INTERAVIA

New Hughes Turbine-Powered Helicopter Sets 23 World Records

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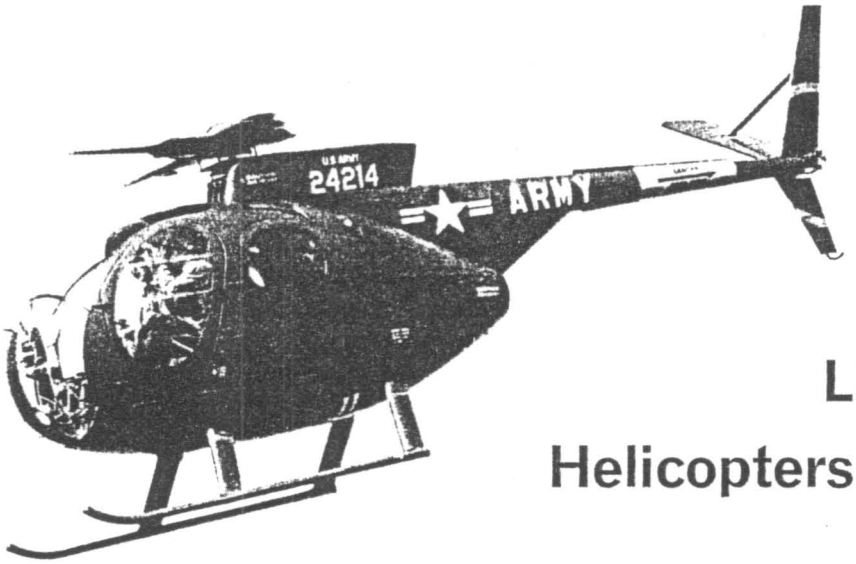


Light Observation Helicopters for the US Army

It is going to be difficult for the US Army to improve on its record in the Light Observation Helicopter (LOH) programme. The LOH development was completed within the initial time schedule, it stayed within the original cost goals, and it pushed the technical state-of-the-art to a significant degree. For example, the LOH will cruise about 50% faster than the light helicopters it will replace in Army service. Such claims for technical advancement plus accurate schedule and cost planning can be made for few other aircraft development programmes since World War II.

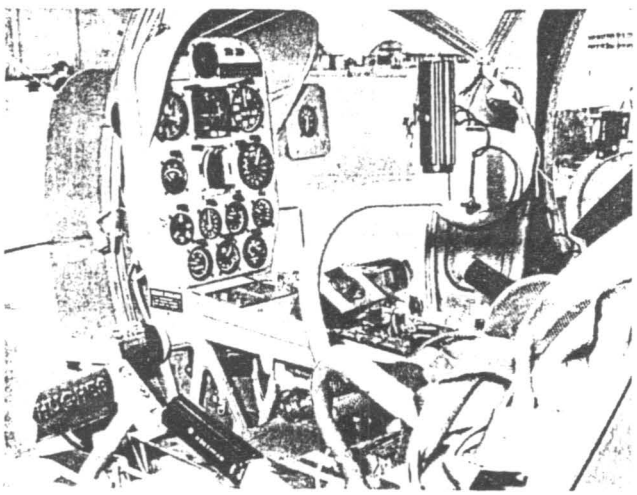
The LOH is highly significant for an additional reason. It is the first US programme since the late 1940's in which a flight test competition was held to select an aircraft design for operational military service. Five prototypes of the Bell Helicopter Company's OH-4A, Hiller Aircraft Company's OH-5A, and the Hughes Tool Company's OH-6A, the three competing LOH designs, were purchased by the Army for the flight trials.

The Army flight competition was far more rugged than any US competitive flight trials of the past. It lasted six months, and each type of LOH was flown an average of more than 10 hours each day for the whole period including Sundays. About 2,000 hours of total flying time was accumulated on each type with a single aircraft of each type operated for at least 1,000 hours to provide a good indication of parts life, durability and ease of maintenance.

