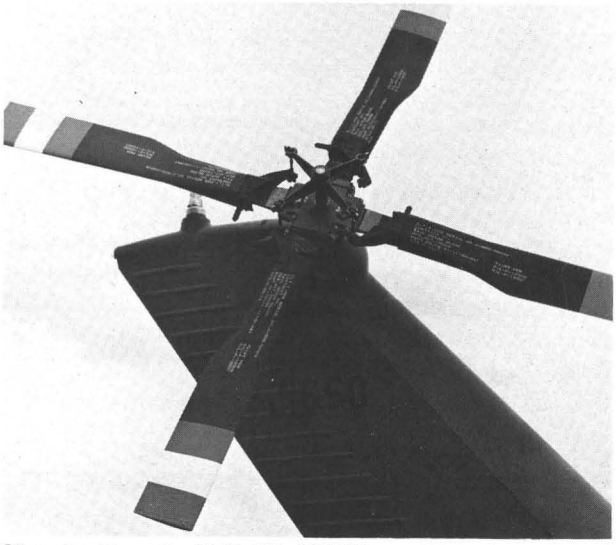
We have eliminated many of the past troublemakers such as seals, short-lived blades and lubrication requirements and where maintenance items couldn't be eliminated, we simplified them and extended the intervals.

Periodic inspections on the YUH-60A, for example, are 500 hours. This is a helicopter for the combat Soldier and the Army mechanic in the field. It will live and fight with him in his hazardous environment and provide him with the best in battlefield staying power and mobility.

The YUH-60A is equipped for example with corrosion-proof composite main rotor blades that have a titanium rather than aluminum spar and a tough fiberglass skin. These blades — with their replaceable aft-swept tips, high twist and advanced airfoils — improve hover capability, rate of climb, high speed performance, safety and maintainability. They also reduce noise and vibration, provide greater inflight stability and give unprecedented ballistic tolerance. Tests have shown that the YUH-60A main blades can provide as much as 100 hours of safe flight after being hit by 23 mm HEI projectiles.

These blades also are equipped with Sikorsky's BIM system for monitoring and confirming structural integrity. This system uses a gauge that changes color if there is a loss of pressure inside the sealed and pressurized spars. The blades are completely interchangeable and pre-tracked to simplify replacement, which can be done in minutes and without tools. The entire main rotor head, in fact, can be removed quickly and easily with the tools found in a mechanic's standard toolkit.

The YUH-60A has a fully articulated, aerodynamically clean main rotor with a ballistically tolerant, one piece titanium hub and elastomeric bearings that need no lubrication or seals, give greatly extended service life, use fewer parts and cut maintenance by up to 60 percent. These bearings, which consist of a stack of rubber laminates, provide all required flap, lag and pitch change motions by incremental deflection. They are field replaceable. The main rotor also is equipped with a unique self-tuning bifilar vibration absorber that reduces vibration, maintenance and crew fatigue while at the same time improving the reliability of the avionics, engines and airframe.



Sikorsky Aircraft's YUH-60A UTTAS candidate is equipped with a simply designed tail rotor that has no bearings, needs no lubrication and is corrosion proof, and has 87 percent fewer parts than a conventional tail rotor. All blade flap and pitch change motion is provided by deflection of the flexible graphite epoxy spars, which are continuous members running from the top of one blade to the tip of the other

The rotor system on the YUH-60A is so stable that IFR flights can be conducted without the automatic flight control and stability augmentation systems in operation.

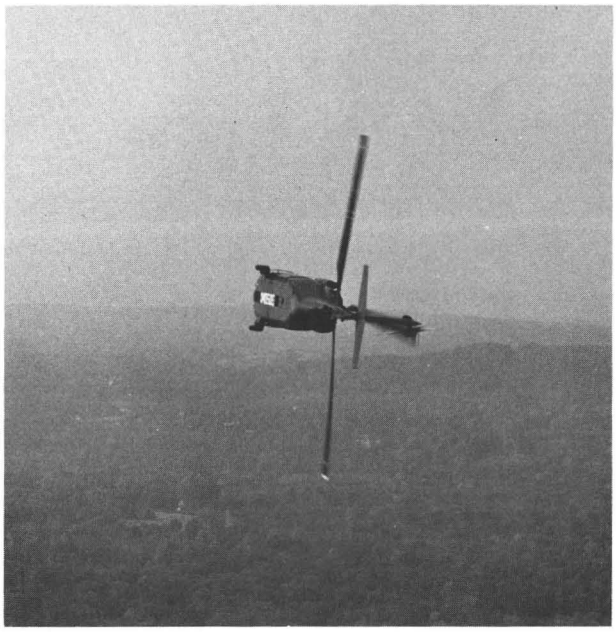
The YUH-60A is equipped with an automatic horizontal stabilator that improves maneuverability and ease of handling in all regimes of flight, including high speed and low, slow nap-of-the-earth missions. It also features a virtually maintenance-free bearingless tail rotor that needs no lubrication, is corrosion proof, and has 87 percent fewer parts than a conventional tail rotor.

The tail rotor has two other unusual features. It is inclined upward 20 degrees and is mounted on the right side of the tail pylon. The inclination gives an increase in lift while the right side location allows for closer mounting, a shorter tail gearbox housing and easy accessibility for maintenance.

The transmission system on the YUH-60A, which is rated at 2,800 horsepower has been designed with safety, reliability and maintainability in mind. It is com-

pletely modularized so that if a problem occurs in one module, it can be replaced without contaminating the entire system. Four of the five modules are completely interchangeable and all have separate chip detectors. The gears and bearings are oversize to increase life, the input and accessory modules are interchangeable, the number of exposed oil lines is minimized and two oil pumps are used.

The gearbox is designed to operate a minimum of 30 minutes after losing all oil, but it has performed successfully under flight load conditions in lab tests for more than an hour after the oil was drained.



Sikorsky Aircraft's YUH-60A has demonstrated 90-degree bank angles and high roll rates that will provide the agility and maneuverability for effective nap-of-the-earth operation

The stability augmentation system is another unique feature of Sikorsky's YUH-60A. Based on research done by the Army this system uses a simple fluidic sensor and amplifier to sense aircraft disturbances and apply control corrections. This fluidic unit completely eliminates the gyros, amplifiers and other electronic hardware used in older designs. The system has no electrical connections and operates even after a total electrical system failure. It also is unaffected by generator switching transients or electromagnetic interference. Furthermore, it has no moving parts and the manufacturer is guaranteeing 8,000 hours mean time between removals.

Since the UTTAS is a combat vehicle that must be able to operate safely in a high threat environment, Sikorsky has designed its YUH-60A from the start to be the most survivable aircraft in the military inventory. It has battlefield staying power plus unprecedented crashworthiness.

The key to battlefield survivability is reduced vulnerability or increased ballistic survivability, the ability of the aircraft to tolerate hits without crashing, making a forced landing, aborting the mission or having to go through a long repair process.

The combat damage data compiled by the Army for helicopters that operated in Southeast Asia shows that the most frequent causes of crashes and forced landings resulting from hits were damage to the engine system, flight controls, fuel system, lubrication system and injuries to the crew.

Sikorsky has designed its YUH-60A to overcome these hazards without depending upon the installation of large amounts of armor.

The main and tail rotor blades on the YUH-60A are ballistically tolerant as are the upper controls, the main rotor hub and the tail rotor drive shaft. All can continue functioning even after sustaining multiple hits. The large vertical stabilizer also can withstand multiple hits and still give the YUH-60A the inherent stability to fly at speeds up to 170 knots and make safe landings at speeds as low as 40 knots, even if the tail rotor is lost.

The main and tail rotor flight controls are redundant, along with the hydraulic, electrical and fuel systems so that missions can be completed if one system is knocked out.

Sikorsky has paid particular attention to the fuel system on the YUH-60A because the Army data showed that damage to this system was the largest single cause of forced landings.

The YUH-60A has two fuel tanks, for example, instead of one and they are crash resistant (fully filled tanks have been dropped 65 feet without leakage); ballistically tolerant (capable of sustaining hits from 12.7 mm projectiles); self-sealing; and completely interchangeable. A crossfeed system is used so that in the event of trouble one tank can supply both engines or both tanks one engine. The fuel lines are self-sealing with self-sealing breakaway valves and the fuel tank vent lines have poppet valves to prevent spillage even if the aircraft rolls over in a crash.

Engine driven suction pumps are used to feed the engines so that if a line is ruptured, the engine will draw air rather than fuel, thus reducing spillage and minimizing the hazards of fire.

To further reduce the possibilities of a post crash fire, Sikorsky has used aluminum for the underside of the fuselage and the wheels to prevent friction sparking, has installed titanium firewalls, encased the fuel tanks in foam, placed the engines in widely separated fire-protected compartments and incorporated a fire extinguisher system that is activated by an inertial crash switch.

The pilot and copilot controls and instruments are redundant and widely separated to reduce the

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possibility of single hit control losses. The seats are armored and load-limiting and the windshield, instrument panel and cockpit structures are all designed to minimize damage or injuries from flying debris.

Also adding significantly to the overall survivability of the YUH-60A are its two GE-T700 turbine engines. They use less fuel, require less maintenance, and have lower overall life cycle costs than the Army's current powerplants. The T700s are lighter, more reliable and have the hot day, high altitude performance to eliminate most of the so-called avoid areas for single engine failures. The YUH-60A has the capability to continue flying after an engine loss for nearly all combinations of speed and height.

As installed on the YUH-60A, the T700s are easy to maintain because of their accessibility. The modular design also permits the removal of any one of the four engine sections without disturbing the others. At organizational level, only 12 nuts and bolts have to be removed to perform required inspections and maintenance, which can be done with 10 of the common tools found in the Army aviation mechanic's toolkit.

Sikorsky has made a detailed analysis of more than 2,500 combat losses and mishaps involving operational Army aircraft. Based on these studies and its own experience Sikorsky incorporated more than 40 specific safety features in the YUH-60A to overcome the hazards and potential injuries resulting from a crash.

The YUH-60A, thanks to its landing gear and seating accommodations, will protect the crew and troops in a 42 foot-per-second vertical crash; which is the equivalent of a 2,500 foot-per-minute descent in autorotation without pulling pitch at the bottom.

Sikorsky has separated all potentially hazardous components. The landing gear is well separated from the fuel tanks, while the electronic and avionics equipment is located in the nose. And there are no fuel tanks or plumbing in the underbelly. As a result, dangerous subsystems and components are far from sources of possible fuel spillage — and the fuel tanks can't be punctured by collapsing landing gear. Most antennas on the YUH-60A are flush mounted and the underbelly lights are recessed to minimize damage in rough terrain and further reduce the possibilities of friction sparking.

Locating all avionics in the nose minimizes the possibilities of interference from the generators and eliminates the need to run wiring anywhere near the fuel cells. This makes maintenance easier.

The landing gear itself is energy absorbing and designed to allow sink speeds as high as 35 feet per second without fuselage contact. The main gear is located outside the airframe to eliminate cabin penetration and each wheel has a two stage oleo strut that will not lock up upon impact. The YUH-60A also has a tail wheel that can absorb high shock loads and thus protect the tail boom and rotor in high flare angle touchdowns. The landing gear arrangement (used successfully for years on the Army's Sikorsky-built CH-34s) allows for easy taxiing over rough terrain and helps keep the YUH-60A from plowing into the ground upon impact, thus reducing longitudinal loads and cushioning the fuselage underside. The use of wheels rather than skids also makes it easy to conceal.

The smooth, rounded design of the forward fuselage minimizes plowing-in nosedown crashes and the YUH-60A has four longitudinal keel beams that help it skid along the ground.

These keel beams, along with the four main support frames and longitudinal roof beams, help to prevent parallelogramming of the fuselage, which in turn can jam doors and windows and prevent escape.

The fuel tanks are located behind a retaining bulkhead that will keep them from breaking loose and entering the cabin, even under high loads. The cabin structure also is designed to keep the engines and gearbox from tearing loose from their attachments under high "G" loads. All equipment in the cabin is similarly retained and Sikorsky has used extra long wires in the tail cone to minimize damage in the event of a break.

The armored cockpit seats are supported by two-stage energy absorbing struts that will stroke up to 12 inches, while the troop seats use a combination of energy absorbers that provide a 10-inch stroke. All seats are fitted with an improved restraint system. The pilot and copilot seats have lap belts, shoulder harnesses with inertia reels and lap belt tiedown straps, while the troop seats, which are 20 inches wide, are fitted with lap belts and diagonal shoulder straps. The crewchief and gunner seats are equipped with body harnesses that also have inertia reels. These harnesses give the crewman complete freedom of movement along with maximum restraint when seated. All of the belts used in the YUH-60A are wider and thicker than conventional ones and have a simple, single motion release to facilitate quick exits in the event of an emergency.

The rudder pedals in the cockpit have been shielded to keep the crewmen's feet from becoming trapped under or between them. And, the YUH-60A is equipped with oversized emergency exits on both sides of the aircraft with clearly marked opening instructions.

There are two large windows on each of the sliding cabin doors. The windows can be jettisoned along with the two cockpit doors, and the gunner's large windows are large enough to be used as exits in an emergency. The cabin exits are located away from the seats and support structures so they will not be blocked and all exits can be opened from inside or out. The cockpit windows are shatterproof glass, while all others are

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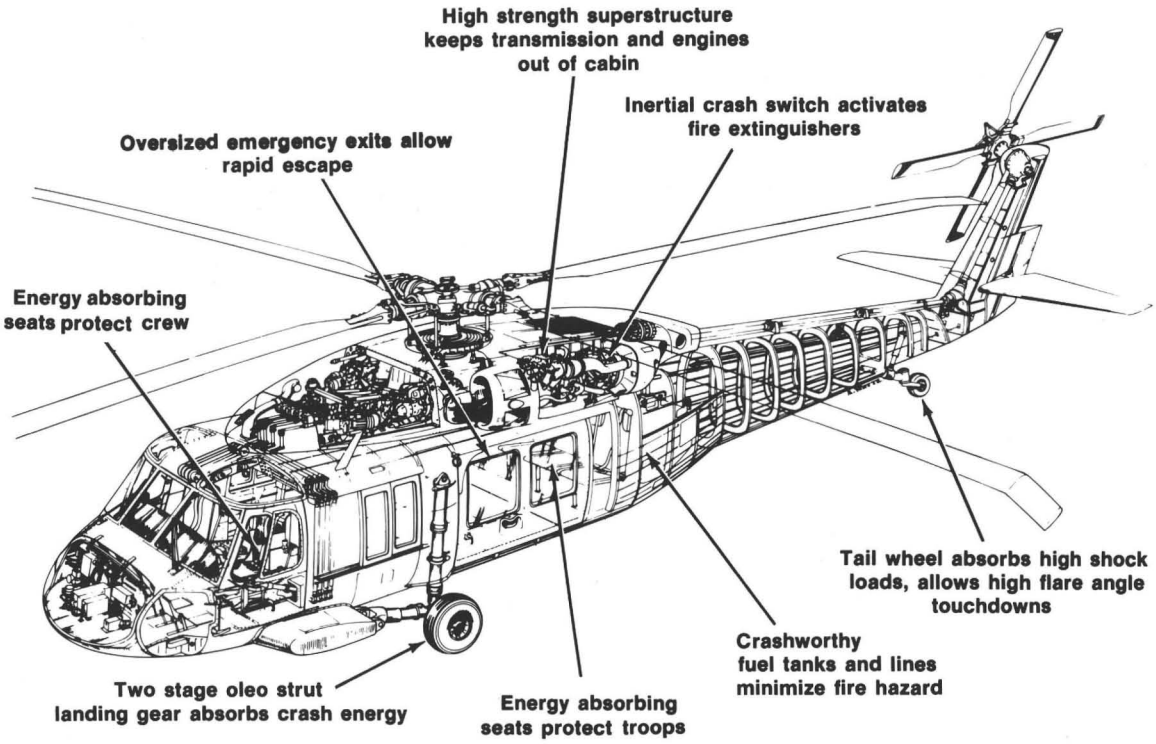

shatterproof plastic.

The large doors on the YUH-60A mean that troops can be loaded or offloaded quickly, thus allowing the helicopter to get in and out of a landing zone, where it is most vulnerable, in a matter of seconds.

The big doors and the YUH-60A's large cabin mean that it can be easily converted for medevac duty or logistics operation. With the seats out, the YUH-60A can carry four to six litters plus attendants and all of their necessary medical equipment.

Using its external hook, the YUH-60A offers the kind of lift capability and range that has never before been available in a utility helicopter. It can carry bulky cargo such as jeeps, howitzers or fuel blivets weighing up to 7,000 pounds.

Although it is not a gunship the YUH-60A's demonstrated ability to hug the terrain in nap-of-the-earth flight, its low noise and excellent visibility, mean that it can be used to supply needed firepower with its door guns in the LZ or elsewhere.

The large cabin gives the YUH-60A the capability to carry the electronic equipment needed for reconnaissance or intelligence gathering missions, or to accommodate the personnel, radios, map boards and other equipment needed for command and control.

The aircraft is air transportable, which gives the Army global deployment capability. One YUH-60A can be carried in a C-130, two in a C-141 and six in a C-5A.

The YUH-60A is, in short, designed from start to finish to help the Infantryman to do a better job and give him the maximum protection possible while he's doing it.

Sikorsky has spent more than 10 years designing and testing its YUH-60A and the result is a helicopter that will give the Army what it needs, when it needs it and at a price it can afford to pay.

Compared to today's transports, Sikorsky's YUH-60A has a greater lift capability, faster cruise speed, longer range, greater maneuverability, more flexibility and adaptability, a lower noise signature, better concealment, higher overall survivability and requires less maintenance.

The YUH-60A is a true combat assault helicopter that will work safely where it counts, in the Soldier's environment. And because it makes maximum use of the most advanced technology available today, the YUH-60A will still be modern and up-to-date a decade or more from now.

YUH-61A

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operational knowledge and the recent dramatic advances in technology that a utility helicopter could be developed that would give greater performance, increased survivability, improved maintainability and do so at a lower total cost than making marginal improvements to existing designs.

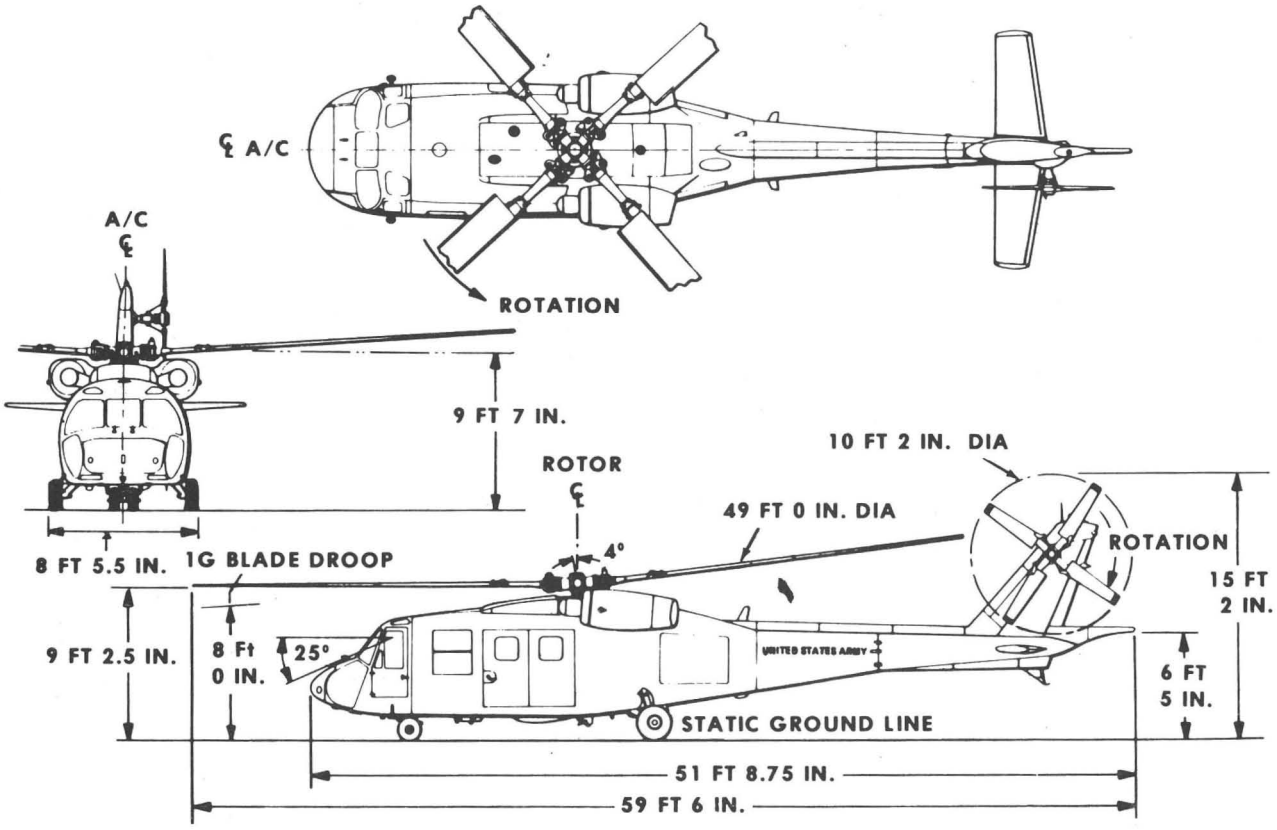
The Army's specification for this new breed of helicopter directs the contractor to develop a helicopter that will do certain things and do them within a specified cost. This approach is called a performance specification and permits the contractor maximum flexibility in developing the design that he has determined will do the job best within the cost specified (design-to-cost). This approach is an extension of the old Army maxim "don't tell people *how* to do the job, just tell them *what* you want and let them do it."