Another unique feature of the LOH programme is that it is the first aircraft development which the Army has been allowed to manage since the Army Air Force was split away to become a separate service of equal rank, the US Air Force, in the middle 1940's. The Army's performance upon reassuming this responsibility must be considered impressive. It has exceeded its stated goals of obtaining a simple, low cost, easy-to-maintain, 4-man, high performance helicopter to serve as an "aerial jeep". The Hughes OH-6A, which won the LOH competition surpasses the Army's requirements in most areas. Undoubtedly, it is the fastest helicopter in the world for its size, cruising at 144 m.p.h. with top speeds above 160 m.p.h.

Even more important, the Army, by making good on its development plans, has secured the support of the top civil echelons in the Department of the Army, and the budgetary authorities in the Office of the Secretary of Defense, and will now purchase 714 Hughes OH-6A LOH aircraft under a three year plan. The OH-6A production costs are well below the cost predictions of several years ago and the prospects seem bright for a total army buy of 3,000 to 4,000 LOH's and a production run of several years, well into the 1970's.

Despite its successes, the LOH programme has not been without its critics. Perhaps this was inevitable. The sheer numbers of aircraft involved give it great importance. Apparently, more LOH's will be produced than any other helicopter in history. And it is a good bet that the US Army will operate more LOH's than any other aircraft in its inventory. These prospects have made the programme the subject of intense industry and government scrutiny from the technical, operational and fiscal standpoints.



Above: Hughes produced the least complex and most inexpensive entry for the US Army LOH competition—and won the contract.

Left: a clearly-arranged instrument panel, simple layout and exceptional visibility characterise the two-seat cockpit of the Hughes OH-6A.

Army requirements

Much criticism has been directed at the Army's LOH requirements during the past five years. These requirements were enunciated officially for the first time early in 1960 by the Army Aviation Requirements Review Board, an ad hoc group of general officers, headed by Lt.-Gen. Gordon B. Rogers. Known as the Rogers Board, this committee laid down a list of priorities for new aircraft, and a general plan for improving Army aviation during the 1960—1970 period.

The Rogers Board backed the early development of only one aircraft, the LOH. It was to be a replacement for three operational models, the Cessna L-19, Bell H-13 and the Hiller H-23. The basic operational objectives for the LOH were to improve the air mobility, reconnaissance, command and control, and the target acquisition ability of small Army units, at battalion level and lower.

To satisfy these operational objectives the Rogers Board pointed out that the number one technical requirement was for the LOH to be able to "live well" in the field with the troops. During the 1950s helicopters had not distinguished themselves in this respect. All types and all models of helicopters had experienced maintenance difficulties during prolonged field operations. Compared to fixed wing aircraft they required large numbers of spare parts and unusual attention from highly trained technicians, equipped with specialized tools.

In calling for the immediate development of the LOH, the Rogers Board expressed the opinion that helicopter technology was advancing rapidly and that the LOH specifications could call for significantly better speed, payload and range performance than that of existing light helicopters. And, the Board enjoined the Army to keep the LOH gross weight low so that costs would remain low and the aircraft could be purchased in the largest possible numbers.

As a result of the Rogers Board action, the primary LOH performance specifications as issued to industry in the original request for proposals (RFP) in 1960 were: a maximum gross weight of 2,450 lb.; hover out of the ground effect at 6,000 feet altitude and a temperature

of 95 °F; cruise at 127 m.p.h. at normal rated power of 212 h.p. and normal gross weight; and an endurance of 3 hours at 85 % of cruise power. The specified powerplant for the LOH was a 250 h.p. turbine engine, and the normal payload, which must be carried when meeting the speed and endurance requirements, was two passengers weighing a total of 400 lb. The payload did not include a 200 lb. pilot and 340 lb. of fuel and oil, which brought the useful load to 940 lb. This performance, in almost every category, represented about a 30 % improvement over the performance of the existing light helicopters.

The Army also gave the prospective contractors a priority list of characteristics to guide their design work. This was: (1) cost and gross weight, (2) reliability, (3) ease of maintenance (4) physical capability for specified overload items, and (5) performance.

Originally there were two basic criticisms raised against the Rogers Board action and the LOH requirements. Many technical men inside and outside of the government were extremely disappointed that the Army had not been more aggressive technically by calling for a VTOL aircraft to do the LOH job. It was their opinion that VTOL technology was in a usable state and that further progress was going to be slow if there was no stimulus from an operational development programme.