The Boeing UTTAS or YUH-61A has taken maximum advantage of this design freedom and has developed a helicopter that will be the pride of the utility helicopter fleet right through the end of this century.

The UTTAS performance capability is a product of the Army's powerplant specification of two General Electric T700 turbine engines of 1,543 horsepower each and overall helicopter dimensions (figure 1) that permit air transportability in both the C-130 and C-141 transport aircraft with a minimum of disassembly. Within the limits of these Army requirements Boeing has developed a UTTAS that is three times as productive as the UH-1 that it replaces while fitting into an overall volume that is actually smaller than that of the UH-1. The Boeing UTTAS productivity is more than triple that of current utility helicopters because its internal capacity is 80 percent greater than the UH-1; it has a 37 percent higher cruise speed and at sea level the UTTAS lifts 7,200 pounds versus 2,400 pounds by the UH-1.

The Boeing UTTAS has the capability of transporting 11 combat-equipped troops and a crew of three at an altitude of 4,000 feet and a temperature of 95 degrees Fahrenheit while maintaining sufficient power margin to climb vertically at 500 feet per minute. This sizeable lift improvement is matched by a cruise airspeed of 153 knots and an endurance of 2.3 hours. These improved capabilities result from advanced technology associated with lighter, more powerful engines, a more efficient rotor system and

Figure 1 The YUH-61A optimizes size and internal capacity



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better transmission gear materials.

Some of the specific technology advancements associated with the Boeing UTTAS are:

- Fiberglass rotor blades
- Hingeless rotors
- Redundant flight control system
- Integral kneeling gear
- Safety and survivability improvements
- Maintainability

Fiberglass Rotor Blades. A major problem with older technology helicopters has been their reliance on metal spars for their rotor blades. Just as metal was a big improvement over the predecessor wood spar blades, fiberglass provides an order of magnitude improvement over metal (figure 2). Unlike metal, fiberglass does not corrode and thus prevents this frequently hidden defect from resulting in unexpected failure.

Because the mode of failure for metal is so rapid, its failure can often lead to catastrophic results. On the other hand damage to fiberglass blades gives a gradual loss of strength over a period of many hours of flight operations. Damage to fiberglass asserts itself in a nondangerous manner such as a buildup in vibration levels over a long period of time. As a confirmation of the increased safety of fiberglass blades, the U.S. Army and U.S. Navy have initiated programs with the Boeing Company to replace metal blades with fiberglass on their CH-47 and CH-46 helicopters, respectively.

In addition to the improved flight safety offered by fiberglass blades there are also manufacturing and performance advantages. In the manufacturing of metal blades, great care must be taken to avoid small discontinuities which could start a crack. This care is unnecessary with fiberglass. A broken fiber cannot pass that break directly to another fiber. Instead, the plastic matrix in which the fibers are imbedded spreads the load to adjacent fibers to share. Small failures do not progress to become gross failures, as happens as a crack progresses through a metal's more brittle inter-crystalline structure. Manufacturing methods have been developed to produce metal spars to a constant airfoil contour. More complex blade shapes would improve performance, but are impractical with metal. By contrast, since fiberglass blades are produced by a layup process—with automatic machines, in production—there is great freedom to vary the shape and contour to attain the best aerodynamic configuration. Moving along the length of the Boeing YUH-61A rotor blade there are three different airfoils from root to tip, offering an optimum performance range between hover and high speed flight.

Hingeless Rotors. The Boeing YUH-61A UTTAS can make use of the inherent superiority of the hingeless rotor because the fiberglass rotor blades, through their natural flexibility, provide all of the required flapping and lead-lag motion for the rotor blades. There are several significant advantages to this design. Immediately apparent to all experienced helicopter personnel is the extreme simplicity of the hingeless rotor (figure 3) compared to current designs such as the articulated rotor. For example, the Boeing YUH-61A hingeless rotor head permits 60 percent fewer parts than an articulated system. This fact translates itself into simplified maintenance, increased reliability and improved safety.

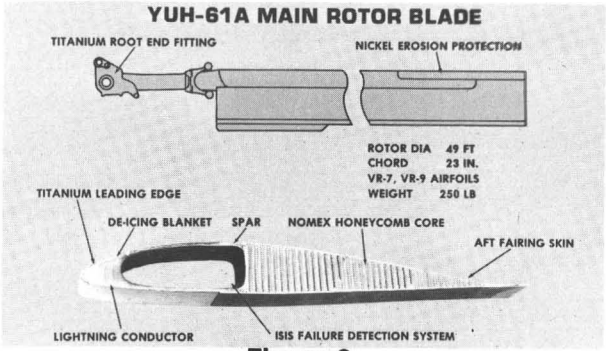

Figure 2

Boeing's fiberglass blade gives performance and ruggedness

The hingeless rotor matches its simplicity with a dramatic advance in helicopter controllability. Because there is a direct, no-hinge connection from the rotor blades to the rotor head to the helicopter fuselage, immediate response follows control inputs. Further, with the Boeing YUH-61A, Army aviators can routinely fly "negative G" maneuvers for the first time and with total safety. Such maneuvers would result in control loss or reversal in both teetering and articulated rotor systems. This means that NOE flight will be enhanced by the hingeless rotor's ability to permit rapid descents. In the high threat environment of the modern battlefield a helicopter that can make rapid changes in direction and altitude will have a decided advantage in breaking "lock-on" by enemy missile systems. The Boeing UTTAS with its hingeless rotor provides such capability beyond that of any other current Army helicopter.

Redundant Flight Control System. The dual flight control system of the Boeing UTTAS ensures that in the event of failure the remaining linkage will continue to perform all control functions and permit mission completion. If system jamming is induced by enemy weapons fire, a breakaway feature causes the operational linkage to break clear and provide complete control of the aircraft.

Kneeling Gear. The Boeing UTTAS incorporates a unique main gear arrangement which will add significantly to ease of maintenance and handling. The

wheels are high flotation which means they will operate better in soft ground than current utility helicopters with their skid gear. The single nose gear with its swivelling capability aids both ground taxi and towing. The main gears are located aft and include an integral ability to kneel either individually or together (figure 4). This ability is self-contained and permits the aircraft to be alternately kneeled or raised without need for external power or other assistance. Maintenance and inspection personnel will enjoy the convenience of lowering the helicopter to a point where even the tail rotor drive shaft is at a level that easily can be reached while standing on the ground. Similarly, this kneeling permits an easy step up to the built-in work platforms for servicing all parts of the aircraft. By differentially kneeling (the right or left main gear individually) the Boeing UTTAS, it is even possible to change a tire or wheel in the field without jacks or other special ground support equipment. Throughout the Boeing UTTAS test program this kneeling capability has been used routinely for maintaining the aircraft. It provides a unique advantage to an already highly maintainable helicopter.

Air Transportability. One of the critical features directed, by the Army, to be designed into the UTTAS is air transportability in both the C-130 and C-141 transport aircraft. In view of the diminishing size of the U.S. Army and the reduction in forces in forward overseas areas, a quick response capability becomes increasingly meaningful. The Boeing YUH-61A has been designed so as to meet or exceed all Army requirements for air transportability (figure 5). The Army requires that the UTTAS be able to be prepared for C-130 loading, from flyable status, within 1.5 hours and the actual loading is not to take more than an additional half-hour, for a total elapsed time of 2.0 hours. The entire operation, preparation plus loading is completed on the Boeing YUH-61A in 71 minutes total time. This is considerably less than the time allowed for preparation only. At the unloading end of the operation a similarly impressive capability exists.

Figure 3

The YUH-61A hingeless rotor gives positive controllability

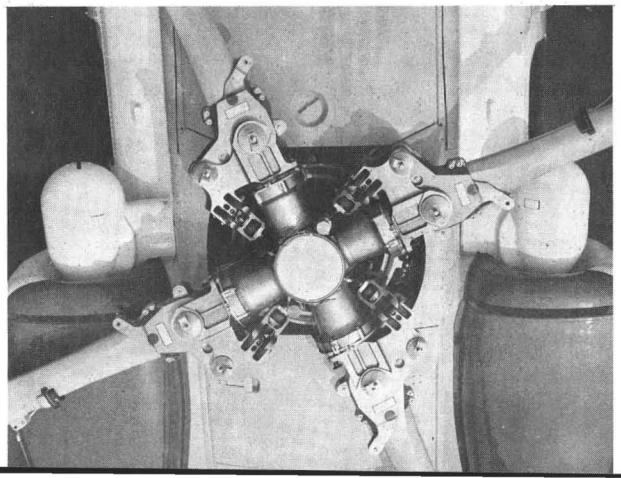

Figure 4

Boeing's unique kneeling gear simplifies maintenance

While the Army allows a total of 2 hours for unloading (0.5 hours) and preparation (1.5 hours) for flight the Boeing UTTAS completes the combined operation in 81 minutes. While the elapsed times are themselves very impressive, it is equally important to recognize that this operation requires no major disassembly, no removal of major components, no special ground support equipment, and does not involve any special personnel skills.

All four main rotor blades remain on the aircraft and are folded in place simply by removing a single pin from each blade. The tail boom is folded against the fuselage using its integral hinges. The tail rotors are scissored together and also remain on the helicopter. These are the major steps in preparing for loading and permit the Boeing UTTAS to be loaded expeditiously into a C-130 or C-141 by use of the onboard winch and the YUH-61A integral kneeling gear capability. For unloading the procedure is simply reversed. This capability means faster response, more effective use of transport aircraft, fewer maintenance hours, reduced damage, no misplacement of major components due to removal, and greater safety based on elimination of errors in reassembly at destination.

Safety and Survivability. Although the benefits of safety and survivability are difficult to measure, few would disagree that their value is considerable. The Army's latest specification for UTTAS resistance to enemy rounds of up to 23 mm and crash loads exceeding anything previously demanded will mean fewer fatalities, fewer injuries and fewer aircraft lost. During a structural demonstration test flight in November 1975, a Boeing UTTAS experienced a main rotor rpm overspeed. The overspeed caused the tail rotor drive shaft to contact a work step platform which resulted in severing the drive shaft and loss of thrust to the tail rotor. Because of experimental

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loading, special test procedures and instrumentation configuration, the flight could not be continued and the aircraft landed in a dense patch of oak trees. As unfortunate as this incident was it provided a dramatic demonstration of the crashworthiness criteria which the Army has specified for the UTTAS. The aircraft impacted the ground at 23 feet per second with 6.0G vertical and 2.5G lateral cockpit measurements. Both pilots were uninjured and there was no aircraft fire.

During entry into the patch of oak trees the main rotor blades repeatedly contacted a number of oak trees ranging in diameter from 9 to 12 inches. The transmission remained firmly in place in the aircraft structure with no evidence of any movement of the transmission and transmission mounting structure. The pilot and copilot both exited normally from the aircraft although it had rolled over on its left side. There was no apparent deformation of the fuselage structure and the total cabin/cockpit area remained intact. Engines remained in place. Doors and hatches were operable.

Figure 5
The YUH-61A establishes new standards of air transportability

The aircraft was reparable and able to return to flight in less than 3 months. Action already has been taken to preclude recurrence of this type of accident. However, as regrettable as the mishap was, the Boeing UTTAS demonstrated survivability that has never before been shown by any other utility helicopter. The incident further confirms the Army's decision to build new helicopters to design specifications that will inevitably give each person flying in these helicopters, passengers and crew-members, a greater chance of avoiding death or injury when compared to current utility helicopters.

Maintainability. The three aircraft in the development program have exhibited an amazing operational readiness and have established maintenance levels that rival those of aircraft that have been flying for millions of hours. The General Electric twin engine installation has been a model of both reliability and maintainability. Although maintenance requirements have been minimal, when they have been required they have been both fast and simple.

The advantages of the kneeling main gear already have been discussed. There are many other significant contributions to simpler maintenance with lower cost. Major elements in helicopter direct operating costs are maintenance costs for parts and labor. Major dynamic components contribute most of these costs. The Boeing UTTAS already has demonstrated a MTBR of 2,500 hours for these dynamic components and can realistically forecast achievement of a 3,200 hour MTBR very early in its operational life. This single improvement will reduce total parts and depot labor costs by about 40 percent. The absence of droop stops and lag dampers also reduce maintenance requirements.

All dynamic components are tested on a GTV prior to actual flight. The Boeing UTTAS GTV has demonstrated the soundness of its design by completing the Army's qualification requirements 11 months early, on 22 September 1975. By using the new, greater strength, VASCO X-2 gear material transmissions have been developed that have shown an ability to operate up to 2 hours with loss of primary lubrication and up to 30 minutes under a no oil condition. Maintenance has been given high priority in establishing tradeoffs for final UTTAS design.

Improvement Through Technology. The foregoing are but some of the many improvements Boeing has designed into its UTTAS through the use of the latest technology. We already have flown the YUH-61A to altitudes of 22,200 feet; at takeoff gross weights of 19,600 pounds; at forward (dive) speeds of 199 knots true airspeed; in climbs of 3,000 feet per minute; and with load factors from 3.1G positive down to 0.6G negative. The three Army aircraft had accumulated 698 flight hours through the first of February 1976.

Optimized Tradeoffs. As in other complex weapons systems utility helicopters represent tradeoffs among many competing elements: maximum cargo capacity versus small size for air transportability; optimum hover versus higher speed; lighter weight versus additional system redundancy. We believe that the Boeing UTTAS has used the lastest technologies to capitalize to the maximum in all areas of tradeoff.

The Boeing YUH-61A UTTAS is technologically advanced utility helicopter and will serve as a fitting vehicle for meeting the U.S. Army's tactical utility helicopter requirements for the foreseeable future.

Hughes

YAH-64

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Extensive and favorable subcontracting experience during OH-6A and the Model 500 commercial derivative production demonstrated the power of the subcontracting approach. Instead of expanding as a prime contractor, Hughes Helicopters is emphasizing the subcontractor team approach on the AAH program.

We have structured a team of blue-ribbon companies with specialty expertise, facilities, management and personnel already in place to assure high quality performance. We believe this is the modern way to go. This concept adds stability to the defense preparedness base by utilizing companies in their specialties and permits the prime contractor to concentrate on the total systems aspects with emphasis on system integration, assembly and test. Success of this concept has been demonstrated by timely operation of the prototype helicopters and minimal technical problems. Production coordination of this subcontracting team will be enhanced by using a computer network linking all of the major subcontractors to a common data bank, each with access only to his own assigned unit. Weekly cost, schedule and change control data entered by each major subcontractor will be available individually and in total only by Hughes Helicopters. The major subcontractors selected are as follows:

- *Bendix Corporation's Electric-Fluid Power Division:* Design and fabrication of drive shafts, couplings and electrical power systems.
- *Bertea Corporation:* Design and fabrication of hydraulic control systems.
- *Garrett Corporation:* Design and fabrication of integrated pressurized air systems.
- *General Electric Aircraft Engine Group:* T700 turboshaft engines (GFE).
- *Hughes Aircraft Company:* Design and fabrication of visionics system.
- *Litton Precision Gear Division:* Main transmission and engine nose gearbox fabrication.
- *Menasco Manufacturing, Incorporated:* Design and fabrication of landing gear units.
- *Solar Division of International Harvester Corporation:* Production of the auxiliary power unit.
- *Sperry Flight Systems Division:* Design and manufacture of automatic stabilization equipment.
- *Teledyne Ryan Aeronautical:* Fabrication of the airframe structure.
- *TRE Corporation, Advance Structures Division:* Main rotor and tail rotor blade fabrication.
- *Western Gear's Precision Products Division:* Intermediate and tail rotor gearbox fabrication.

This team concept is proving to be effective in bringing to bear highly specialized experts to produce, each in his own field, those components required to make the YAH-64 a truly outstanding helicopter. The team concept is working well!

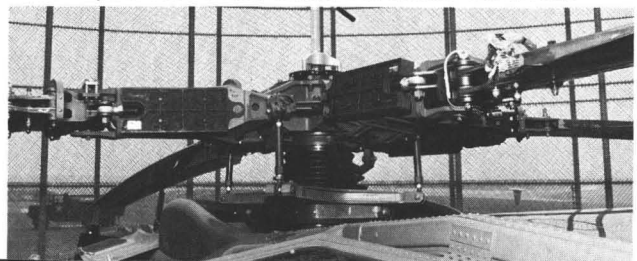
The Hughes YAH-64 is a twin-engined, four-bladed helicopter designed as a stable, manned aerial weapons system to deliver missiles, 30 mm and rocket rounds for maximum effectiveness. It will perform these missions under day, night and marginal weather conditions. To enhance survivability and mission effectiveness, the YAH-64 is capable of conducting low level and NOE flight enroute to and within the operational area. The flightcrew consists of a pilot and a copilot gunner.

A four-blade, fully articulated main rotor system with offset hinges was selected as the optimum configuration for the YAH-64. This system provides maximum control power with minimum risk of dynamic problems. Control power is maintained at zero "G" flight maneuver conditions thus facilitating safer NOE operations. The four-bladed configuration requires a smaller diameter rotor which in turn requires less torque and lower gear ratios, all of which lead to a smaller, more compact and less costly aircraft. The OH-6A articulated rotor system, with millions of hours of operational experience, has substantiated these conclusions.

The Hughes fully articulated rotor system employs a hub and a V-strap retention system uniquely different from the conventional three-axis bearing-hinge system. There are no flapping or feathering bearings to require lubrication and servicing, combining reduced maintenance with reduced weight. With the exception of dual elastomeric dampers (replacing friction dampers), the YAH-64 rotor hub system (figure 1) is a scaled-up version of the OH-6A hub.

In order to provide invulnerability to 12.7 mm API and 23 mm HEI projectiles, the main rotor blade structure (figure 2) features a four-cell box of laminated stainless steel and fiberglass construction. These superior fatigue-strength stainless steel sections are reinforced by filament-wound inner fiberglass tubes to arrest crack propagation and provide backup strength to the steel spars in the event of a projectile hit. Ballistic tests have indicated that these multiple

Figure 1. Elastomeric dampers replace the friction dampers used in the similar but smaller OH-6A hub



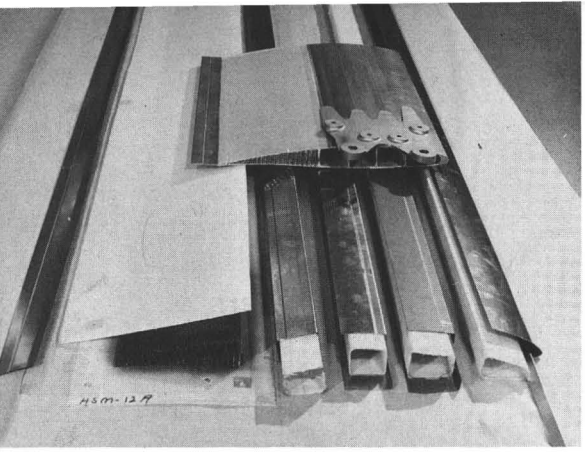
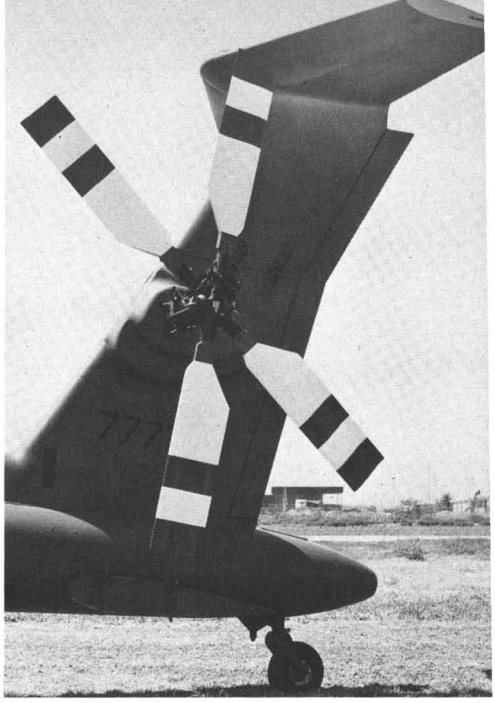


Figure 2 (left). Main rotor blade constructed of laminated steel and fiberglass is capable of sustaining flight loads after impact by high explosive rounds. Figure 3 (right). The low rpm four-bladed tail rotor affords quiet operation. Figure 4 (below). Main gear struts are capable of kneeling for transportability



redundant spars should be capable of sustaining flight loads after impact by high explosive rounds and inherently provide a fail-safe rotor blade.

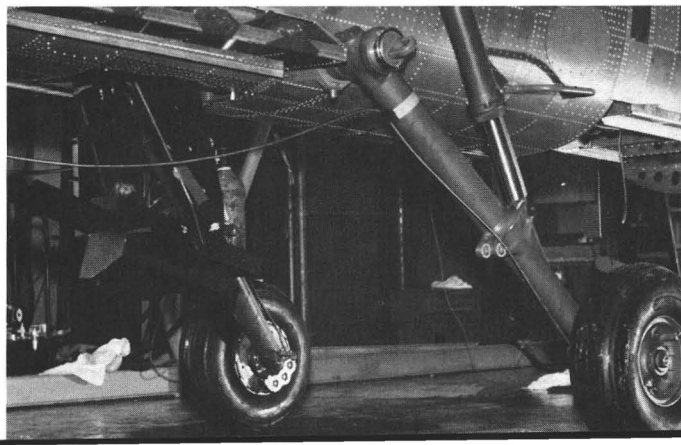
The empennage of the YAH-64 is made up of a "T-Tail" configuration similar to the new Hughes Commercial Model 500. This configuration was chosen to provide good longitudinal stability in transition from hovering to forward flight. The low rpm tail rotor (figure 3) which is mounted on the left-hand side below the horizontal stabilizer, is of a four-bladed double teetering configuration. The two blade sets are approximately 55 degrees apart to enhance quieting. This configuration was chosen for reduced size, mechanical simplicity and the successful operating experience associated with teetering tail rotors.

The fuselage of the YAH-64 is specifically designed to provide a spacious cockpit for the crew; unencumbered access to accessories and subsystems and adequate protection for crew and aircraft. The tandem arrangement with the pilot behind and above the copilot gunner affords the pilot excellent visibility. The pilot is close to the axes of rotation where he will be more able to sense pitching and yawing motions of the aircraft in NOE flight. Protection of the crew is afforded by a transparent blast shield between the cockpits, armor plate on sides, bottom and back, and two sturdy overturn trusses. Multiple load paths have been incorporated throughout the fuselage with sufficient separation to provide damage tolerance to high explosive threats. Redundant design provides for sustaining design loads in the event of loss of one or more primary structural members. High-lift wings incorporating flaps are mounted on the fuselage below the powerplants. External stores are carried under the wings by means of four identical and quickly detachable pylons.

The alighting gear configuration (figures 4 and 5) is a conventional fixed, three point type with two forward main wheels and a tail wheel, to facilitate soft autorotational landings with minimum pitching. The main struts have a kneeling capability for transportability. The tailwheel (figure 5) is a 360-degree free swivelling and self-centering assembly fitted with a swivel lock for landing.

Two General Electric T700-GE-700 engines furnish power for the YAH-64. Each engine is equipped with an air turbine starter coupled to the accessory gearbox of the engine by a clutch. The air turbine starters are powered by compressed air provided by a shaft drive compressor. The engines have integral lubrication and particle separator systems. An Airesearch infrared suppression system is supplied on each engine. Cooling air is pumped across the engine and into the IR suppression unit where it mixes with the engine exhaust thereby diluting the exhaust plume. The widely separated engines and appropriate armor on the inner surfaces of the nacelles provides propulsion system protection from both 12.7 mm API and 23 mm fragments to assure that both engines cannot be rendered inoperative by a single round.

The normal fuel supply is contained in two internal fuel cells located in the lower fuselage forward and aft of the ballistically isolated ammunition bay. The cells are self-sealing against 12.7 mm and crashworthy. In addition, the lower portions of these cells, containing the volume for a total 30-minute fuel reserve are self-sealing against 14.5 mm projectiles. Fire suppression material fills the tank volume and surrounds the external surfaces of the cells. Both single point and closed circuit pressure refueling and defueling provisions are included in addition to gravity fueling and defueling. Auxiliary tanks, externally mounted on the wing pylons, provide the capability of long-range ferry flight.



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The somewhat conventional mechanical drive system of the YAH-64 has two major features contributing to survivability: static mast rotor supports on main and tail rotor, and the capability of operating dry at least 30 minutes in the event of a gearbox lubrication failure. The primary unique feature of the static or nonrotating mast design is that flight loads are taken as steady stresses and go directly from the rotor through the mast and into the primary fuselage structure, bypassing the rotating main rotor drive shaft and main transmission. The rotor drive shaft is relieved of flight loads and transmits only torque. In addition, the main transmission housing, bearings and supports are relieved of the fatigue stresses normally contributed by the rotor loads. This feature provides the unique ability to make an autorotational landing after a failure in either the gearbox or the main drive shaft. The tail rotor support is a similar design.

The Hughes YAH-64 flight control system is a hydro-mechanical system with an electro-hydraulic system for redundancy. A mechanical subsystem of linkages is used to actuate the primary flight control hydraulic actuators in each axis. A three-axis stability augmentation system is provided. The control system between each pilot and the hydraulic actuators has a complementary backup electro-hydraulic control system. In case of a failure or jam in the mechanical linkages, the mechanical system can be decoupled instantaneously and the electro-hydraulic system assumes full authority. When in the backup mode, electrical inputs from the control stick or pedal transducers go directly to the ASE system and the hydraulic servo valves for cyclic, collective and directional control. The major flight control structural elements such as mixer and swashplates are of 7049 aluminum and ESR steel for ballistic damage tolerance. Pitch links and all self-aligning bearing sleeves are made of ESR 4340 steel of sufficient thickness to tolerate a 12.7 mm projectile hit.

Independent and separated primary and utility 3,000 psi hydraulic systems are provided for the collective, cyclic and directional control systems. The utility system also provides power for the rotor brake, chaingun aiming, APU start and wing store pylon elevation. The hydraulic actuators for flight controls are ESR steel; in addition to being redundant, they are designed to provide invulnerability to both 12.7 mm API and 23 mm HEI projectile fragments.

Complementing the flight performance and combat survivability of the Hughes YAH-64 is its integrated ordnance system, providing the sustained antitank firepower and mission versatility which is the attack helicopter's prime role. Of particular significance to the design and integration of the ordnance system for the YAH-64 is the fact that the Hughes Ordnance Division has been, for the past 30 years, in the forefront of the development of guns, accessories and complete airborne ordnance systems. The intimate communication links and close support of the airframe design team made possible the integration of a highly effective, lightweight and low cost ordnance system for the YAH-64.

The YAH-64 will be armed with a 30 mm cannon with 1,200 rounds of ammunition and up to 16 antitank missiles or 76 2.75 inch rockets, or a combination of these. The 30 mm cannon, designated as the XM-230 chaingun (figure 6) was conceived early in 1973 and went from drawing board to firing in a period of only 4 months. Since that time it has successfully fired 150,000 rounds in development and integration testing. The chaingun brings to the AAH a highly effective firepower with the added advantages of one-half the size, weight and cost of competitive guns.

The hydraulically powered 30 mm area weapon turret (figure 6), specifically designed and optimized for the YAH-64, is small, lightweight and low drag. The mounting structure for the turret has been designed to absorb energy during a crash while displacing in a mode that will cause the turret and the gun to fold into fuselage areas not occupied by crewmembers or fuel tanks. The ballistically tolerant ammunition magazine containing 1,200 rounds of ammunition is located centrally beneath the rotor to minimize effects

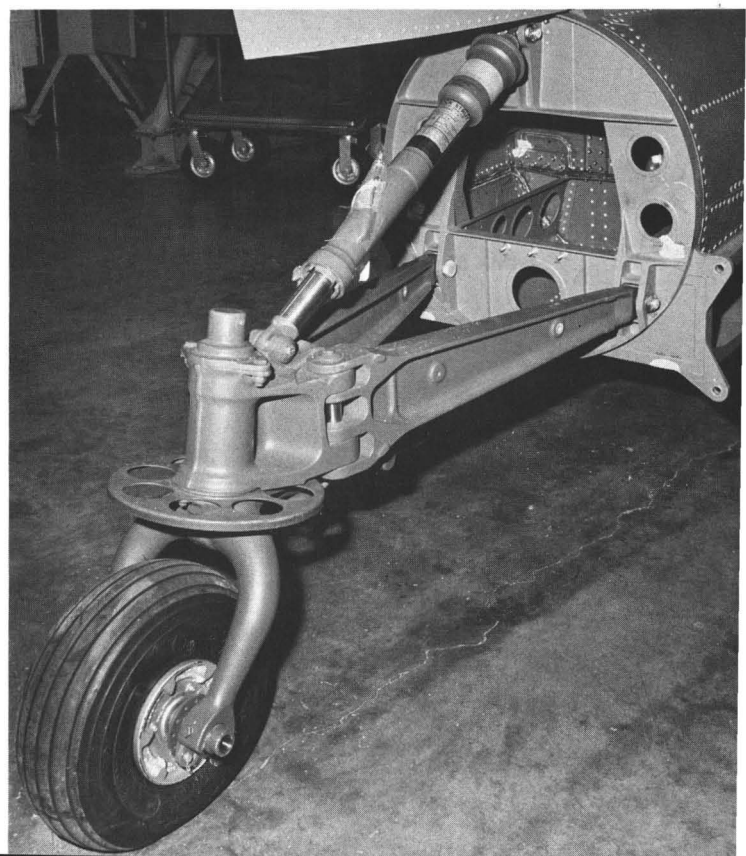

Figure 5. YAH-64 tailwheel free swivels full 360 degrees and has a self-centering assembly with swivel lock for landing

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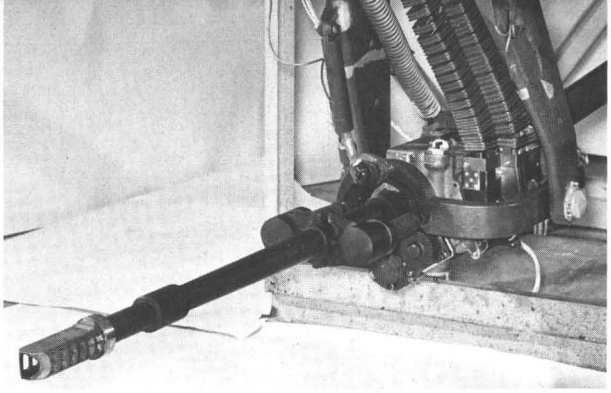

Figure 6. Hydraulically powered 30 mm area weapon turret was specifically designed for lightweight and low drag

of ammunition consumption on stability of the helicopter. The ammunition handling system selected is a linkless system utilizing a rotating-clip magazine, conveyor and a rapid turnaround, bulk ammunition loading system. The total ammunition complement can be loaded in less than 10 minutes.

The Aerial Rocket Control System is automatically adaptable to a mix of up to five fuze/warhead combinations and will fire a mix from either two or four 19-tube launchers in a variety of firing rates and modes. The ARCS features simplified rocket loading by zoning the rocket pods. The inventory system eliminates the need for programing switches. It is automatically reprogramed each time power is applied, by means of an interrogation of the rocket pods. The presence of rockets is identified by reading squib resistance. R-C fuzing capability of the XM-132 rocket is an integral part of the ARCS.

The missile launchers, the aerial rocket launchers and the extended range fuel tanks attach to the underside of the wings by means of pylons. All four of the stores pylons are identical and thus interchangeable. In order to assure a positive and safe ejection of any stores throughout the flight envelope, each of the pylons contains a force ejection system. A high degree of stiffness was designed into the pylons to assure meeting accuracy requirements for both the missile and 2.75 inch rockets. The external stores system will position the stores in flight to a fixed position for minimum drag and will reposition the stores parallel to ground prior to landing.

Twenty-four hour mission capability is accomplished with proven copilot/gunner visionics and pilot night vision system. Hughes Helicopters, in conjunction with Hughes Aircraft Company, developed a very similar system for the NIAS. The thermal imaging device used in both the stabilized turret and for pilot's night vision is revolutionary in concept. It was developed for a separate Hughes Helicopter program that already has accumulated hundreds of hours of operational NOE night flights.

The stabilized sight provides the means for target acquisition, missile launch and the most accurate means for directing the 30 mm gunfire. Inasmuch as a wider field-of-view is desirable for rapid target acquisition and for other firing, Hughes has incorporated a helmet sight for both the pilot and the copilot gunner. The helmet sight system is particularly effective for rapid control of the 30 mm cannon for suppressive fire.

Figure 7. Full-scale rotor whirl tests were conducted at Lockheed's Rye Canyon test facility

Figure 8. Hughes ground test vehicle was operating in June 1975

Survivability is a paramount consideration in assuring successful mission accomplishment. To this end, the Hughes Helicopter design team has devoted the utmost effort toward incorporating in the design of the YAH-64 proven concepts and hardware to reduce vulnerability, improve crashworthiness and to enhance survivability of both crew and aircraft. A recap of the major provisions to this end is as follows:

- Superior performance and agility, particularly in vertical rate of climb, negative "G" maneuver capability, and sideward flight to minimize exposure time.
- Reduced visual detection afforded by low profile of the configuration, reduced noise from the four-blade main rotor and four-blade tail rotor, infrared suppression of the hot spots, engine and plume, reduced visual glint from the canopy, and the greatly reduced rotor flicker afforded by the four-blade rotor.
- Damage tolerant structure through use of redundant separated load paths, ballistic tolerant materials on critical components and extensive testing leading to the selection of materials to withstand impact of 12.7 mm API and 23 mm HEI projectiles.
- Effective use of armor selectively chosen and effectively utilized to afford crewmembers maximum protection and to protect the essential flight systems and components from damage.
- Improved crash survivability afforded by high energy-absorbing landing gear and structure, static masts supporting main rotor and tail rotor, sturdy overturn structures and fuel tank isolation.

The flight safety, performance, reliability, survivability and operational capability of the YAH-64 is being assured by a most comprehensive testing program. Structural tests to assure integrity of components, and subsystems for static, fatigue, proof pressure and damage tolerance conditions are required to qualify. Subsystem and system development tests, utilizing full size working mockups, have been utilized to verify the required characteristics of the electrical/avionic system, hydraulics and control system. Full-scale instrumented rotor whirl tests of the main and tail rotor systems were completed at the Lockheed Rye Canyon rotor testing facility in 1975 (figure 7). A total of 50 hours on each system was accumulated prior to flight approval.

A GTV was placed in operation in June of 1975 (figure 8). The instrumented GTV is a complete operational aircraft less the landing gear, certain flight instruments, the avionic systems and the ordnance systems.

During September 1975 the required 50 hours of preflight acceptance tests covering full-range control operation were completed. An additional 250 hours of testing of the GTV will be accomplished prior to Army flight evaluation in June 1976.

The first flight-test helicopter performed a most successful maiden flight of approximately 1 hour on 30 September 1975, on schedule. On 22 November the second flight test vehicle was flying (figure 9). All initial flight test objectives for both helicopters were successfully accomplished including hover, sideward, rearward and forward flight modes. The test pilots reported enthusiastically that the aircraft exceeded their expectations for a maiden flight. Contractor flight test demonstrations and qualifications will continue until 31 May 1976 when the helicopters will be turned over to the Army for competitive fly-off.

Throughout the design and development testing of the YAH-64, Hughes Helicopters has focused unrelenting attention to the objective of providing the U.S. Army with the most combat-effective, survivable, crew-safe and easily maintained advanced attack helicopter possible. The YAH-64 is living up to these expectations.

Figure 9. By November 1975 the second flight test vehicle was flying

Left, Mr. Gerald Tobias, President of Sikorsky Aircraft presents the Honorable Edward A. Miller a scale model of the YUH-60A

Right, UTTAS prototypes in flight. The Sikorsky YUH-60A (above) and the Boeing YUH-61A

UTTAS at Fort Benning

ON BEHALF of Secretary Hoffmann* and the men and women of the United States Army, it gives me great pleasure to accept the Sikorsky YUH-60 prototype for Army Competitive Evaluation. Rather than the culmination of a program, this ceremony today marks a real beginning—a beginning of a new era wherein the Army utility aircraft for mobility on future battlefields was designed from the wheels up to the top of its rotors with the Soldier in mind. Inherent in its design are more reliability, availability, maintainability and survivability features than ever before combined in a single rotary wing aircraft which wears the Army green.

Advances such as these were not easy in the making—or quick to achieve. The systems we see before us are the result of a very deliberated process which was originally conceived in the early 60s with the introduction of an advanced engine development leading ultimately to the T700 which now powers the UTTAS as well as our AAH. The engine itself represents a giant technological step—not only is it far simpler in its construction and easier to maintain, but it delivers more power at half the weight and with 20 percent less fuel than the current [UH-1] Huey engine. In spite of its

*The Honorable Martin C. Hoffman, Secretary of the Army

Continued on page 33 (Column 1)

Gerald Walter T. Kerwin accepts a model of the YUH-61A from Mr. H. N. Stuverude, President of the Boeing-Vertol Company

ON BEHALF OF General Weyand,* I am pleased and honored to accept the Boeing-Vertol prototype for the Army's new tactical transport helicopter. As you can probably imagine, this is a long-awaited, exciting day for the Army and another great step forward for Army aviation.

We of the Army are looking to the UTTAS to provide us with the mobility and flexibility to survive, move and fight on the battlefield of the 1980s. To fight against a larger force. . .and to *win*. The helicopter is the key element in the all-important third dimension of the modern battlefield.

The lethality and deadliness of the battlefield of tomorrow are beyond description. The ability of modern weapons technology, both nuclear and conventional, to decimate massed formations in tomorrow's conflict is awesome. What can be seen can be hit. . .and what can be hit can be killed.

The key to tactics. . .to survival. . .and to winning on the battlefield of tomorrow is going to be mobility. . .the mobility to be where you're not expected to be; the mobility *not* to be where your enemy expects to kill you; and the mobility to strike in force, anywhere on the battlefield. . .without warning. . .at a time and at a place of your choosing.

Any static or slow-moving force on the modern battlefield is almost sure to be destroyed. The modern commander will have to keep his maneuver forces, his combat support elements, and his sup-

*General Fred Weyand, Chief of Staff, U.S. Army

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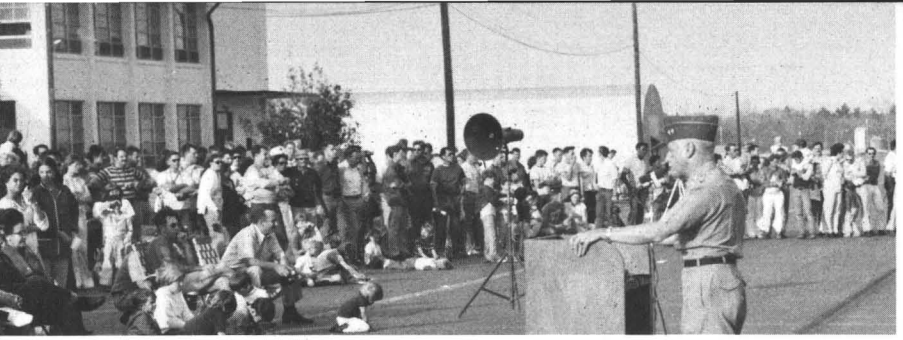

Major General William J. Maddox addresses spectators at Cairns AAF on arrival of the UTTAS helicopters. At right, Major General Jerry B. Lauer speaks to the Fort Rucker audience about the status and future of the UTTAS program

nveiling at Fort Rucker

WE HAVE JUST sent the first radar returns of the UTTAS onto the radar scopes at Cairns Approach Control. . .and placed the first imprint of the UTTAS wheels on the ground here at Shell Army Air Field at Ft. Rucker. We have just flown in from Ft. Benning, GA, where General Walter T. Kerwin, the Vice Chief of Staff of the Army, and the Honorable Edward A. Miller, the Assistant Secretary of the Army for Research and Development, accepted these four aircraft and released them to be flown here to Ft. Rucker for testing. What all this means is that Ft. Rucker is fully involved in the Army's plans for the future. At the Army Aviation Center we not only are writing future doctrine and tactics; tailoring training programs; and delineating how flight operations should be standardized; but we are also deeply into the hardware business. And, today we have three major Army developments represented in these four aircraft:

- The Boeing-Vertol YUH-61A
- The Sikorsky YUH-60A
- And powering both of these birds is the T700 General Electric engine, an advanced technology engine which also will populate our advanced scout helicopter.

After a short 4 year program since the Aviation Center wrote the original UTTAS requirements, these UTTAS have been delivered on time and in a configuration that we asked for. We owe great appreciation to Boeing-Vertol, Sikorsky and General Electric for the successful development of these aircraft. They were built to meet the Army's Big Five needs. The UTTAS is to be the prime Army lift ship and its first true aerial squad carrier. It will be joined in a few months by the AAH and in several years by the advanced scout helicopter and a product improved CH-47 Chinook. Together this group of aircraft will carry us into the next century—beyond the year 2000.

MG WILLIAM J. MADDOX JR.
Commander
U. S. Army Aviation Center

IT'S A PLEASURE FOR me to be here today and I appreciate the opportunity to share with you a bit of what we are doing at the present time in the UTTAS program.

Each contractor built three aircraft—two from each company are here in front of you today. The other UTTAS from each contractor is at the U. S. Army Aviation Systems Test Activity at Edwards AFB, CA. They will be flown at Edwards for about 6 months, then be taken to Alaska for arctic testing.

The two aircraft here at Ft. Rucker will be tested for about 3 months by the U. S. Army Aircraft Development Test Activity. Then they go to Ft. Campbell, KY, for operational testing by the 101st Airborne Division (Air Assault). The 101st program is scheduled to be completed by the end of August or the first of September. The ground test vehicle that each contractor has will be sent to the Eglin AFB, FL, climatic hangar for testing.

By the time the Army decides late this fall on which contractor has won this competition, the aircraft will have been shaken out extremely well. We'll know what it can do. And, different from a lot of programs, we will be going directly from the prototypes you see here today into production. Many other competitions have gone from one stage prototype into another prototype stage before production. When we sign a contract at the end of this year, it will be for a production helicopter that will show up ready to go out to the units in the late 1970s. In August 1978 the first delivered production helicopter will be accepted by the Army.

Meanwhile, though, we must find out which one of the two will win the competition. Having been around them now for quite a while, I can assure you it is going to be a very difficult decision. I would hate to have to decide based on what we know at this date. It's extremely important therefore that the testing bring out all of the points we are looking for.

You have seen a little of what the UTTAS competitors can do as far as performance goes. But there are other things that the Army really went for in the UTTAS. These had to do with reliability, maintainability, survivability, vulnerability—and these things you don't see just looking at the aircraft out here.

Another thing to note is the size of the UTTAS compartments. Earlier today at Ft. Benning, GA, infantry squads with dragons and TOW missiles were loaded in each UTTAS. Those that have ever had to put troops into our current helicopters recognize what an advancement this is.