In answer to this criticism, Brig.-Gen. Clifton F. von Kann, then Director of Army aviation, and a member of the Rogers Board, expressed the opinion of the Board and other LOH proponents by stating four helicopter advantages which tipped the scales in favour of the helicopter over the higher speed VTOL. He pointed out that VTOL fuel requirements were considerably higher, that considerably more stability and control research would be needed to make the VTOL the equal of the helicopter in low speed piloting qualities, that the VTOL downwash velocity was much higher than the helicopter's and the effect of this in tactical operations was unknown, and that the helicopter had considerable growth potential that could be exploited in relatively short time.

The three competitors in the LOH programme: in the foreground Hiller's entry, the OH-5A; behind, the Bell-developed OH-4A helicopter and on top, the Hughes OH-6A.

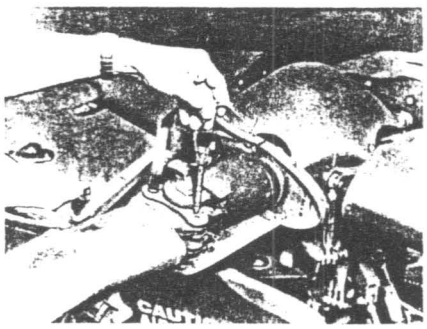
In selecting a helicopter for this mission, the Rogers Board also was in step with the predominant technical opinion in the Department of Defense. At about the same time, the Air Force re-evaluated its position on VTOL technology and revised its plans by cancelling development of a Mach 2 VTOL fighter for the Tactical Air Command and replacing it with a 3,000 foot take-off STOL aircraft, which has now become famous as the TFX and F-111.

The second 1960 criticism concerned the LOH performance specifications. A significant number of technical experts believed that the Army had been too rigid in specifying the LOH's exact gross weight and the single 250 h.p. powerplant. This had limited the speed, payload and endurance of the aircraft and it did not provide the designer with enough latitude to build in the kind of growth potential needed for the 1970's.

A great deal of growth potential was considered necessary if the LOH was to remain operationally useful for ten to fifteen years as desired, and if it was to fit into the Army's air cavalry concepts which were still in the formative stage in 1960. The Howze Board had spelled out the nap-of-the earth air cavalry operations which are now becoming operational in Viet Nam with the First Cavalry Division. The Howze Board foresaw large aerial convoys moving at treetop level at more than 150 m.p.h. This concerned the critics, for the LOH with its 127 m.p.h. cruise speed would not be able to keep up with such attack forces, much less provide an armed escort.

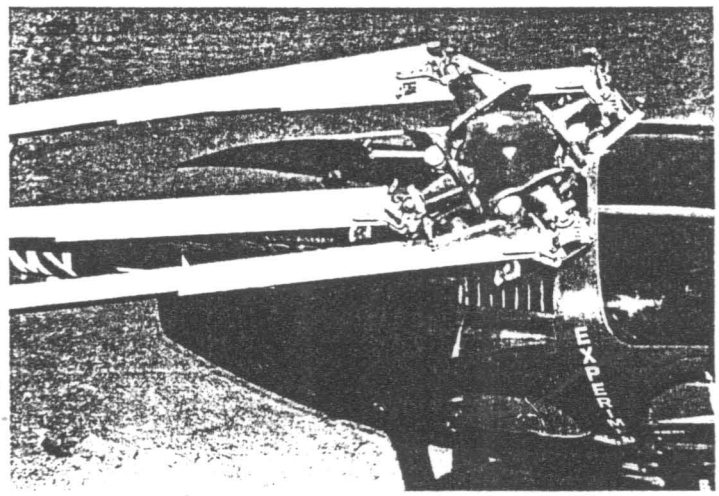
In addition, many critics pointed to the fact that most Army aircraft had been underpowered upon entering operational service and had been modified later at considerable expense. Consequently, they believed that in the long run it would save money to give the LOH an initial capability of 200 m.p.h. speeds, and five hours of endurance, because such performance would be an absolute necessity in the 1970's.