Now it is time to turn these aircraft over to Colonel Bob Kellar, president of the Development Test Activity, and to wish him great success in this test program.

MG JERRY B. LAUER
UTTAS Project Manager

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Bell

YAH-63

Continued from page 4

threats, Bell relied on the prioritized AAH requirements to synthesize a design which meets the need. Although priority was given to the first three requirements—flight performance, firepower and survivability—the remaining requirements also are met, ensuring a balanced design.

DESIGN PHILOSOPHY: Management's objective was to design a balanced cost effective system—one that would meet or exceed all requirements with minimum deviation. Looking at the Army's design priorities, Bell's designers noted that requirements pertaining to flight performance and firepower were very specific and comprehensive but could be met with essentially conventional design approaches. However, survivability requirements were different. They were of necessity more general in nature but more demanding than before.

To minimize the impact of increased weight on performance, Bell's design uses no parasitic armor except to protect the crew. Guidance given during the predesign effort centered around the application of component redundancy and separation, maximum use of component shielding and proper sizing of components to accomplish this objective. To aid in developing ballistically-tolerant components and systems and to ensure compliance with requirements, Bell tested each design with gunfire until it could be shown to be survivable.

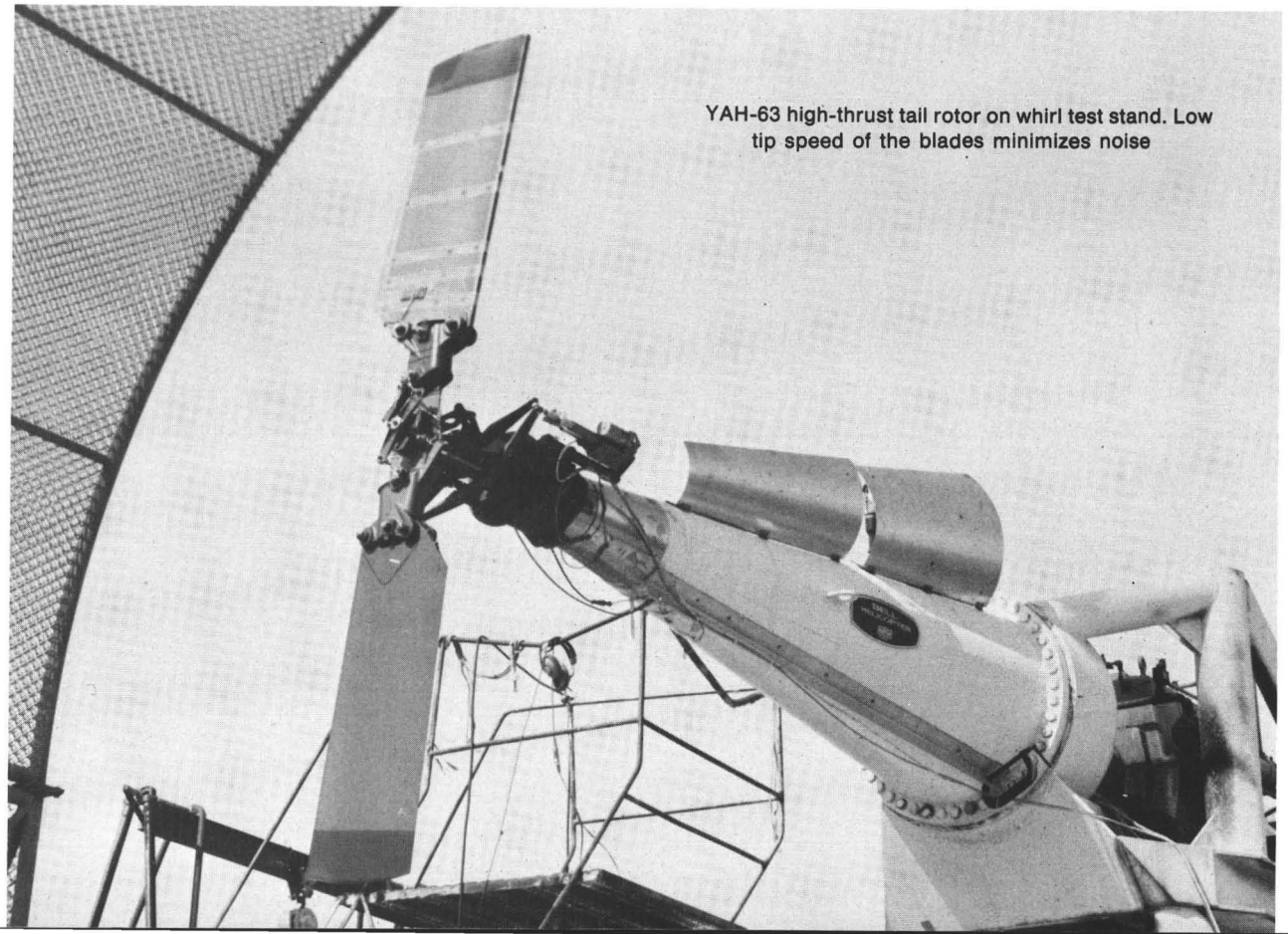
Bell recognized the importance of R&M characteristics, so components and systems were designed for simplicity, located for accessibility and grouped for convenience.

Underlying Bell's emphasis on technical aspects of the aircraft design was an equal emphasis on cost. Even though the DTC requirement for the AAH is specified in terms of acquisition cost, the importance of overall system (LCC)—all development, investment and operating costs—was not minimized.

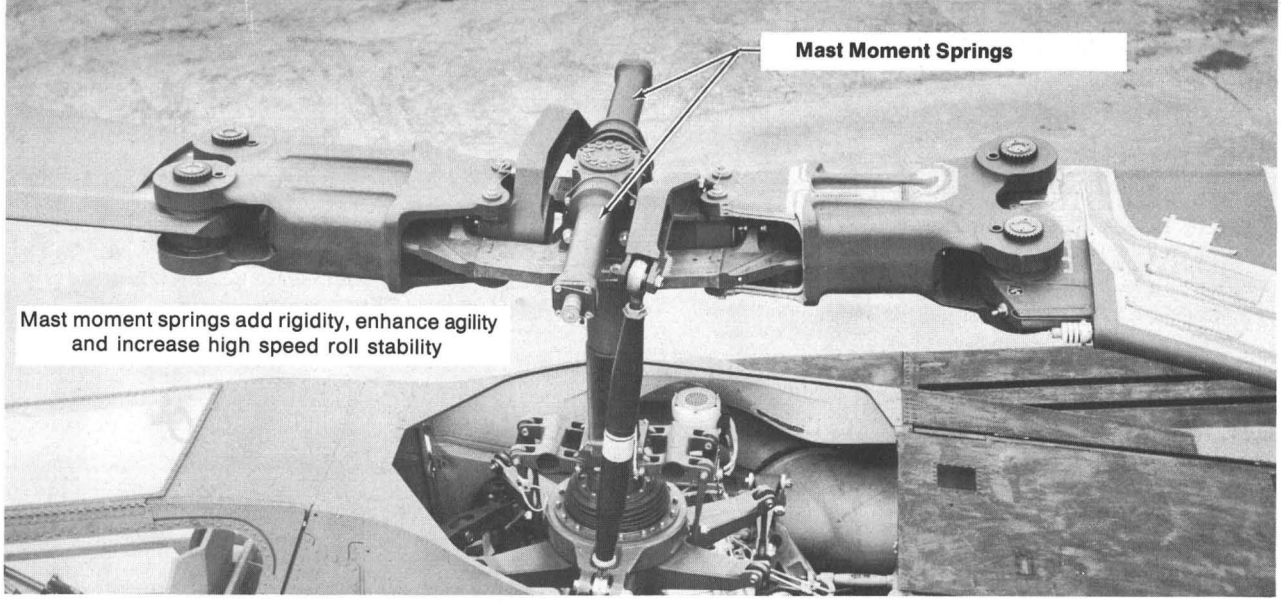
Operating costs comprise the largest percentage of total LCC. During combat an aircraft's survivability is the most important operating cost characteristic and during peacetime R&M features are dominant factors. Since these design characteristics are both principal cost drivers and important technical priorities, Bell singled them out as areas for very intense design concentration. The final system design reflects these efforts. All principal aircraft design characteristics are detailed in the following section.

DESIGN CHARACTERISTICS:

- *Rotors:* The two-bladed main and tail rotors for Bell's YAH-63 have fewer parts and are inherently



YAH-63 high-thrust tail rotor on whirl test stand. Low tip speed of the blades minimizes noise



less complex than multibladed systems.

The 51.5-foot diameter, 42.6-inch chord high-inertia main rotor meets all performance and maneuver requirements. The wide chord blades have widely separated redundant spars to assure 23 mm HEI survivability. Blade construction incorporates stainless steel spars and fiberglass skins with aluminum and Nomex honeycomb cores. No blade drag braces or sweep adjustments are required.

Characteristically, along with reliability and survivability advantages of the two-bladed rotor, there used to be several disadvantages: noise, vibration and lack of zero "G" capability. These problems have been solved in the YAH-63. To significantly reduce the noise, the tip speed was slowed and the blades were fitted with special swept tips. To isolate two-per-rev vibrations, the aircraft was equipped with a nodalized suspension system. To provide zero "G" control power, mast moment springs were added to the hub.

The 9.5-foot diameter, 17-inch chord high thrust tail rotor meets all handling qualities and satisfies all 12.7 mm survivability requirements with redundant blade retention and pitch change controls. The no-lube uniball hub simplifies maintenance and stainless steel blades tolerate foreign object damage. The low tip speed of the blades minimizes noise.

• *Nodalized Suspension System:* The nodal beam suspension system isolates the fuselage from rotor-induced two-per-rev vibrations. It provides a smooth ride, reduces crew fatigue, assures a stable gun platform and reduces maintenance requirements. This concept has been tested and proven by Bell and has been incorporated in the production Model 214 and Model 206L LongRanger. Nodal beam systems require no adjustment and are insensitive to center of gravity and weight changes.

• *Mast Moment Springs:* The moment springs add rigidity to the main rotor hub and permit zero "G" flight without control reversal. They enhance agility by providing instant fuselage response to cyclic control inputs. In addition, they increase hover stability, provide damping in roll and pitch, produce high speed roll stability and permit rotor starts in 60-knot winds.

• *Two-Position Mast:* Contrasting requirements—a high rotor for full field of fire for the weapon systems and a low rotor for air transport by C-141—required a unique solution which involved retracting the mast into the transmission.

The mast retraction technique is safe, positive and reliable. Helical splines on the mast mate with an adapter in the main transmission; a 3/8-inch speed wrench provides gear rotation to draw the mast down into the transmission.

• *Twin ATEs:* The YAH-63 is powered by the ATE, the T700-GE-700, in a twin configuration. These engines are widely separated for ballistic survivability and are equipped with infrared suppressors to reduce the signature associated with hot metal and exhaust plumes. Engine cowlings when open serve as work platforms and fully expose the engines for maintenance.

• *Simplified Drive Train:* The drive train of the YAH-63 is greatly simplified. The engines drive directly into the main transmission through widely separated dual input shafts, thereby eliminating the need for intermediate reduction gearboxes. This configuration is the lightest weight, least cost design approach and has a lower overall vulnerable area than one with intermediate gearboxes.

The all new "flat-pack" main transmission has twin laterally-disposed reduction stages which transfer power to a center collector gear. It has approximately 38 percent fewer components than conventional transmissions. The herringbone gears used in the YAH-63's transmission are strong, slow turning, quiet and self-aligning.

The straight line tail rotor drive train requires only a single 90-degree gearbox and includes large

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diameter, slow turning drive shaft elements. This simplified drive train has about 40 percent fewer components than current systems with an intermediate tail rotor gearbox.

Sizing of components for 12.7 mm survivability provides the benefit of additional strength margins. All gearboxes and hanger bearings are designed to have at least 30 minutes of "fly-dry" capability.

• *Small CG Travel:* The YAH-63's small center of gravity travel eliminates the need for movable tail surfaces and improves the aircraft's handling qualities.

• *"I" Tail:* Wind tunnel tests conducted during the predesign effort optimized the YAH-63's empennage arrangement for stability and handling qualities. The resulting "I" tail with fixed surfaces provides pitch stability regardless of fuselage attitude and directional stability in the event of tail rotor loss. Aft placement of the horizontal surfaces results in minimal pitch change during transition from hover to forward flight. The lower horizontal surface remains in clear air during autorotation and high "G" pullups entered from low airspeeds. It also serves as a work platform.

• *Tailboom:* The YAH-63's circular cross-section tailboom is producible, maintainable and survivable. It has fewer parts than normal Bell tailbooms and incorporates hand wrapped, automatically riveted skins. In addition to making production easier, the circular cross-section enables the tailboom to take a 23 mm HEI hit and survive because of its efficient blast-pressure-equalizing characteristics. The detachable tailboom allows for fast field removal and replacement.

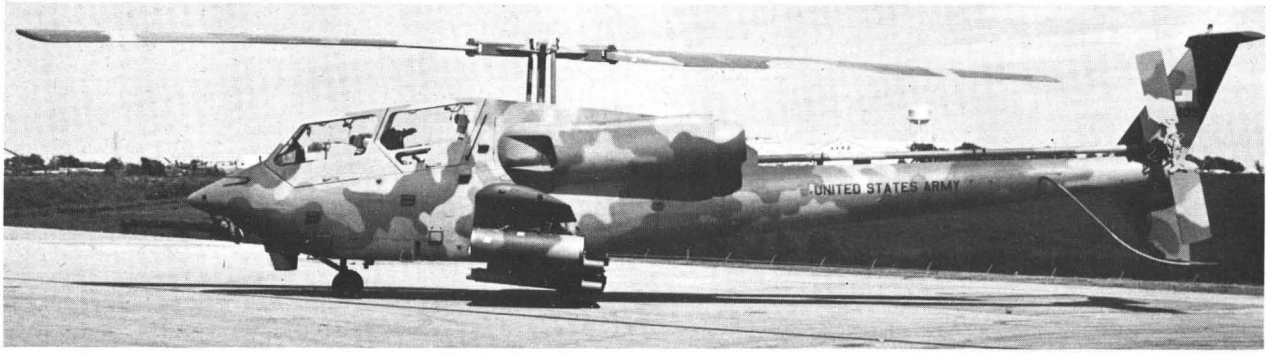
• *Forward Avionics/Electronics Bay:* In the YAH-63, avionics and electronics are consolidated in a single area below the crew compartment, remote and isolated from all on-aircraft gun and missile blast effects. This location greatly simplifies cooling and reduces wire lengths.

Quick opening hinged access doors on both sides of the aircraft permit excellent accessibility and rapid maintenance to reduce downtime and increase availability. Components are grouped according to system to permit rapid, simultaneous maintenance actions on different systems from two sides of the aircraft.

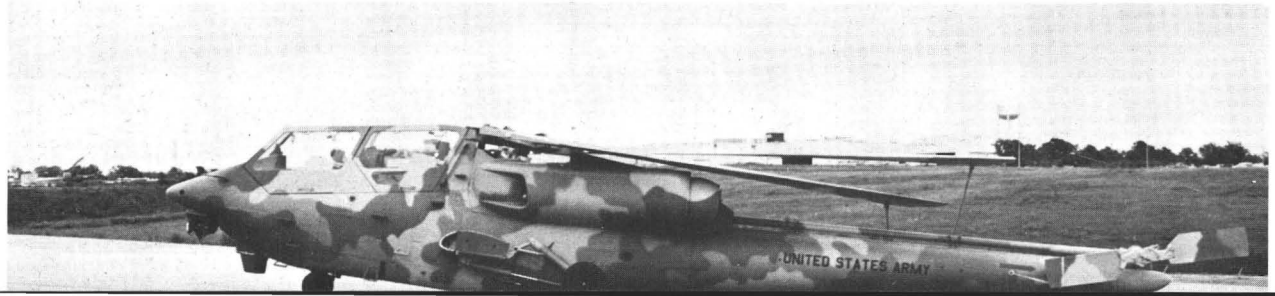
• *Service Center:* A ground level service center allows preflight checkout of fuel quantity, lubricant levels and hydraulic system pressures from one convenient location on the right side of the aircraft. Fiber optic sensors permit the check of oil levels in the main transmission, accessory gearbox, environmental control system compressor and APU. In addition, the service center provides hookups for ground operation and servicing of the hydraulic systems and for auxiliary air to start the engines. A pressure refueling port is located to the right and slightly below the other three service center access areas.

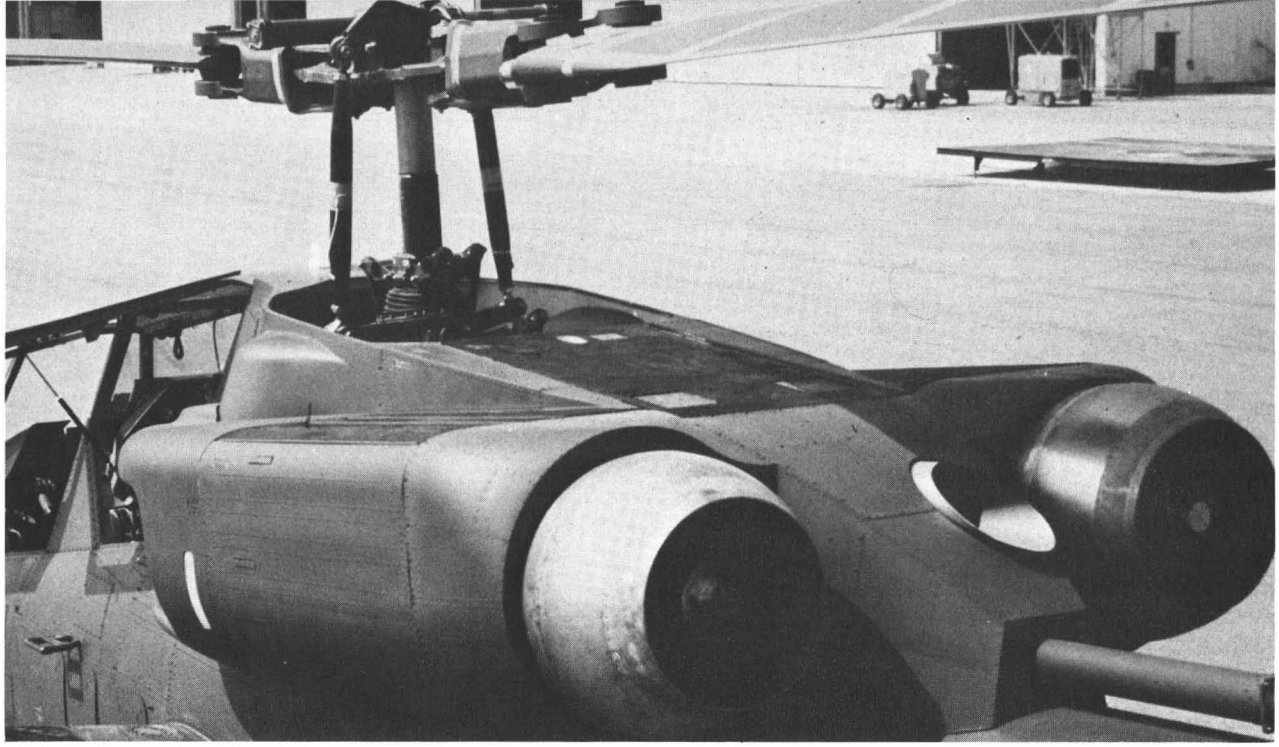
• *Tricycle Landing Gear:* A tricycle landing gear was selected for the YAH-63 because a nose wheel permits easier ground handling, protects the stabilized sight from damage during hard landings and eliminates the additional tailboom structural requirements inherent with a tail-wheel installation.

Bell has drawn upon space-age technology in designing crashworthy, energy absorbing gear that, in combination with crushable structure and seat stroking, protects the crew for vertical landing velocities up to 42 feet per second. The design employs strut-tube cutting in combination with oleo-pneumatic stroking for energy attenuation in a crash sequence. Many tube



The high rotor of the YAH-63 allows full field of fire for weapons and mast may be retracted (below) into transmission for air transport





Engines are widely separated for ballistic survivability. Cowlings when open fully expose engines and may be used as work platforms

cutting tests were conducted to produce a gear that is both lighter and cheaper than a conventional design.

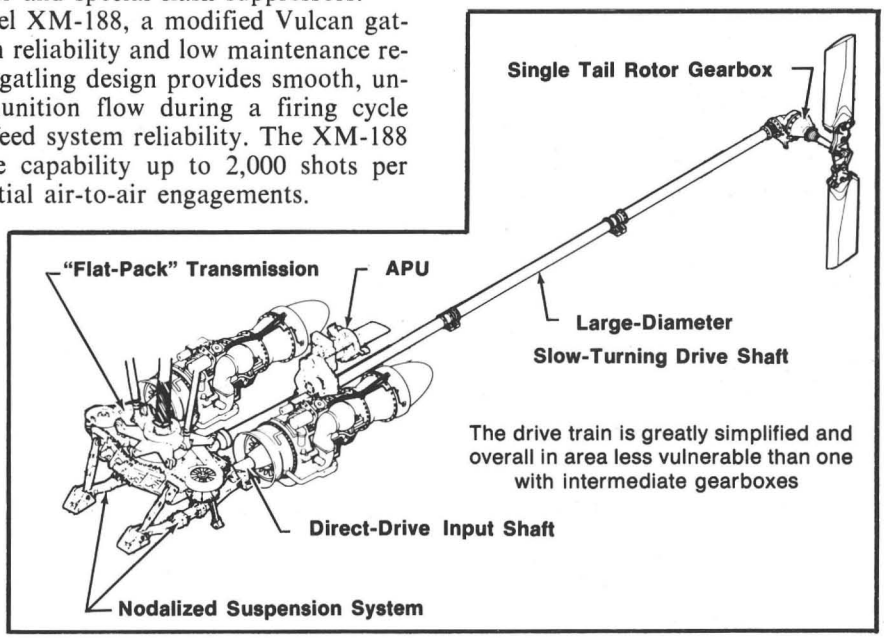
• *30 mm Area Weapon System:* The YAH-63's nose-mounted XM-188 30 mm cannon is ahead of and above the stabilized sight. This forward location eliminates harmful muzzle blast effects on the sight and airframe and fully complies with field-of-fire requirements. The sight picture is not obscured by either muzzle flashes or gunsmoke because of the long 54-inch barrel cluster and special flash suppressors.

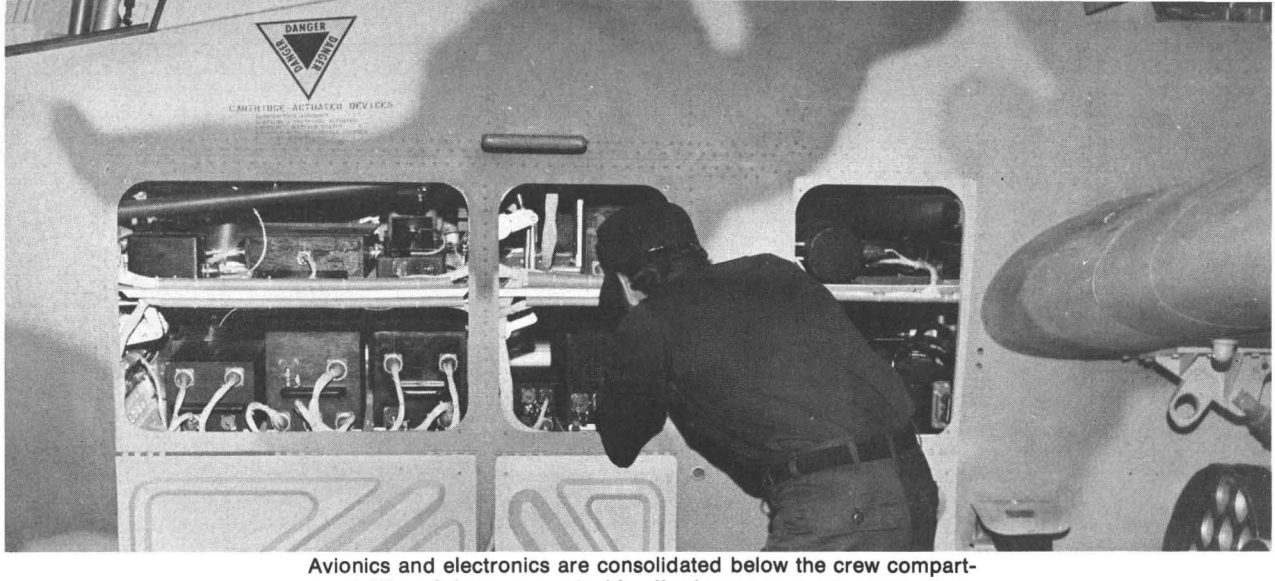
The three-barrel XM-188, a modified Vulcan gatling gun, has high reliability and low maintenance requirements. The gatling design provides smooth, uninterrupted ammunition flow during a firing cycle which enhances feed system reliability. The XM-188 has a rate-of-fire capability up to 2,000 shots per minute for potential air-to-air engagements.

Since hot gun barrels provide a possible signature for infrared-homing missiles, it is important that their temperature be low both during and after gun firings. The three barrels of the XM-188 heat more slowly than would a single-barrel design firing at the same rate.

The ammunition storage system consists of a 1,200-round capacity, low profile rectangular container with an all-new linkless stoke-feed mechanism. The linkless feed system and fixed instead of flexible chutes (except at the turret) greatly reduce the possibility of gun and ammunition system jamming.

The ammunition storage container was designed





Avionics and electronics are consolidated below the crew compartment. Hinged doors on each side afford easy access to components

and located to ensure aircraft and crew survivability in the event of a 23 mm HEI projectile impact or a crash landing. It is remote from the crew, separated from the fuel by a protective barrier, outside of primary structure, and jettisonable like all wing stores. All rounds are stored projectile end down to protect the primers and direct the warheads away from the airframe.

The 30 mm ammunition handling system is designed for rapid reloading through the use of a built-in loader powered by a 3/8-inch speed drive wrench. This system permits quick mission turnaround times in combat situations.

• *Point Target Subsystem:* The HMMS gives the YAH-63 the latest state-of-the-art antiarmor capability. Missiles and launchers will be provided by the Government; Bell will develop the cockpit controls and displays and integrate required electronics and wiring. The YAH-63 can carry up to 16 HELLFIRE missiles on four wing pylons and meet all launch and operational requirements.

• *Aerial Rocket Subsystem:* The YAH-63 can carry up to 76 rockets in four M-200 pods and meets full field of fire and maximum range requirements. The aerial rocket subsystem incorporates remote fuse setting and warhead selection while permitting an adjustable ripple rate.

• *Target Acquisition Designation System:* TADS provides the primary means of acquiring, recognizing, tracking, ranging and designating targets for the YAH-63's weapon systems. It consists of these major subsystems: a stabilized turret assembly; direct-view optics; gunner's night vision; day TV; laser rangefinder/designator; laser spot tracker; automatic video tracker; and displays, controls and associated electronics.

Searching for and acquiring targets can be accomplished by externally computed pointing commands, such as from the helmet sight subsystem or by the copilot/gunner's manual commands. Target tracking can be performed manually or automatically with the video tracking subsystem. Additionally, the laser spot tracker subsystem can track targets designated by another laser located on the ground or on another aircraft.

• *Helmet Sight Subsystem:* Ultrasonic helmet-mounted sights, requiring no mechanical linkages, are provided for the YAH-63's pilot and copilot/gunner. A helmet-visor reticle allows a crewmember to establish the line of sight to a distant target for weapons fire control, visual cueing and TADS target acquisition. Four piezoceramic ultrasonic transmitters, mounted in pairs on each side of a helmet, in combination with six seat-mounted receivers (three on each side), permit the digital fire control computer to calculate target line of sight.

• *Pilot Up Front:* The threat environment and Army tactics dictate that the AAH will spend its combat life operating NOE. The YAH-63 locates the pilot up front where he has maximum visibility and maximum 30 mm area coverage for close-in aircraft defense with his helmet sight. In the rear tandem seat the copilot/gunner looks forward through the thick transparent armor which degrades his visibility. In addition, the gunner's over-the-nose visibility is less from the rear.

Earlier Bell gunship design placed the gunner in the front seat to enable him to use the then available simple direct-fire sights. State-of-the-art remote view systems now free the YAH-63's gunner from this restriction.

Human factors studies indicate that the pilot can handle NOE flying with the greatest safety from the front position.

• *Flat Canopy Surfaces:* The YAH-63's flat-plate canopy has only four different planes. This significant-

Refer to Glossary on page 9

ly reduces the area on the ground where an observer can detect canopy glint (sun reflection) and receive a visual cue that an aircraft is in the vicinity. Analysis shows that all-flat canopy surfaces on the YAH-63 reduce the area of glint coverage by at least 75 percent over that for a compound-surfaced canopy.

With the pilot in the front crew station, the reflection of exterior lights and images is not a distraction.

• *Crew Station Design:* Bell conducted many human factors engineering experiments and time-and-motion studies to determine the best possible crew station layout and instrument lighting intensities, scale design, arrangement and function integration for both day and night operation.

In seeking a way to eliminate instrument light reflection from the flat canopy, Bell pioneered the use of antireflection louvers attached to the panels between rows of instruments. These louvers were tested at night and proved to be extremely effective in preventing reflections.

Bell also developed an integrated display status panel for the copilot/gunner's station. It provides the status of all weapon systems on one panel—information that otherwise would be found individually on several different panels.

• *Optimized Crew Protection:* Optimized armor placement protects both crewmembers. Armor seats and opaque panels attached to the sides of the seats, walls and floor protect against the 12.7 mm threat. A transparent armor barrier located between crew compartments prevents the incapacitation of both crewmen from the blast and fragments of an exploding 23 mm HEI projectile.

COST CONSIDERATIONS: Bell's DTC program has been very effective in controlling average unit aircraft production cost. Fluctuations have occurred in the DTC value as it has been tracked throughout the program; but no major cost excursions have been experienced because of remedial actions taken by the DTC group.

Specification design changes were permitted by the Government during development within certain stated limits. This ability to make changes permitted creative solutions to control potential cost increases. Producibility analysis proved very valuable in redesigning components to reduce their cost without altering their design effectiveness.

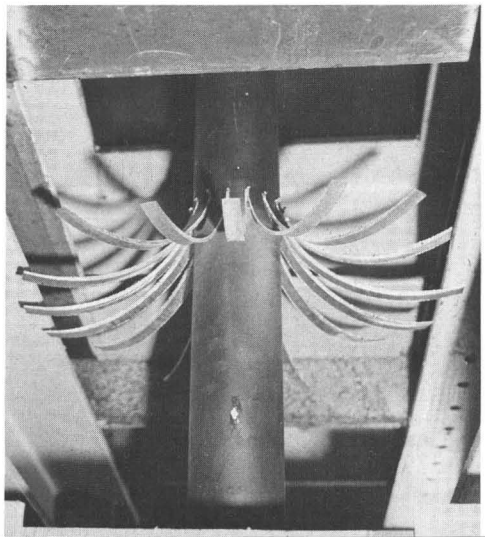
Bell's LCC efforts have centered around developing a comprehensive computer model and using it in the design decision process by determining the total cost impact of design changes and by conducting system trade-offs and assessments. This model permits both peacetime and combat situations to be considered during the fleet's life so that primary operating cost drivers—R&M and survivability—and their related design characteristics can be fully evaluated along with all other pertinent cost contributors.

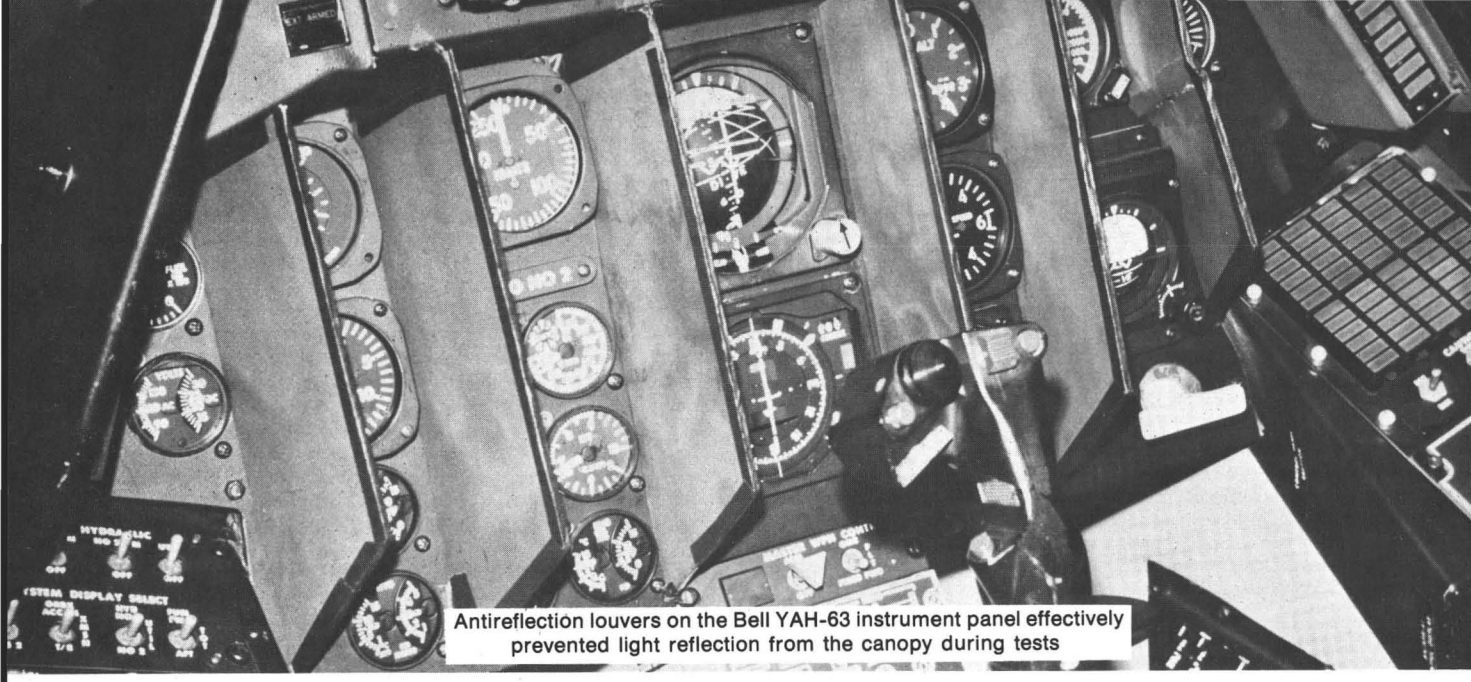
AAH PHASE 1 DEVELOPMENT PROGRAM: Phase 1 required that two flying prototypes, one ground test vehicle and one structural test article be built and tested. A goal of 255 flight hours was established for development testing and envelope expansion. The GTV was used to prove and qualify the dynamic components in support of the flight program.

In early stages of development, a complete aircraft mockup was built and used to investigate component arrangement and clearance interfaces to refine total system design. Also a complete hydraulic/pneumatic subsystem simulator was constructed to aid in checking the functioning of the entire installation prior to aircraft assembly. Both the aircraft mockup and hydraulics simulator proved invaluable in the design development process.

Throughout Phase 1 many bench, fatigue and static tests have been conducted to support the aircraft development program. All drive train components are being thoroughly bench tested. All critical load carry-

Energy absorbing main gear employs strut tube cutting (left) as shown during test. Three-barrel XM-188 30 mm cannon (right) is a modified Vulcan gatling gun. It has a rate of fire of up to 2,000 rounds per minute





Antireflection louvers on the Bell YAH-63 instrument panel effectively prevented light reflection from the canopy during tests

ing components were fatigue tested to substantiate a safe life prior to Government Competitive Test. Of the 23 dynamic components that were tested, most had lives well in excess of the 4,500-hour requirement for the production aircraft. Extensive static testing of the STA has been accomplished, including a simulated 3.5-G jump take-off from zero forward velocity, high speed yaw flight condition and critical nose-gear landing. These tests demonstrated the structural integrity of the YAH-63's airframe.

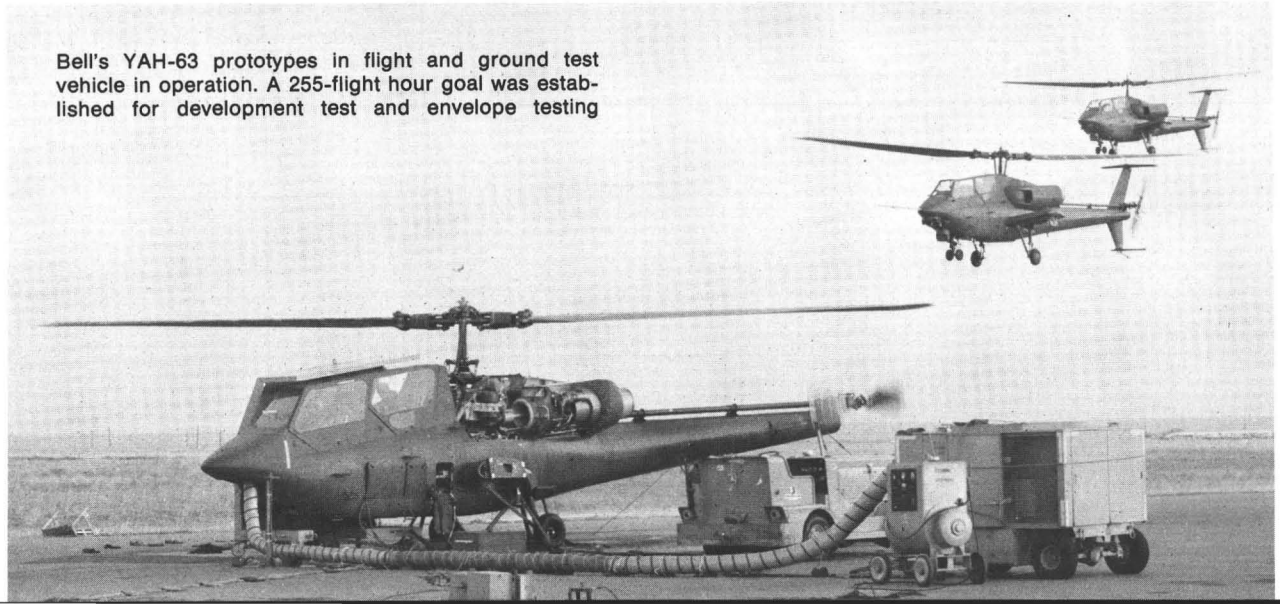
Prior to and during Phase 1 more than 150 design support tests were performed. These included ballistic impact and damage tolerance tests of both components and subsystems.

Also during Phase 1 Bell conducted the first vulnerability verification tests ever performed during development of an Army aircraft. These tests successfully demonstrated 23 mm HEI ballistic damage tolerance of such items as the tailboom, ammunition container and main rotor blade. The tolerance of the main rotor pitch links, controls mixer, and tail rotor blade grip was demonstrated to multiple hits by 12.7 mm AP projectiles.

New mid-intensity requirements for the AAH demanded an innovative approach—one that led to designing, developing and testing an all-new aircraft capable of meeting the tough air defense threats and special mission prerequisites of the 1980s. The result—the YAH-63—is a combination of Bell's gunship manufacturing and systems integration experience. The aircraft's design characteristics fully satisfy both technical and cost requirements. These characteristics are a sound balance of performance, firepower, survivability and R&M requirements.

Lack of major configuration changes to the YAH-63 during development has resulted in cost, weight and performance savings. The YAH-63 as it exists today is essentially identical to the pre-Phase 1 proposal mockup.

The design of the AAH weapon system is not finished. The important job of full aircraft qualification and subsystems integration still remains. Bell looks forward with confidence to the further successful development of the YAH-63.



Bell's YAH-63 prototypes in flight and ground test vehicle in operation. A 255-flight hour goal was established for development test and envelope testing

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UTTAS Unveiling

Continued from page 24
Column 1

relative sophistication, it can be maintained in the field with 10 simple tools—less than you use on your car at home. These engine features coupled with the tremendous improvements found in the airframe and dynamic components mark the UTTAS as one of the most advanced rotary wing developments to roll from U.S. production lines.

It is most fitting that this acceptance ceremony should take place at Fort Benning, GA, the home of the Infantry, for it is here that the need was first expressed and the documentation prepared which has led us to this milestone. It is the Infantrymen who will benefit most from the tactical advances the UTTAS will offer. Not only can a full squad be carried into the battle aboard a single aircraft, but the squad can be moved quicker and with far greater survivability than ever before. From crashworthy seats to crashresistant fuel cells and unprecedented agility, this aircraft is designed to survive the rigors of battle more so than any of its predecessors in the Army fleet.

With respect to the actual development schedule, it is sometimes said that hardware is too long in coming. But the UTTAS is an excellent example of what can be done once the requirement is clearly defined, the program approved and industry swings into action. The bulk of our time is sometimes spent in deciding what we want, not how to build it. In this case, from contract award in late August 1972, first flight came only 26 months later. And, subject to the outcome of these competitive tests, production aircraft could be available in 1978. It is just such visible evidence as this of Army hardware on the move that we need to posture our forces for the future. Much has been said in all forums of late about the Soviet threat and how the Warsaw Pact is out-stripping us in men and materiel. In the area of helicopters, we continue to have a qualitative and quantitative lead. With systems such as the UTTAS and the technology it represents, this lead can be protected.

Today, the UTTAS moves into the home stretch. As it now passes into the hands of the trainers and the testers, I challenge you who will do the testing, to wring it out. Find its faults. Test it to the very limits. Don't pull any punches and don't use kid gloves. [We want] to know what's good about these aircraft and what's bad. Now is the time to identify problems and fixes—not after the first UTTAS companies have rolled from the production line to the troops in the field.

We have done the research and development, now the true measure of our product lies ahead in its test and evaluation. In hundreds of flying hours, these aircraft have proven themselves airworthy in the eyes of the contractor. Now we in the Army must determine which is most worthy to join the Army team.

The Honorable Edward A. Miller
Assistant Secretary of the Army
For Research and Development

Major General William J. Maddox and Major General Jerry B. Lauer pause for a chat during UTTAS unveiling

Continued from page 24
Column 3

port elements fluid and continuously on the move.

Before the attack, the commander is going to have to keep his force sufficiently dispersed and fragmented to prevent a lucrative target for mass destruction weapons. At the critical moment of the attack he must mass his forces quickly; gain sufficient combat power to achieve his strike objective; and immediately disperse.

To gain this kind of mobility and tactical speed, our Army is going to need a full-squad utility helicopter with improved speed. . .reduced maintenance demands. . .and a high ability to survive. But that helicopter has to be more:

- It's got to be a fast, reliable medical evacuation ship.
- It must provide the lift and capacity to move large quantities, long distances.
- But most of all, it has to be reliable.

High inflation, competing budget demands and long development lead times allow few opportunities for quantum improvements in aviation systems. And once those new models are developed and deployed, we are going to have to rely on them for a long time.

That is specifically why these [UTTAS] prototypes you see here today have got to be the best. . .the very best that the genius of American business can put together. I'm convinced that this is exactly what is represented here.