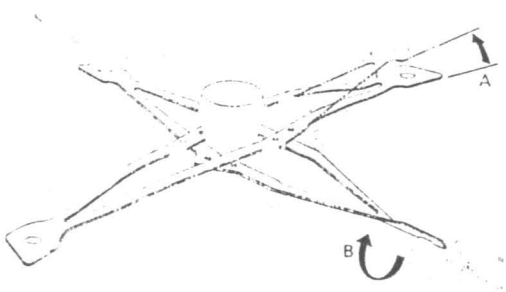
Despite these criticisms, some of which have persisted until today, the Army has followed through with the original LOH development plan. The basic objectives and milestones of the original plan have been met. Unfortunately, this has not always been the public impression of the programme. Contractor changes and



One of the most complex assemblies on a helicopter and one requiring the most maintenance is the rotor head and blade attachment. In their attempts to eliminate this weak spot on the OH-6A, Hughes engineers discovered some surprisingly simple solutions: the picture *above* shows the blade attachment which allows quick changing or folding of the blades. Two adjustable-diameter bolts (Expando-Grip) hold the blade, whilst a similar bolt of smaller diameter retains the damper arm. The drawing *below* shows the construction of the *Flexrotor* brackets which are a lamination of fifteen flexible steel plates. Hinges for flapping and swivelling movements (A and B) are thereby eliminated.

Right, the rotor head shown with blades folded rearwards. Dismantling or fitting of a blade can be done in less than one minute.





Army reviews have been made which have given the impression that plans and schedules were fluctuating. Some top officers believe that the programme was explained very poorly within the Army and that this resulted in much unwarranted criticism. This criticism, plus the contractor changes and official reviews resulted in a "poor press" at times in US trade journals.

The programme actually began in 1960 when the request for proposals was issued. Early in 1961 a total of 17 proposals were submitted to the Army by 12 contractors. Initially Bell and Hiller were selected to compete for the LOH production contract. This selection was made under the supervision of the Navy which was acting as the technical manager for the programme at the direction of the Department of Defense, and was supplying most of the personnel to monitor the development programme.

At this point the first cloud of misunderstanding passed over the programme. Many army officers looked with favour on the Hughes proposal in which many "traditional" helicopter design techniques had been discarded and replaced with new ideas in an effort to reduce weight, cut costs, and increase performance. At the same time, the Army was also pushing to take over completely the technical management and procurement of its aircraft and cut out the extra step of operating through one of its sister services.

The three contractors, Bell, Hiller and Hughes, all signed fixed price LOH contracts in mid-1961. They guaranteed the performance and weights set forth in their design proposals and they guaranteed delivery dates. The total airframe development cost to the Army was about $20 million spread among the three contractors.

The first major problem concerned the powerplant, the Allison T63, 250 h.p. shaft turbine engine. Late in 1961, there were persistent rumours that the engine was behind schedule and was not meeting its performance specifications. The rumours were substantiated during the first half of 1962 when the Army contracted with Continental to prepare the T65 as an alternate LOH powerplant. The engine developments also were covered by fixed price contracts with the cost to the government for both engines totalling about $7 million. Especially in the case of the engines, the fixed prices were exceeded, but under the terms of the contracts the manufacturers absorbed all overruns.

The next major sign of uncertainity came later in 1962 when complaints about the LOH being underpowered and undersized reached their peak. A new board was formed under Brig.-Gen. Donald C. Clayman to review the entire LOH programme. The contractors and technical authorities from the Department of Defense and the National Aeronautics and Space Administration were consulted along with all major Army Commands. Studies were made concerning the technical problems and costs which would be encountered in enlarging the LOH, adding considerably more engine power, revamping the rotor system, and adding stub wings to allow higher speeds. The Clayman Board concluded that the original LOH specifications and the original development programme correctly met the Army's needs. The Board re-emphasised that the primary concern was to produce a small, low-cost, "jeep like" helicopter for use by all Army units for reconnaissance, liaison, target acquisition, troop movement, and even fire support, using two standard M60 infantry machine guns or 40 mm. grenade launchers in light brackets. If heavier weapons, higher speeds and heavier payloads were desired the Clayman Board recommended the use of larger special purpose aircraft.