We see in these splendid aircraft not just the genius of huge business enterprises like Boeing-Vertol, Sikorsky and the General Electric Corporation, but we see here the combined genius of hundreds of subcontractors who contributed in their specialized ways toward making this day possible.

Our Soldiers deserve to have. . .and must have. . .a tactical helicopter which is second to none—a helicopter that will give our Soldiers and our field commanders the airmobility which, in conjunction with the combined arms team, will knock the enemy off balance; keep him off balance; provide a battlefield fluidity heretofore unknown; and give our Army the added edge it needs to meet any foe, anywhere, and make him wish he'd never taken the field of battle against the modern American Army.

General Walter T. Kerwin
Vice Chief of Staff
U. S. Army

GOING UP!

Ted Kontos
Publications and Graphics Division
U. S. Army Agency for Aviation Safety

NORTHBOUND GEESE, budding trees and sprouting greenery all signal the approach of spring and summer; but the one infallible sign that winter is on its way out can be found at virtually every department store in the form of fall and winter merchandise clearance sales. And these have been in progress for some time.

To many, the approach of summer conjures visions of placid lakes, sunny beaches, fish fries, swimming, boating and all the usual warm-weather activities. But to most Army pilots, mechanics and supporting aviation personnel, it means an end to the old problems of ice, snow and slush, and the beginning of a new set associated with heat. What effect will summer temperatures have on you? Your equipment? General safety? Let's take a look at what we can expect.

Personnel. When temperature is within the comfort zone, the human body gets rid of heat primarily by radiation and secondarily by evaporation. As environmental temperature rises, the two processes reverse their roles, with evaporation becoming the chief means of transferring body heat, and radiation the secondary one. If the humidity is high, hindering evaporation, or if for any reason cooling is inadequate, perspiration will increase, causing the body to lose an increased amount of both water and salt. Should hyperventilation (panting) occur, the level of carbon dioxide (CO_2) in the blood may also decrease. These losses can set the stage for any of the various heat illnesses.

In addition, the body's circulatory system plays an important role in ridding the body of excess heat. Blood vessels dilate and the heart beats faster to transfer more heat from the center of the body to the skin. Consequently, the cardiovascular system is operating under a strain—a condition that can be aggravated by dehydration which results from excessive loss of water.

The three common forms of heat illness (cramps, exhaustion and stroke) can occur singly or in combination.

Heat cramps are painful cramps of the voluntary muscles of the extremities, usually involving the abdominal wall. They usually result from heavy salt losses, and treatment consists primarily of replenishing the body with salt.

Heat exhaustion occurs when excessive amounts of both salt and water are lost. Symptoms include headache, mental confusion, incoordination, weakness, lack of appetite, vomiting and visual disturbances. Cramps may also occur. Skin is generally cool, moist and pale. Pulse is rapid and blood pressure low. Treatment includes movement of the patient to a cool environment and replacement of water and salt losses.

In contrast to heat cramps and exhaustion, heat stroke is a serious medical emergency. The mortality rate for victims who do not receive prompt and adequate treatment is extremely high. While symptoms of headache, dizziness, nausea and weakness may appear, the onset usually occurs suddenly, with collapse and coma. Convulsions may occur. The patient's skin is usually hot, dry and red, with an absence of sweating. Breathing is generally deep and rapid. Body temperature is markedly elevated (106°-110° F.). As the patient's condition deteriorates, the pulse becomes more rapid, blood pressure decreases

and breathing becomes shallow and irregular. The first most important objective of treatment is the rapid lowering of body temperature. Needless to say, *professional medical help should be obtained without delay.*

The best prescription for ills that can be brought on by summer heat is prevention. This involves acclimatization which results in a remarkable increase in the capability of an individual to live and work efficiently in a hot environment. But acclimatization takes time—usually around 10 to 14 days for a healthy individual. The procedure consists of following a work schedule that allows a gradual increase in the expending of energy until the body becomes capable of accomplishing normal workloads without being adversely affected by heat. Some factors that can prolong the time it takes an individual to become fully acclimatized include obesity, fatigue, dehydration, use of alcohol, the presence of any vascular disorders, and any prior occurrence of heat illness. But regardless of how good an individual's health and physical condition may be, a minimum period of time is still necessary for acclimatization to be completed. It cannot be rushed. Therefore, it is important to be particularly cautious during the first few days of hot weather or the first few days after moving into a hot geographical area, keeping in mind that regardless of the degree of acclimatization, water and salt losses must constantly be replaced.

Because of the limited physical activity of the aviator and the decrease in temperature with altitude, heat stress in military aviation is often underestimated. Yet, airfields can become extremely hot places, and heat stress during ground operations is likely to be extreme for aviators as well as for ground personnel. Even at altitude in cooler temperatures, the heat gained by radiation through the canopy is significant.

Mechanics, on the other hand, by the nature of their work are much more susceptible to heat exhaustion than are aviators. Consequently, ample supervision is needed not only to ensure maintenance is properly performed but also to make certain that mechanics are obtaining adequate water, salt and rest necessary to maintain peak efficiency.

Since water and salt losses cause dehydration and reduced efficiency long before any sign of heat illness, ensuring an adequate intake of water and salt is essential. Even though our bodies can recover after water deficiencies of 10 to 15 percent of body weight, losses of even 1 to 5 percent produce discomfort and a decrease in efficiency. The amount of water required depends on the amount of sweating which occurs and varies from one individual to another. And remember, thirst is not a dependable indicator. Water should be taken frequently. And while the amount of salt in food may be adequate under average conditions, additional salt is usually required during hot weather operations. Because salt tablets taken whole tend to cause nausea in some individuals, it is better to dissolve the tablets in water. Two salt tablets in a canteen of water make a satisfactory solution.

It is the pilot's responsibility to ensure that an adequate supply of water for himself, crew and passengers is included along with survival gear aboard his aircraft.

Wearing proper clothing should be another prime consideration as sunburn can be extremely painful and, in many instances, a serious matter.

Equipment. Aside from the direct effects on the human body. extreme heat poses other hazards to both personnel and equipment. Aircraft surfaces and metal tools exposed to direct rays of the sun can become hot enough to cause severe burns and blisters. When the sun is shining and the outside air temperature is 96° F., the metal skin of a parked aircraft painted olive drab registers 136° F. In one test, the pilot's shoulder harness buckle reached a measured 150° F. In addition, canopies and other acrylic surfaces soften and can be easily damaged. Fuel drums are more likely to spring leaks; and fuel can vaporize more readily, increasing the chances of fire and explosion. Similarly, oil- and grease-soaked rags add to the threat of fire.

To prevent personal injury from hot tools and aircraft surfaces, gloves and mats or pads should be used when practical. If possible, aircraft should be protected from excessive surface temperatures by covering with canvas or native matting. Canopies should be left partly open to permit circulation of air within the cockpit, except during dust or rain storms. And all windshields and acrylic surfaces should be gently cleaned by flushing with water and using hands to remove dirt, dust and other particles.

If fuel is being used from drums, the drums should be kept covered and, if possible, the temperature maintained below 102° F. When drum temperatures exceed 120° F., extreme care must be exercised to prevent sparks and possible fire or explosion. As always, only bronze or nonsparking tools should be used to open gasoline drums. The drums should be opened cautiously to relieve internal pressure and prevent fuel from spewing. Rags saturated with fuel, oil or grease should be disposed of promptly.

Some items of equipment will require more frequent inspections and care. For example, heat and

friction are two major enemies of tires. Obviously, a pilot who lands his aircraft at speeds of 10 to 20 knots above normal is going to generate a lot of extra BTUs. Add to this any heat generated by excessive or improper brake application, and permanent accumulative tire deterioration will occur, with a strong possibility of blowout.

Proper inflation is of prime importance. Underinflation can cause high tire temperatures during ground rolls and premature tire wear. Overinflation coupled with high temperatures can result in excessive tire pressure, uneven wear and tire failure. In addition to deterioration from improper inflation, friction and high temperatures generated during operation of the aircraft, tires can deteriorate during storage if they are subjected to high temperatures or to a corrosive atmosphere.

Tires and similar equipment, such as seals and bungee cords, should also be inspected frequently for blisters and other signs of deterioration. Vibration isolators may have to be checked as often as every two weeks and replaced if cracking or permanent set is excessive.

Batteries require extra care during hot weather operations. Vents should be checked often to ensure they are clear, proper electrolyte level is maintained and unnecessary battery drain during ground checks with engines shut down is avoided.

Density altitude. The relationship of pressure, temperature and humidity of air establishes density altitude. Basically, we can express density altitude as the relative altitude or loadlifting ability of air as it expands and contracts. And this expansion and contraction can, at times, seem unbelievable. For example, depending on weather and time of day, density altitude at one Army airfield may vary from minus 1,000 feet to plus 4,000 feet. A UH-1H at a given weight that will permit it to clear a 50-foot obstacle with a zero ground run under standard (15° C.) sea level conditions will require a takeoff distance of 225 feet and an airspeed of 20 knots to clear the same obstacle when the temperature rises to 35° C. As a rule, shifts in density altitude in desert areas occur rapidly, often and are usually large.

Not only does low density air (high density altitude) affect lift but also engine performance. A reciprocating engine can lose as much as 12 percent of its rated brake horsepower from high humidity alone. A gas turbine engine will operate approximately 85 percent as efficiently at a temperature of 100° F. as it will when the temperature is 59° F. Although the volume of air flowing through the engine may remain constant, the thinner air at high density altitude contains less mass, and thrust (power) is lost.

Following are a few time-proven, commonsense rules to follow:

- Compute density altitude before weight and balance.
- Always assume density altitude to be a trifle higher than it probably is.
- Study the dash 10 density altitude tables and act accordingly.
- Use the go-no-go placard available in your aircraft.
- Perform HIT checks before flight.

In addition, it is important to ensure all maintenance is properly performed. Last summer, compressor stalls plagued one Army aviation unit to the extent that they grounded all their aircraft until the cause could be determined. Rerigging the inlet guide vanes and bleed bands eliminated the problem.

Keep in mind that an engine with some degree of compressor blade erosion may function normally under heavy loads during cold weather operations; yet, that same engine may suddenly encounter compressor blade stall and fail when operated under similar loads in hot weather.

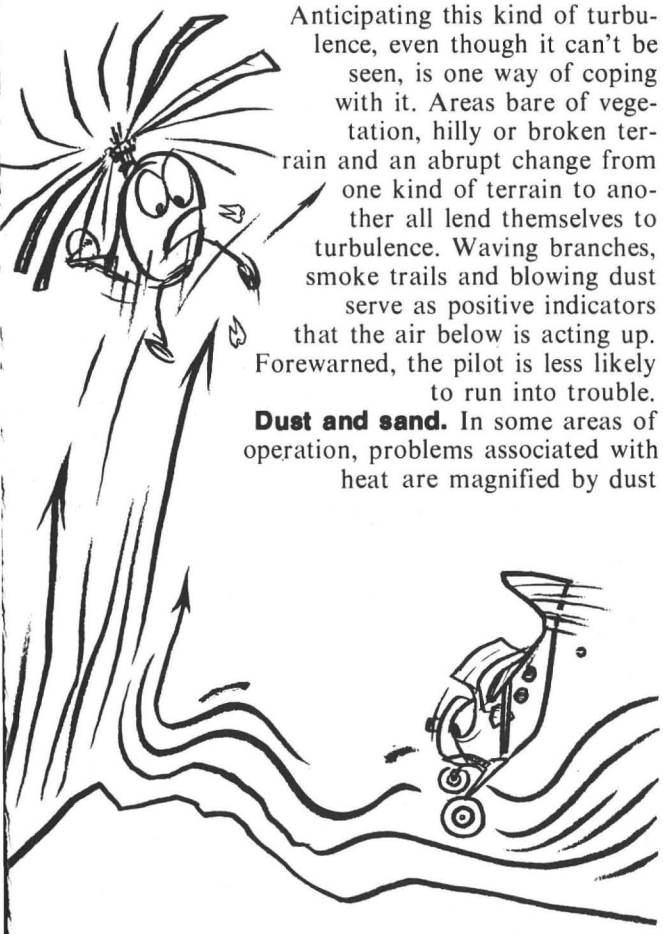
Weather. As if heat, humidity and altitude were not enough to contend with, the pilot also must face severe thunderstorms and turbulence during summer operations. One source estimates that approximately 1,800 thunderstorms are in progress over the earth's surface during any given moment. *Since no procedures exist that can guarantee safe flight through thunderstorms, the best course of action is avoidance.* With all the facilities such as weather forecasts, advisories, special advisories, pilot's reports and radar coverage available to the pilot, in addition to alert flying on his part, there is little reason for accidentally flying into a thunderstorm.

Nature provides us with numerous devices to warn us of impending thunderstorms. Clouds are excellent signposts of convective air currents that build cumulus clouds. Billowy white puffs may increase in number and size, change in form and often become cumulonimbus or thunderstorm clouds with varying degrees of turbulence, rain, lightning, and sometimes, hail. A towering cumulus can change into a raging thunderstorm in as little as 10 to 15 minutes. Excessive radio static may also indicate the approach of a thunderstorm.

While airmass thunderstorm cells usually build up over land during the heat of the day and break up in the early afternoon or early evening, either airmass or frontal type thunderstorm may be encountered at any

time. Storms that are scattered can generally be circumnavigated; *but no attempt should be made to climb over, slip under or penetrate a solid squall line.* In addition, gusty surface winds and downdrafts that precede a thunderstorm can be exceptionally violent and have caused fatal accidents. Trying to take off or land when a thunderstorm is approaching an airfield is an extremely hazardous practice.

Turbulence. Although turbulence caused by thunderstorms is the most violent variety, that associated with heat and terrain should not be overlooked. Heated thinning air rises in the form of thermals, pulling cooler air along the ground. Thin air boils and bubbles as it flows over hills, and hits peaks and ridges. While under normal conditions turbulence is little more than an added irritation, when it is teamed with high density altitude, it can place the pilot in a precarious position. He may suddenly find himself on the ground after encountering an unexpected gust he would ordinarily have been able to handle with ease.



Anticipating this kind of turbulence, even though it can't be seen, is one way of coping with it. Areas bare of vegetation, hilly or broken terrain and an abrupt change from one kind of terrain to another all lend themselves to turbulence. Waving branches, smoke trails and blowing dust serve as positive indicators that the air below is acting up. Forewarned, the pilot is less likely to run into trouble.

Dust and sand. In some areas of operation, problems associated with heat are magnified by dust and sand, and special precautions must be exercised. The gas turbine engine, for example, easily ingests blowing dust, sand and any other particles that may be in the air. This sandblasting effect causes rotating and stationary vanes to change shape, varying the airflow and fuel-air ratio. Surge, loss of power, possibly compressor stall, along with a rise in egt, can result.

Sand and dust have equally adverse effects on reciprocating engines. Air filters become clogged, cylinders become scored, compression decreases and loss of power or even failure can result. In addition, propeller blades can become pitted; pitot and static ports, clogged; and fuel, oil and hydraulic fluid, contaminated.

To prevent entry of sand and dust, covers and dust excluder plugs should be installed on all engine openings, vents, air intakes, exhaust outlets, breathers and over all other vital components and openings, including pitot and static ports. Similarly, engine runups on hard surfaces, when possible, will lessen the chances of damage to engines and rotating airfoils as well as to canopies and surface skin.

Care must be exercised when performing all servicing operations to prevent sand from entering aircraft and engine systems. Oil and hydraulic fluid should be transferred directly from can to tank.

Inspections should be frequent and thorough. Filters should be cleaned or replaced at regular intervals. Flight controls should be checked often for freedom of movement, and control cables for specified tension. Aircraft and engines should be cleaned as needed.

During ground operations, adequate distances should be maintained between aircraft. Aside from clogging air filters, the sandblasting effect produced by blowing sand can cause havoc to windshields and canopies.

Dust and sand can adversely affect flight safety by drastically reducing visibility. Helicopter pilots who attempt hovering takeoffs, and fixed wing pilots who reverse their propellers during landings may find themselves suddenly and completely on the gauges.

Blowing dust and sand can also effectively hide terrain features and landmarks as well as wires and other obstructions. Thorough ground and air reconnaissance is a pilot's best insurance.

Yes, winter is gone; and like the elevator operator who loudly announces, "Going up!" as he beckons his passengers to enter, all the signs of summer are emphatically proclaiming that temperatures are about to start their long, and sometimes rapid, climb in true and ancient tradition. The smart pilot will be ready for them.

Third in a series of four articles on

why pilots make errors

USAAAVS

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IN PRECEDING ARTICLES we talked about the scientific approach to psychology, i.e., the study of behavior. We talked a little about learning. The procedures we use to produce a learned behavior are positive and negative reinforcement. One procedure we can use to suppress a learned behavior is punishment. We viewed positive reinforcement as presentation of something the person likes. Negative reinforcement was removal of something the person does not like. Punishment was presentation of something the person does not like.

We need to take a closer look at likes and dislikes as we have discussed up to this point. How do I know what a person likes or dislikes? Having no direct channel to devine truth, I don't have any idea what a person likes or dislikes. I wouldn't even rely on people, especially aviators, to tell me what they like or don't like. Some aviators would say they like to fly 24 hours a day and they would rather fly than eat. Chances are that after flying 48 hours with no food, you'll find they've been pulling your leg.

Well, if we can't trust our judgment about other people's likes and dislikes and if asking them won't help either, what do we do? The answer is, simply, start being an "expert people watcher." The "expert people watcher" is a rare fowl who leaves his preconceived notions back in his nest. Knowing that people will engage in behavior for something they like, the "people watcher" looks at repeated behavior and the consequences of this behavior.

Be prepared to accept the fact that all people do not like the same things. Bob Hope likes laughter at the end of every sentence; my boss is not all that hopped up about it. The commander may feel that some form of restriction is excellent punishment. What he doesn't see are the barracks buddies sympathizing with the restrictee's unfortunate plight. The sympathy may be more of a reinforcement than the punishment of restriction. If it is, you can bet the trooper will be back for some more restriction. The unsafe pilot who relates his hairy tales of derring-do and receives the hearty approval of his comrades over a glass of ale will

continue to bask in the glory of his deeds—until the consequences change, like C-R-A-S-H. Look for a behavior and look for the consequences.

Changing Behavior

If you run across a behavior that is undesirable, look closely for the consequences. Also keep in mind that behavior may be a product of the physical state of the person. John Schmuck has been a brilliant worker, perfect in all ways, the gleam in the eye of his supervisor. Lately Schmuck's performance has been below par. Everything he does just turns into a puddle of proverbial sewage. The first thing anybody should do, be he supervisor, bosom buddy, or one of Schmuck's lackeys, is to get Schmuck to the flight surgeon. One of the symptoms of physical illness is a change in behavior. Kids with colds don't play as much. Pilots with the flu don't fly as effectively. Let's take care of physical problems first. Only after the possibility of physical illness has been ruled out should we attempt a behavioral change.

The first thing we must do to bring about a behavioral change is specify a behavior. Improving a man's job performance is a pretty big order.

Look at specific behavior that makes up the overall job performance. In a previous article we talked about Joe Turkey leaving tools in aircraft. This is a specific behavior we can work on. Of course, up to now with all this talk about people behaving, receiving something they like, then repeating the behavior, one way of changing behavior should be fairly obvious. Simply remove that thing that reinforces the behavior. If praise and attention is something Joe Turkey likes, stop praising and showering attention on Joe Turkey. Psychologists refer to this as *extinction*. Extinction or the removal of reinforcement is not the most efficient way to change behavior but it's a start.

There are a multitude of funnies you should know about attempting to change behavior by extinction. First of all, initially you'll most likely get an increase in the behavior you are not providing reinforcement for. Joe Turkey may move the whole toolroom out to the next aircraft he works on. Secondly, you'll probably notice just a whole bunch of behavior that Joe Turkey has never done before. It may be good, such as doing a fast job, or it may be bad, such as blowing up half the aircraft on the line. Third, if the behavior has been reinforced for a long time, extinction could take quite a while. We'll talk more about this in a later article.

Since problems arise when we use only extinction as a procedure for changing behavior, let's go one step further.

Not only do we want to stop undesired behavior, we want to replace it with a more desired behavior. We can handle this all at the same time. Let's take a look at Joe Turkey and see how we might change this undesired behavior, "leaving tools in the aircraft," to something more desirable, "removing tools from the aircraft." We have pretty much established that Joe Turkey likes praise and extra attention (reinforcers). Here we go: Turkey finishes a job, walks in and states, "Well, there's another job done." Joe's supervisor holds his praise and attention. He does not make a big deal of getting someone to inspect Joe's work. He simply takes Joe to the aircraft and inspects his work. The effort is made to put all "tool-leaving-in-aircraft" behavior on extinction. No praise, no attention, no fuss.

During the inspection the supervisor finds a tool left in the aircraft. He does not pick it up, carry it back or make a big issue of this problem. Again, Joe's supervisor is holding the behavior on extinction (no praise or excessive attention about leaving tools in aircraft). The supervisor may point to the tool or mention that Joe should get it. Joe picks it up, carries it back to the shop and deposits it somewhere in the required manner. Now we have a behavior that is desired. Now we reinforce Joe Turkey. Lavish praise is heaped upon him for a good job (if the job was good).

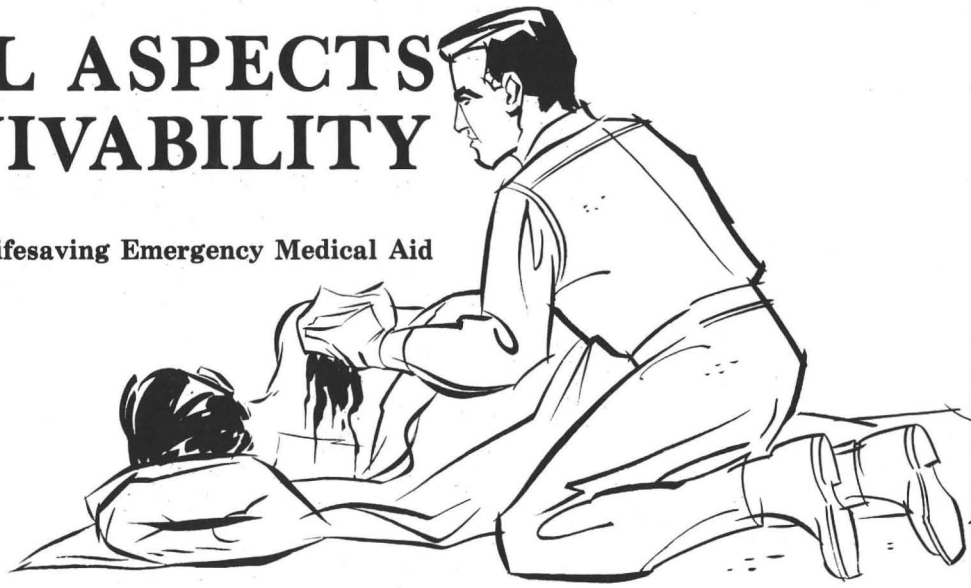
To recap, there are some very important points we should begin to draw from this simple example. The supervisor made no effort to bring any attention to Joe until he was assured of the desired behavior. The supervisor did not help Joe do Joe's job by removing a tool or carrying it. A natural reaction for many supervisors is to grab the tool, shake it at Joe and inquire, "What the h--- is this, Turkey?" then carry the tool back in a disgusted manner. The supervisor who uses sound behavioral principles will get Joe to do the desired behavior. The supervisor should reinforce Joe's behavior when it gets close to what the supervisor desires. Praise, attention, a soft drink, given as rewards for a job well done, go far in assuring that jobs will continue to be done well.

To Sum Up

We have looked a little deeper at how psychologists picture reinforcement and punishment. We emphasized that before attempting to change any behavior we should ensure that a physical or medical problem exists. We have talked about one way (extinction) that behavior can be changed. We used a simple example of how an undesired behavior can be changed to a more desired behavior. In the next article, we will look at some more methods used to bring about a desired behavior.

Many lives can be saved with adequate emergency medical aid within the first few minutes after an accident. This article is not designed to make you an expert in emergency medical aid or survival medicine, but it is intended to refresh your memory in these areas and motivate you to learn more about the subjects.

MEDICAL ASPECTS OF SURVIVABILITY



Part I - Lifesaving Emergency Medical Aid

FEW PEOPLE REALIZE how much the human body can tolerate in a survival situation. Fortunately, not many have to find out the hard way as did Captain Eddie Rickenbacker, America's "Ace of Aces" of World War I, and his seven companions in 1942. After ditching their B-17 Flying Fortress in the Pacific, all except one endured exposure to heat and cold, hunger and thirst and injuries for 21 days while afloat on three small liferafts.

Having time to prepare for the ditching, they filled the thermos jugs with water and coffee and placed them and the emergency rations box close to the exit. Because of high swells and the overturn of one of the rafts, the water and rations were lost.

Their total possessions consisted of four oranges, a first-aid kit, 18 flares and a flare pistol, two hand pumps for both bailing and renewing the air in the liferafts, two service sheath knives, a pair of pliers, a small pocket compass, two revolvers, and two collapsible rubber bailing buckets.

During the first eight days at sea, they were without water and food other than the four oranges. The only other food they had during the 21-day ordeal was a sea gull and a few mackerel. When rain came, they caught and stored the water in the Mae West life jacket by forcing it down a narrow tube past the valve into the compartment which previously had been occupied by air.

Suffering from burned, blistered and raw faces, necks, hands, wrists, legs and ankles; salt water sores; injuries; and a great loss of body weight (some as much as 45 pounds), these men were determined to live and, Rickenbacker particularly, never lost hope they would be rescued.

In any survival situation, a person's will to survive is usually tremendous, yet a basic knowledge of survival is also required, especially in cases where medical attention is needed.

When a person is critically injured, three basic lifesaving measures must be taken immediately. These are (1) clearing the airway and restoring breathing, (2) stopping massive bleeding and restoring heart action and (3) administering shock control measures.

When confronted with a casualty, quickly confirm whether he is breathing and check for a heartbeat. A quick examination can determine whether a casualty is breathing. Observe his chest for any movement or place the cheek and ear in front of the casualty's mouth

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and nose to detect any air movement by sound and the sense of touch. If neither breathing nor heartbeat are present, the following should be accomplished immediately and almost simultaneously.

Clearing the airway and restoring breathing. Before administering artificial respiration, always check to see that the airway is unobstructed. The airway must be clear to allow free flow of air to the lungs. To clear the airway, turn the casualty's head to one side and quickly remove any foreign material from the back of the mouth and throat by running the fingers behind the lower teeth and over the back of the tongue. Also remove full or partial dentures. With the victim lying on his back on a hard flat surface, place one hand under the neck to elevate it and use the other hand to tilt the head backward. (If neck injury is suspected, extreme care must be taken during this procedure! Time is of the essence, but resuscitation attempts will be in vain if extensive damage to the spinal cord is caused by vigorous manipulation of a broken neck.) Next place a thumb in his mouth, fingers under the chin, and pull forward to open his mouth. In many cases breathing will begin spontaneously once this has been done. If not, ARTIFICIAL RESPIRATION MUST BE STARTED IMMEDIATELY.

The mouth-to-mouth method of artificial respiration is preferred except when there are severe facial, jaw or neck injuries, muscle spasm locking the jaw closed or voice box spasm preventing free flow of air. These require a tracheotomy performed by an individual trained in emergency resuscitation.

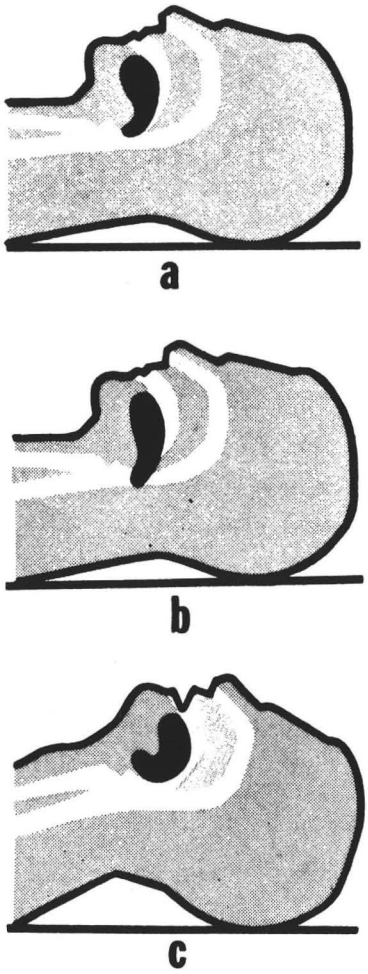
To perform mouth-to-mouth ventilation, hold the casualty's head in the proper position to maintain a clear airway. Keeping his head back and jaw forward with one hand and holding his nostrils closed with the fingers of the other hand, take a breath, place your mouth over his and exhale firmly into his mouth. Exhale deeply enough to produce chest expansion roughly equivalent to a normal breath. Extreme pressure is unnecessary and quickly causes fatigue and symptoms of hyperventilation in the rescuer. At the end of a normal, forced expiration, remove your mouth well clear of his. While taking another breath, observe for chest expansion to confirm that air is flowing into his lungs. This completes one respiratory cycle and, after a short pause, the entire procedure is repeated. Repeat this cycle about every 6 seconds until the casualty starts to breath on his own or you determine that further resuscitation is futile. If you should have to use the mouth-to-nose method of ventilation, follow these same procedures except close the lips while breathing through the nose.

Before artificial respiration is begun, the casualty's skin and particularly his lips, ear lobes and fingernails will have a bluish color, instead of the usual healthy pink because of lack of oxygen in the blood. After six to eight cycles of artificial respiration, the pink color should return if there is adequate circulation. If the skin remains bluish, however, artificial respiration, once started, should be continued until the casualty starts to breathe spontaneously. If breathing returns to normal but the casualty is still unconscious or semiconscious, turn him to a semiprone position to prevent his airway from becoming obstructed by his tongue falling back into the throat. This position is obtained by placing the casualty on his stomach and putting one of his arms immediately behind him to prevent him from rolling onto his back. The other arm is outstretched and the leg which is uppermost is flexed and positioned forward of his other leg (figure 1). If possible, it is best to position the whole body in such a way that the head is at a lower level than the feet. This position improves blood circulation to the brain and makes it less likely that the throat will become blocked.

Checking circulation and restoring heartbeat. Circulation can be checked by feeling for a pulse at the side of the neck (carotid artery), in either temple or on the bare chest over the heart just below the left nipple. These areas are easier to feel than the pulse in the wrist if it is weak. If a pulse cannot be felt in any of these sites and if the pupils of the eyes are dilated, it is likely that circulation has stopped. In this case, external (closed) heart massage must be instituted immediately to restore circulation. If on initial examination the casualty is not breathing and there is no heart beat, mouth-to-mouth resuscitation must be combined with external massage simultaneously.

To correctly administer closed heart massage, place the heel of one hand on the lower half of the sternum (breastbone) and spread and raise your fingers so you apply pressure without pressing the fingers against the ribs. Place the other hand on top of the first. With your hands in this position and your arms straight, lean forward to bring your shoulders directly above the casualty's breastbone, then press straight downward using the full weight of your body. Apply enough pressure to depress the breastbone 1½ to 2 inches. (Pressing down

more than 2 inches or applying too much pressure may fracture ribs, but this may be unavoidable in some instances.) Release the pressure immediately and quickly, slightly lifting the hands. Repeat this press-release cycle once every second. After a few minutes, check the side of the neck for a pulse. If only a feeble, irregular pulse or no pulse can be detected, elevate the casualty's legs about 6 inches above the head level to help the return of blood to the heart. Then resume the heart massage until the casualty's circulation is restored.



(a) This diagram shows a normal clear airway in a conscious person

(b) When a person is unconscious the tongue is likely to fall back and block the throat

(c) When the head and neck are extended, jaw forward, the airway is both clear and enlarged

The ideal situation is to have two persons available; one to give artificial respiration and the other closed heart massage. However, if you are the only person available to perform both of these resuscitation measures, you will have to administer four to six cycles of heart massage and then one cycle of artificial respiration regularly and systematically.

Once a regular pulse and heart beat have been established, the next important thing is to stop all external bleeding to treat or prevent shock. Massive bleeding from injuries to major blood vessels must be controlled during cardiopulmonary resuscitation to prevent total blood loss.

Stopping bleeding. The best way to control bleeding is by the use of a pressure dressing. Cut clothing and lift it away from any wound to avoid further contamination. Unless absolutely necessary, do not tear the clothing as it could result in rough handling of the injured part. At this point do not attempt to clean the wound even if it is dirty as this may increase bleeding. Cover the wound with a dressing and apply pressure. If additional pressure is needed to stop the bleeding, apply another dressing or place your hand over the dressing and press hard. Five or 10 minutes of hand pressure may be required for a clot to form and blood vessels to retract and constrict sufficiently to hold with only the help of the dressing and bandages when the hand is removed. Frequently, bleeding can be lessened by raising the injured part above the level of the heart. However, avoid using this method if the limb has a broken bone, because moving an unsplinted fracture causes extreme pain, can increase shock and may further damage nerves, muscles and blood vessels.

If blood is spurting from the wound, pressure can be applied to a pressure point between the heart and the injury with the fingers, thumbs or hands until a pressure dressing can be unwrapped and applied. A pressure point is the site at which a main artery supplying the wounded area lies near the skin surface and over a bone. By pressing at these points, the flow of blood from the heart to the wound is shut off or at least slowed down.

Improper use of a tourniquet may result in subsequent loss of the limb. Thus, tourniquets should never be used unless other methods fail to control the bleeding, such as with an amputation of a limb or injury to a major blood vessel. When a tourniquet is used, it is placed between the wounded area and the heart. Do not place it directly over a wound or fracture. Tighten the tourniquet only enough to stop the blood from passing under it. To determine whether it is properly adjusted, check the pulse in the wrist or foot of the affected limb prior to tightening the tourniquet. When it is of sufficient tightness, no pulse in these areas can be detected.

After proper tightening, heavy

bleeding will stop but blood will continue to ooze from the veins in the lower part of the limb until vessels are drained of the blood already in them. Do not tighten the tourniquet in an attempt to stop this drainage, but frequently inspect it to ensure that it has not slipped and that there is no further sign of heavy bleeding. If necessary, tighten the tourniquet but *do not loosen it*. Once a tourniquet has been applied, it must not be loosened by anyone except competent medical personnel. If a casualty is only bleeding internally, he will usually be pale, anxious and ill, or unconscious, with a feeble pulse and no outward sign of severe bleeding. In these cases, obtain expert help as soon as possible. Try not to disturb him and administer nothing by mouth.

Shock control measures. Shock may result from any type of injury, but the more severe the injury the more likely shock is to develop. It can also be aggravated by emotional and psychological factors. Early signs are usually restlessness, pale clammy skin, and a rapid, weak pulse which may quickly progress to unconsciousness. A person in shock may be excited, or he may be calm and appear very tired. He may be sweating profusely and complain of thirst. As shock becomes worse, he breathes in small, fast breaths or gasps even when his airway is clear. He may stare vacantly into space and his skin may develop a blotchy or bluish appearance, especially around the lips and mouth. So measures must be taken early to prevent shock or to keep it from getting worse.

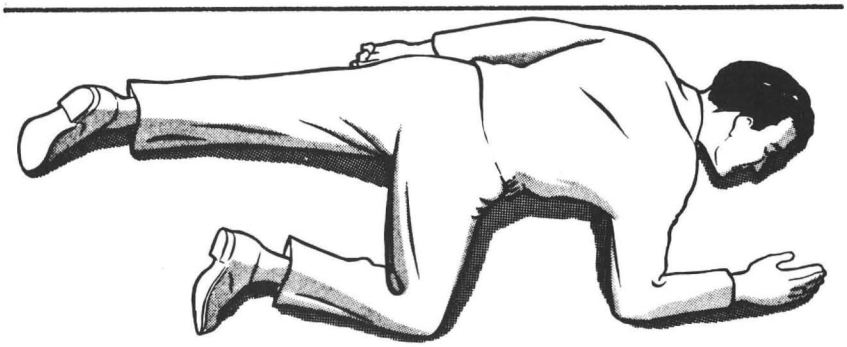
As shock is common in persons suffering from moderate-to-severe injuries, do not wait for these signs to develop as shock alone can be a killer. Always anticipate shock and take care to prevent or treat it along with treatment of the specific injury. The patient should be made as comfortable as possible and all constrictive clothing should be loosened. Do everything possible to keep him calm and avoid further excitement. If conscious, place him on his back and elevate his feet unless he has a head or chest injury. If unconscious, place him on his side or abdomen with his head turned to one side (as described earlier) to prevent obstruction of the airway. He should be kept warm but not overheated as this will aggravate the condition by causing extra fluid loss through perspiration.

As a general rule, do not give anything by mouth. Pain contributes to shock and should be relieved. Properly dressing and bandaging wounds, carefully and thoroughly splinting fractures, and properly positioning a person are the best first-aid measures for relieving pain.

The three lifesaving measures discussed above, if understood and practiced before their need, should provide nonmedical personnel with sufficient knowledge to render effective emergency first aid at an accident site.

In addition, there are some special types of injuries and treatment methods with which nonmedical personnel should be familiar. Some of these are:

Chest injuries. Injuries of the chest are common, painful and incapacitating. Of particular importance is the penetrating chest wound. This type wound is easily recognized by its sucking noise, the appearance of foam or bubbles in the wound with breathing, and evidence of severe shock. A penetrating chest wound causes lung collapse, so a person's life depends on how quickly the wound is closed and sealed airtight to prevent loss of air from the chest cavity and to allow for adequate expansion of the uninjured lung. First, if he is able, have the casualty forcibly exhale and hold his breath while the wound is being sealed. The best method is to apply petroleum gauze, if available, directly over the wound. If not available, the first-



Never leave an unconscious casualty unless it is absolutely necessary and if you do so, always ensure that he is stabilized in the "unconscious position" so that his airway is unlikely to become obstructed

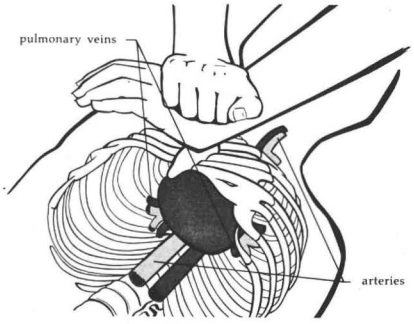
Figure 1

aid dressing with the foil liner will suffice. The foil should be applied against the wound and held in place securely while bandaging the dressing to the body. The bandages should overlap each other to provide firm, evenly distributed pressure. To prevent the bandage from slipping, bind it securely (e.g., with a belt), but do not bind it so tightly that it restricts chest movement. In a pinch when no medical dressings are available, use any relatively airtight material like a plastic bag or thick jacket to cover the open wound. A penetrating chest wound must be closed immediately for adequate ventilation of the uninjured side.

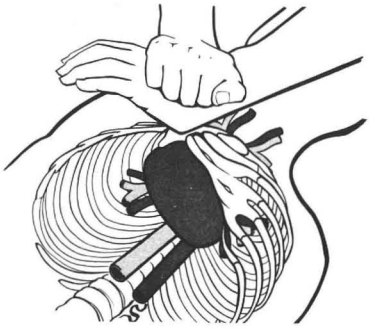
With other injuries such as severe bruises or fractures of the ribs, the chest may be immobilized with some type of chest binder only to reduce pain. But care must be taken not to restrict respiration. Avoid binding the chest unnecessarily to allow maximum ventilation.

Abdominal injuries. Wounds in the abdominal area are also particularly serious. Such wounds have an extremely high mortality rate and render a person unable to care for himself. The most serious wound to this area is one in which an object penetrates the abdominal wall and pierces internal organs or large blood vessels. If an intestine is not already protruding through the wound, a bandage should be applied securely over it to prevent this from occurring. However, if the intestine is protruding, do not attempt to replace it unless the wound is so large that the casualty cannot be transported without some rearrangement of exposed organs. The dressings should be secured loosely with bandages, as internal bleeding cannot be controlled by pressure and excessive pressure can cause additional injury. The correct position of the body is on the back with the head turned to one side to maintain an open airway and to prevent choking or drowning in one's own fluids. Care should be taken in moving the casualty to avoid additional protrusion of the internal organs. Nothing should be given by mouth, as it will eventually pass through the injured intestine and further contaminate the abdomen; however, the lips can be moistened to help lessen thirst.

Head injuries. This type of injury is difficult to treat because little can be done to the injury site, shock is common and the feet should not be raised to prevent or treat shock. However, the other lifesaving measures can be taken. A head injury with a scalp wound is easily recognized, but when there is no wound, you should suspect a head injury if the casualty (1) is or has recently been unconscious, (2) has had a convulsion, (3) is confused or incoherent, (4) complains of a headache, (5) has blood or other fluid escaping from his nose or ear canals, (6) has a slow pulse, (7) is nauseated or vomiting, or (8) is breathing very slowly. To treat an open head wound, apply a dressing and bandage without disturbing any foreign matter that may be in or protruding from the wound. Do not attempt to remove any foreign matter as this may cause further extensive brain damage. Until skilled help is available, keep the casualty as quiet and comfortable as possible.



When pressure is applied on the sternum, the heart is compressed against the spine, forcing blood into the arteries and pulmonary veins



When pressure is released, the chest expands, permitting blood to flow back into the heart

Face and neck injuries. Usually wounds of the face and neck bleed profusely because of the numerous blood vessels in these parts, so bleeding may be difficult to control. However, every effort must be made to stop the bleeding. At the same time, the airway should be checked for pieces of broken bone or teeth, loose bits of flesh and large blood clots as well as dentures to ensure that the airway is and remains open. If the casualty is conscious and chooses to sit up, he should lean forward with his head down to permit drainage from the mouth. Otherwise, even though conscious, he should be placed on his side or abdomen with his head turned to one side to permit drainage of blood and fluids from the mouth.

Severe burn injuries. Burns pose serious problems because of loss of body fluids and salts resulting in shock. They cause severe pain and the wounds are very susceptible to infection. The initial

treatment is to prevent or lessen shock, avoid further tissue damage and prevent infection. The burned area should be covered with a sterile dressing and secured loosely by bandages. If clothing covers the burned area, it should be cut and lifted gently from the area prior to dressing. When giving initial first aid, if pieces of cloth stick to the burn, do not attempt to remove them or clean the burned area. Neither should any medication be applied to the area. The casualty can be covered with a clean sheet if the burn area is extensive. He should then be treated for shock as noted previously. If he is conscious, is not vomiting, has no abdominal or neck wound and immediate medical care is not anticipated, he should be given sodium chloride-sodium bicarbonate mixture, NSN 6505-00-663-2636, to restore body fluid and salt. This mixture should be dissolved in one canteenful of cool, *not warm*, water and consumed over a 1-hour period. If he becomes nauseated, no further solution should be given as this will cause further loss of fluids from vomiting.