Development work continued unabated during all of the criticism, review, and adjustment of the engine programme. All three of the LOH aircraft were FAA certified on schedule. Both the T63 and T65 engines came along well and were certified for civil use, on schedule. Deliveries of test aircraft to the Army were made on schedule and the six-month field trials were conducted as planned. Many Army officers and industry leaders believe that the strong competition in both the airframe and engine developments were responsible for keeping the programme on schedule. It was apparent that any contractor who slipped was in great danger of being eliminated from the competition.

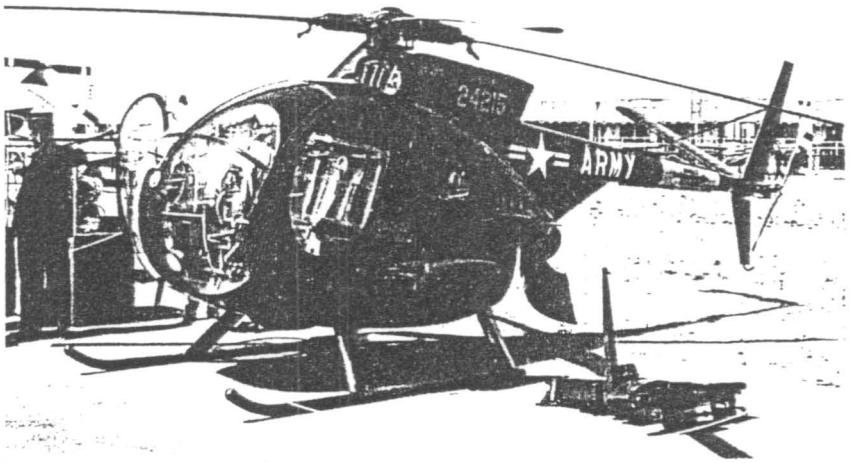
Technical competition

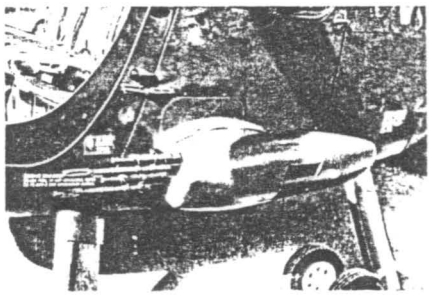
Technically, there was one major question to be answered in the LOH competition. Hughes had staked its chances on the belief that the LOH specifications were somewhat conservative. The company believed it could build a helicopter to perform the LOH mission which was about 400 lb., or nearly 20 %, lighter than the Army had specified. That is, the normal gross weight of the Hughes OH-6A was about 2,050 lb. compared to 2,450 lb. specified by the Army for the primary observation mission. Bell and Hiller on the other hand produced aircraft that grossed out near the Army's maximum allowable weight of 2,450 lb.

On the basis of empty weight, the Hughes proposal was even more startling. The OH-6A weighed 1,050 lb. compared to about 1,500 lb. for the other two entrants, or nearly 30 % less. Largely on the basis of the lower weight, Hughes also forecast substantially lower initial costs and higher speeds. For example, Hughes guaranteed a sea level cruise speed of 142 m.p.h. at normal rated power, compared to 115 m.p.h. by Bell and 127 m.p.h. by Hiller. According to the LOH contracts each company would pay penalties if these guaranteed speeds were not met.

Seldom in the history of aircraft design competition has the conflict of technical opinion been more clearly drawn. Seldom has one design group contended that it could produce an aircraft to perform a given mission, which had 30 % lower empty weight than its competitors.

Fortunately the Army had revived the system of flight testing prototypes to select an LOH design for production. It is doubtful that any paper design competion could have properly resolved the conflicts of technical opinion con-





Armament of the OH-6A can be of several types, all of which can be quickly mounted on the sides of the helicopter. The cabin behind the cockpit can be used for ammunition stowage. In the photo, *left*, taken at the recent Paris Salon, the OH-6A carries twin machine guns mounted on either side of the fuselage, and a heavier gun can be seen lying on the ground. A detailed view of the MG mounting is shown, *right;* the ammunition belt is fed out of the cabin through the pylon mounting and the empty cartridge cases are ejected from the two openings in the fairing.

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cerning the three LOH designs. However, the strenuous six month, 2,000 hour LOH flight trials were adequate to establish beyond reasonable doubt whether the aircraft could perform as guaranteed and could stand up to the rigours of performing the Army's nap-of-the-earth missions, day in and day out with little maintenance.

Three design features are the keys to the Hughes weight cutting formula. First, the simplified power train which transfers power from the engine to the main and tail rotors. The main gear box in this train has only two gear meshes compared to approximately 22 gear meshes in the average light helicopter in Army service today. The OH-6A main gear box greatly resembles an automobile differential in its simplicity. Another improvement in this system is the elimination of the heat exchanger and oil transfer plumbing normally associated with helicopter gear box cooling. On the OH-6A, the gear box is cooled by drawing the main engine air in around it with a fan. This fan is attached to the main engine drive shaft and does not require a separate shaft, gearing and bearings. Still another important feature of the power train is the aluminium tail rotor drive shaft which weighs less than six lb. Only one right angle gear mesh is required at the tail and the tail rotor drive shaft is a completely straight tube with none of the bearings and universal joints normally associated with such drives.

The second key to the OH-6A weight cutting formula is the rotor system, from which all bearings have been eliminated. A series of thin stainless steel straps absorb all of the torsion, drag, lift and centrifugal loads from each blade. This strap system not only reduces weight by eliminating the feathering and flapping hinges normally associated with an articulated rotor, it also reduces the size of the hub because it carries the centrifugal loads across the hub, from one blade into the opposite blade.

Hughes went to a four-blade rotor which, for a given power level, is relatively efficient at high speeds and relatively inefficient at low speeds and in the hover compared to the two-blade design used by Hiller and Bell. The four-blade system is 26 feet in diameter, several feet less than the two-blade system.

The third major element in the Hughes weight cutting plan was to keep the outside dimensions of the OH-6A to an absolute minimum. In terms of length and rotor dimensions the OH-6A is 25 % smaller than the H-13. Still it is possible in the short range overload configuration to carry six men in the OH-6A, including the pilot.

Hughes also reports excellent success in reducing the aerodynamic drag of the OH-6A. For a number of years now the National Aeronautics and Space Administration and several of the manufacturers have pointed out the gains which could be made in forward speed and fuel economy by "cleaning up" helicopters and streamlining them to reduce drag. An indication of the potential in this area is the fact that most 1950 helicopters, such as the H-13 and H-23 had a parasite drag area equivalent to a flat plate of more than 16 sq. ft. NASA in its studies had estimated that it would be possible by 1965 to cut this by more than 50 % to 7.4 sq. ft. Hughes, however, reports that the equivalent parasite drag area of the OH-6A is only 4 sq. ft., while predicting that the minimum area which ever could be achieved for a four-place helicopter with side-by-side seating probably will be about 3 sq. ft.

The low weight and low drag of the OH-6A resulted in some rather significant performance predictions by Hughes. One is a useful load which is nearly 110 % of the empty weight. In this definition the useful load is the pilot, payload, fuel and the communication gear. By comparison the other LOH's had a useful load of less that 90 % of the empty weight. In addition, the company predicted that the OH-6A would have about 30 % lower fuel consumption than its competitors.

Technical data on the OH-6A

Powerplant: one Allison T63-A-5A turbine of 250 h.p. at 6,000 r.p.m.

Main dimensions	
Length, rotors turning	30 ft. 4 in.
Length, rotors folded	23 ft. 0 in.
Width between skids	6 ft. 9 in.
Height over rotor fairing	8 ft. 2 in.
Main rotor	
Diameter	26 ft. 4 in.
Disc area	544.63 sq.ft.
Blade area (4 blades)	29.625 sq.ft.
Tail rotor	
Diameter	4 ft. 3 in.
Disc area	14.19 sq.ft.
Blade area	1.70 sq.ft.
Weights	
Empty weight	1,163 lb.
Design gross weight	2,100 lb.
Maximum gross weight	2,700 lb.
Payload with full fuel	400 lb.
Overload payload	937 lb.