Fractures. Fractures are generally common in accidents and are easily recognized when a bone is protruding through the skin, the part is in an unnatural position, or the chest wall is caved in. Other signs and symptoms which may indicate a fracture are tenderness or pain when slight pressure is applied, swelling and a bruise-like discoloration of the skin at the site of the injury. If there is any doubt, assume the worst. Do not manipulate the part in any way and treat it as though it were fractured. The first rule in treating a fracture is to do no further damage by unnecessarily moving the injured part. If the fracture is simple or closed (no penetration through the skin), the treatment is to immobilize the limb with a splint in the fractured position. When the fracture is open or compound (break is through the skin), the bleeding should be stopped and the injury dressed and bandaged before the limb is immobilized. *No attempt should be made by non-medically trained personnel to reset a fracture, as this could convert a simple fracture to a compound one or cause greater tissue damage in an existing compound fracture.* When splinting a fractured limb, the joints above and below the fracture should be immobilized as well as the fracture site. To prevent further injury to tissue, blood vessels and nerves due to pressure from the splint, some type of padding should be placed between the injured extremity and the splint before binding it with bandages.

Infection. The cardinal signs of infection or inflammation are redness, swelling, pain and warmth surrounding a wound. Particularly in tropical climates, moisture, heat and less than ideal hygiene combine to encourage rapid infection in the most minor wounds. Regardless of climate, it is most important to thoroughly clean any wound, even the small scratches, cuts and insect bites. A sterile compress should then be applied and secured with a bandage. Antiseptics or antibiotic ointments may be used if available such as those in the survival kit. Avoid scratching minor wounds and bites to prevent further injury and infection.

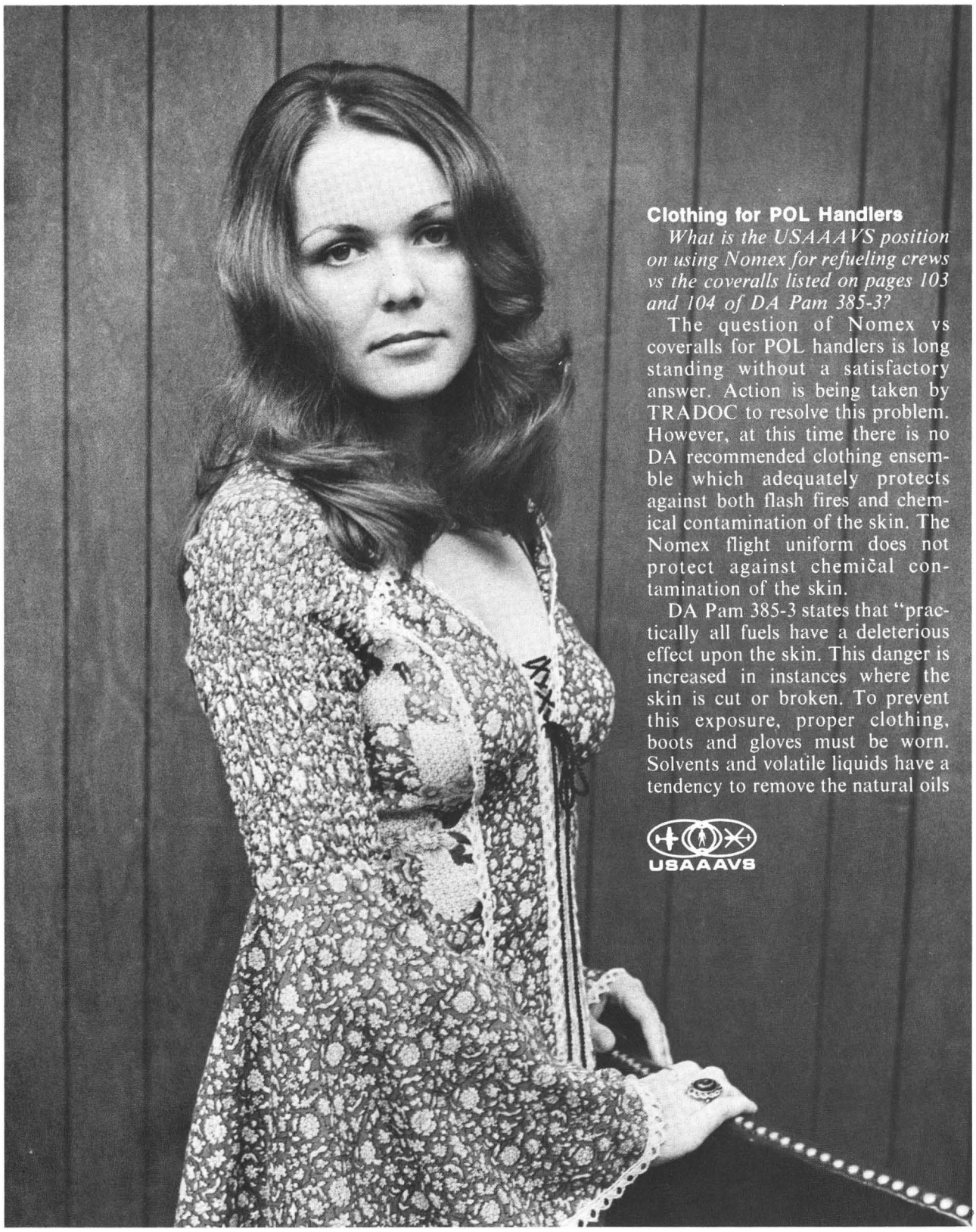
Pain. CAUTION: The use of any medication to relieve pain warrants special attention as it can worsen shock, cause unconsciousness and be lethal with some types of injuries. Therefore, any pain relief medication, particularly morphine, should not be given to casualties who (1) have head injuries, (2) have breathing difficulties, such as those with sucking chest wounds or those who are not breathing at a normal rate, (3) are unconscious or (4) show signs of shock. Medication should be considered only in an extreme situation such as when a casualty is in excrutiating pain and immediate aid is unforeseeable. Administer only that amount necessary to relieve pain, taking care to avoid overdose. As noted earlier, proper bandaging, immobilization, splinting and positioning will adequately relieve most pain due to injuries.

This is part one of a two-part article dealing with medical aspects of survival. While this part deals with the immediate problems following an accident, part two will discuss the management of medical problems in a prolonged survival situation.

HEIMLICH PROCEDURE

A special everyday situation which affects breathing is choking on a foreign body, such as a peanut or bite of steak. One procedure to prevent choking to death is known as the "Heimlich Procedure." This procedure has been used on some 374 potential choking and drowning victims in the past 1½ years and all survived. To perform this procedure:

- Stand behind the victim and place your arms around his waist, slightly above the belt line (or navel). Allow his head, arms and upper torso to hang forward.
- Grasp one wrist with the other hand and press into the victim's abdomen rapidly and forcefully, repeating several times. This pushes up the diaphragm, compresses the air in the lungs and expels the foreign body which is blocking the breathing passage.



Clothing for POL Handlers

What is the USAAAVS position on using Nomex for refueling crews vs the coveralls listed on pages 103 and 104 of DA Pam 385-3?

The question of Nomex vs coveralls for POL handlers is long standing without a satisfactory answer. Action is being taken by TRADOC to resolve this problem. However, at this time there is no DA recommended clothing ensemble which adequately protects against both flash fires and chemical contamination of the skin. The Nomex flight uniform does not protect against chemical contamination of the skin.

DA Pam 385-3 states that "practically all fuels have a deleterious effect upon the skin. This danger is increased in instances where the skin is cut or broken. To prevent this exposure, proper clothing, boots and gloves must be worn. Solvents and volatile liquids have a tendency to remove the natural oils

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from the skin and are a principal cause of dermatitis. Ingestion of such materials as lead, which is a common ingredient in certain types of fuel, can be prevented by changing clothing and washing thoroughly before (eating) and at the end of the work shift."

Par. 4.8.2, DA Pam 385-3, lists general protective clothing and equipment for fuel handling. It should be noted that the additional hazard of "fire, heat and explosion" must be addressed and this is provided for in par. 4.8.3. Par. 4.5.2 lists general protective clothing and equipment for this hazard. Here you will find, among other items, the same coveralls listed as protective clothing to provide protection from fuels. These coveralls are described in par. 3.3.2.9 and are pictured in figure 55 on page 31.

USAAAVS' position regarding the wearing of protective flight clothing is that it must be worn by all *aviation personnel authorized flight clothing* when on board or when performing maintenance or servicing of U.S. Army aircraft at any time an engine is operating or when the individual is involved in any situation where exposure to a fire environment is a possibility, whether or not there is intent for flight. Protective flight clothing is listed below along with the recommended method of wear as determined jointly by The Surgeon General and USAAAVS:

a. Nomex flight suit (if two-piece, both shirt and trousers will be worn). The Nomex flight suit will provide optimal fire protection if it is worn in such a manner as to cover the maximum body surface possible.

(1) Shirt should be worn tucked deeply in the trousers. Belt and adjusting tabs should be properly fitted to preclude the shirt from slipping out of the trousers.

(2) Shirt sleeves should be rolled down and tightly closed by the velcro tabs. Shirt sleeves should be long enough to fasten securely over the outside of the cuff of the glove and not slip over the cuff and onto the forearm during maximum extension or range of motion of the arm or hand.

(3) Shirt zipper should be fully closed and covered by the overlapping Nomex panel to preclude flames tunneling in and contacting body surfaces.

(4) Shirt collar should be worn up and snugly closed at the front of the neck, secured by the velcro tab provided.

(5) Trouser fly should be securely closed (zippered or buttoned) and covered by the overlapping Nomex panel, again to preclude tunneling of flames into contact with body surfaces.

(6) Trouser legs should be secured tightly by the velcro tabs, over the upper half of the shank of the leather boot. Additionally, trouser legs should be long enough to cover the upper half of the leather boot with the leg maximally flexed or involved in maximum range of motion activities. Under no conditions should the trouser leg be so short as to ride up over the boots and onto the calf of the leg.

(7) Pockets should be closed, using the securing means provided, and covered by the flaps.

(8) Pin-on insignia should not be worn on any type of flight clothing. Sew-on or leather type should be used as authorized in AR 670-5.

b. Nomex gloves. Worn with gauntlet extended under snugly fastened sleeve cuff.

c. Leather boots. Laced completely with trouser cuff fastened snugly over the boot at the ankle.

d. Protective flight helmet. Properly fitted, chin strap snugly fastened and visor lowered.

e. Underwear. Standard Army issue underwear should be worn by all aviation personnel as a part of the protective flight clothing system. Other underwear can be worn, but at no time should non-fire-retardant synthetic materials be worn as undergarments.

f. Socks. The Sock, Men's, Wool Cushion Sole, should be worn by all aviation personnel as a part of the protective flight clothing. Other socks may be worn, but at no time should these garments contain non-fire-retardant synthetic materials which extend above the top of the combat boot.

The potential for thermal injuries and fatalities exists when open refueling is used. Since there is no ensemble available which adequately protects against the stated hazards, you must evaluate your particular operating situation and identify those hazards which most need to be protected against. DA is considering the need for additional protective equipment for POL handlers. For more information on clothing for POL handlers, see chapter 5, FM 10-68, dated 31 December 1975.

USAASO Sez

The National Microwave Landing System (NMLS) is great for helicopters

WAY BACK WHEN, we promised a followup blurb on NMLS, so here 'tis. Stretch your memory: The NMLS is an electronic landing system intended to replace ILS (instrument landing system) and GCA (ground-controlled approach) radar.

This new electronic wizardry is similar to ILS in that the aircraft's black box figures where it is from ground transmitted signals; the old crossed needles job in the cockpit. But hold it! that's as far as it goes. Instead of the old ILS fixed radio beams, the NMLS has beams that scan or move. This lets the pilot select which beam he will ride so that he can select his glide slope angle and his approach path. This is great for helicopters yet it still works fine for fixed wing birds at the same time. Instead of watching those old marker beacon lights, a pilot can check his range to touchdown meter to figure out how long it will take to get home to mama. This is done by using the NMLS distance measuring equipment (DME). To accommodate the many users of a national system, it was designed to be modular. A bug smasher pilot with a few bucks to spend might start off with a localizer, then add glide slope and finally DME to build up a full system. At the other end of the pipe, an airlines 747 would add a computer and autopilot coupling for fully coupled curved approaches.

The airport owner can do the same thing on the ground to build up his system to a full localizer, glide slope DME capability. A full blown system at a major airport would include wide angle coverage, flare guidance and missed approach guidance.

The Army's been telling the Federal Aviation Administration that we need a good lightweight battlefield version of this new baby. Right now it looks like we'll get some engineering prototypes to test sometime next year.

We'll try to get another NMLS blurb out to keep you informed as things progress.

YOU many guys who have reason to contact AIR ROUTE TRAFFIC CENTER in Hampton, GA, one day in the near future may be surprised to hear a familiar voice on the "Horn." Jo Ann Cole, whose many duties included that of answering the telephone at the *AVIATION DIGEST*, has left the magazine to learn to be an air traffic control (ATC) specialist for the Federal Aviation Administration (FAA).

Jo Ann was hired under the ATC Center option plan. Before she takes over her new duties, however, she must undergo a 2-year training program. Included is a study course at the ATC Academy in Oklahoma City, OK. She then will return to Hampton for extensive on-the-job training.

Jo Ann's selection for the FAA position was based on the results of a written examination. She also had to pass an intensive physical and psychological test to qualify.

HELLFIRE Designated AAH Missile

Captain Mark Robison

HELLFIRE Project Manager's Office
Redstone Arsenal
Huntsville, AL

A DEPARTMENT of the Army decision was made on 6 January 1976, designating HELLFIRE as the point target, antitank weapons system for the advanced attack helicopter.

HELLFIRE is a completely modular, terminal homing missile system. It is designed for helicopter launch against hard point targets found on the mid-intensity battlefield. The system recently has completed its advanced development contract effort and has received a favorable DSARC decision to proceed into engineering development. The missile is capable of tactically engaging targets in the direct, indirect, or pseudo-direct modes of fire and by either sequential fires or multiple fires thereby increasing firepower, enhancing mission flexibility and improving survivability.

The AAH, when armed with HELLFIRE and containing the FLIR imaging capability on the TADS, and used in conjunction with a pilot/gunners steering indicator and the GLLD, will have the capability to acquire and engage targets during both day and night with a high single shot kill probability. With either airborne remote designation by a scout aircraft equipped with TADS or ground remote designation by a forward observer equipped with a GLLD, the attack helicopter, taking advantage of the terminal homing accuracy of the missile, can immediately remask and maneuver after launch.

The ability of the HELLFIRE system to acquire, identify and accurately engage targets at ranges in excess of existing systems and its ability to engage targets in an indirect fire mode, enhances aircraft survivability by minimizing aircraft exposure and signature. The modularity concept, with its inherent capability to accept and interface with a family of seekers, demonstrates more than adequate potential for future growth.

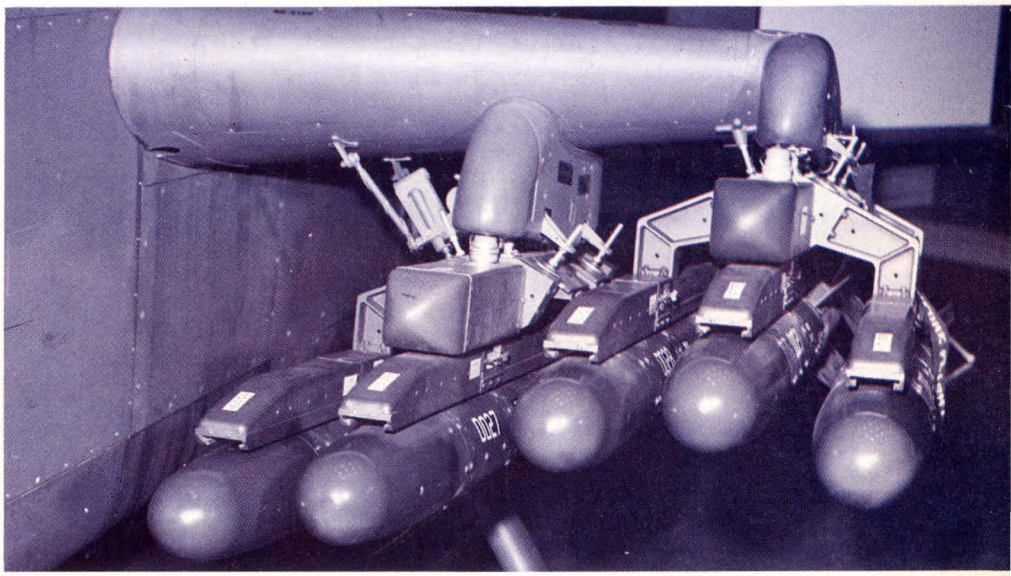
The HELLFIRE missile is a portion of a system, or network, of laser-guided weapons planned for the battlefield of the future. HELLFIRE complements both CLGP and MAVERICK and through triservice laser coding will respond to either a scout helicopter, forward air controller, or another attack helicopter equipped with a TADS as well as to a forward observer or ground scout equipped with a GLLD. As the primary point target weapon system on the AAH, the missile will be used to engage threat armor at maximum ranges commensurate with acquisition and designation capabilitites, destroying as much enemy combat power as possible before it can influence any action.

The LOAL capability of the missile enhances its versatility and demonstrates potential for use in a ground mounted support role. It is ideally suited for mounting on many standard tactical vehicles currently in the inventory and can increase the Infantry battalion commander's available firepower. Using an "on carriage" fire control mode select capability, the missile, in its ground configuration, has the same engagement characteristics as in the helicopter-launched indirect and direct fire modes.

Under the modular design concept, two additional seekers are being evaluated for possible future development—the RF/IR seeker, for air defense suppression, and a true fire-and-forget passive infrared seeker.

In conclusion HELLFIRE offers several benefits—maximum range, tactical versatility, survivability, pinpoint accuracy and growth potential through modularity.

(See "HELLFIRE" by COL John B. Hanby Jr., in the January 1975 *DIGEST*.)

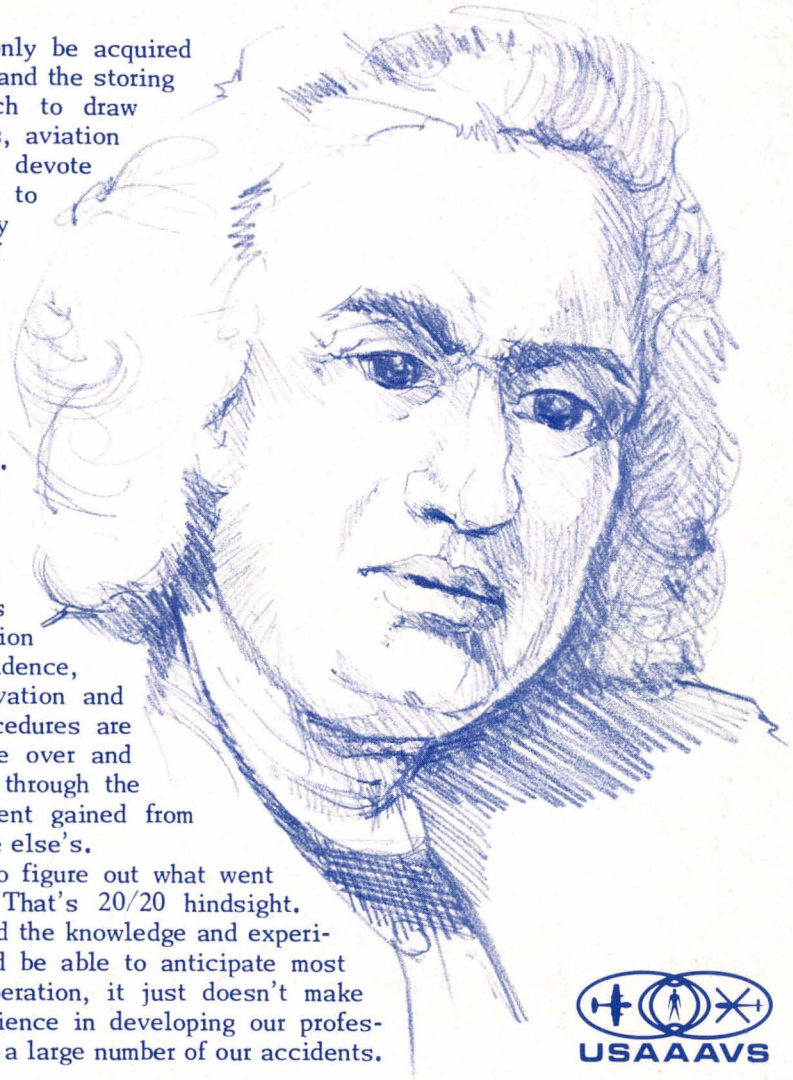


Refer to Glossary on page 9

GOOD JUDGMENT CAN only be acquired with the passage of time and the storing up of experience from which to draw precedence. To achieve this, aviation accident prevention programs devote considerable time and effort to education. Aviation safety officers should make use of all media available to them. Briefings, magazines, films, courses and posters all pass on the accident experiences of others to hasten the development of good judgment in all aviation personnel.

How successful are these programs? The only indicator of success or failure is the number of accidents we have—particularly those accidents from the same causes—in relation to previous years. Overconfidence, complacency, excessive motivation and disregard for established procedures are some accident causes we see over and over which can be prevented through the use of good judgment—judgment gained from experience, preferably someone else's.

It's easy after the crash to figure out what went wrong and who to blame. That's 20/20 hindsight. However, since we have gained the knowledge and experience the hard way and should be able to anticipate most of the hazards in aircraft operation, it just doesn't make sense to disregard this experience in developing our professional judgment and preventing a large number of our accidents.



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"Judgment is forced upon us by experience." SAMUEL JOHNSON

Make Aviation Safety THE SPIRIT OF '76