Performance	
Maximum speed	128 kts.
Cruising speed	120 kts.
Rate of climb	2,120 f.p.m.
Hover ceiling (Std.atmos.)	
in ground effect	14,600 ft.
out of ground effect	12,000 ft.
Hover ceiling at 35°C	
out of ground effect	6,000 ft.
Range	280 n.m.
Ferry range	1,400 n.m.
Endurance at 100 kts.	3 hrs.

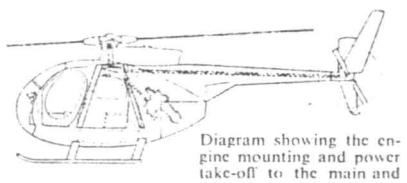
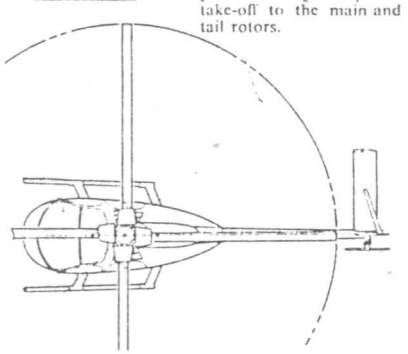
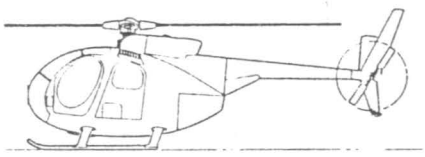


Diagram showing the engine mounting and power take-off to the main and tail rotors.





Field trials

The Army's six-month logistical evaluation and field trials which were conducted primarily at Ft. Rucker, Ala., were an unqualified success. All three aircraft performed well. For example, the OH-6A was scheduled for a total of 550 missions and only 16 of these aborted. Seven major problems areas were revealed by the prolonged field tests. These were: high frequency vibrations in the tail rotor, low frequency vibrations in several parts of the rotor and power train, airframe structural defects, landing gear wear, electrical system and instruments, exhaust pipe support structure and the main gear box. The number of occurrences of each type of problem ran from a high of 32 landing gear skid plates replaced, to only 2 instances when the main gear box gave trouble. It was possible to correct all of these problems and to prove the fixes, so it is expected that the production aircraft has been thoroughly debugged.

The trials also proved that all three of the aircraft could be maintained by two men using only the tools in a standard Army tool kit. The cost of normal maintenance exclusive of major overhaul for the OH-6A was found to be $1.90 for unscheduled overhaul and parts replacement, and the maintenance personnel requirement per hour of flight has been guaranteed to be less that 0.25 manhours. These are radical improvements over past Army experience.

Cost competition

On the basis of the field trial results, a selection board of general officers reported in the fall of 1964 that two of the LOH aircraft met the Army's requirements, the Hiller OH-5A and the Hughes OH-6A. After this ruling it was decided that the production LOH would be selected on the basis of the lowest price bid, from the two companies. The production run for which they prepared fixed bids totalled 714 aircraft over a three year period, from fiscal year 1965 through 1967. The first year's production is 88 aircraft, the second 168, and the third year 458.

The companies were given from October 1964 to May 1965 to prepare these detailed fixed price bids which they would guarantee. Hughes was awarded the LOH production contracts on the basis of a $19,860 cost for each LOH airframe, not including engine, avionics or other equipment. The Hiller bid was $ 29,415 for each airframe. The lighter weight, about 400 lb., of the Hughes machine is reflected quite accurately in this bid. Past experience indicates that the cost of light helicopters ranges from $30 to $40 per pound of empty airframe weight. Consequently, the 400 lb. lower weight of the OH-6A results in savings of more than $10,000 while still allowing the company a profit potential.

The Allison T63 which also was selected for quantity production will be purchased by the government under separate contract arrangements.

The chances appear to be good that the LOH will be a strong competitor in both civil and military aviation in all non-communist nations. Mass production of the LOH to meet Army demands is certain to lower initial cost to an unprecedented level for a helicopter of its type. Unprecedented mass operations, both in terms of numbers of aircraft and hours flown will have a similar effect in improving service life and lowering operational costs. The triple advantages of low initial cost, low operating cost and exceptionally high performance will make the LOH a prominent aircraft for years to come. ++