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US Army Aircraft for the 90s

L. L. Feaster

and

D. C. Borgman

Headquarters, US Army Aviation Research

and Development Command

St. Louis, Missouri, USA

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Garmisch-Partenkirchen
Federal Republic of Germany

Deutsche Gesellschaft fur Luft- und Raumfahrt e. V.

Goethestr. 10, D-5000 Koln 51, F.R.G.

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L. L. Feaster and D. C. Borgman
Headquarters, US Army Aviation Research
and Development Command
St. Louis, Missouri, USA

ABSTRACT

The technology emerging from our industrial and government research and development base presents an excellent opportunity for improving the fleet of US Army aircraft. For the near term, this technology could be applied in a piecemeal fashion to aircraft which are already in the field. A look at the threat, however, suggests that some of our current fleet may lack the growth potential which is required. Recognizing these deficiencies, the US Army Aviation Research and Development Command has begun concept formulation for a new Family of Light Helicopters (LHX). Basic to the LHX design philosophy are simplicity with small size and light weight (6000-8000 pounds). A high performance aircraft is envisioned with cockpit displays perfected and pilot functions automated to a level which allows single crewmember operation. Studies completed include an integrated subsystem and cockpit architecture, a preliminary weaponization analysis and an investigation of chemical protection alternatives. Studies have also been conducted to investigate the value of aircraft performance parameters in evading threat weapon systems. The model developed for this work is now being used for rotary wing, air-to-air combat simulation. Further work in related areas as well as refinement of the above will be conducted throughout the 1981-1982 time frame to provide information necessary to enter advanced development in 1983. Engineering development is projected to begin in 1986-1987 with initial fielding in the mid-1990s.

1. PROJECTED REQUIREMENTS.

The US Army's inventory of light helicopters (under 15,000 lbs) is comprised of several thousand scout, attack and utility aircraft. As shown in Figure 1, these aircraft were acquired in the 1960s and early 70s and will soon reach a normal 20-year service life.

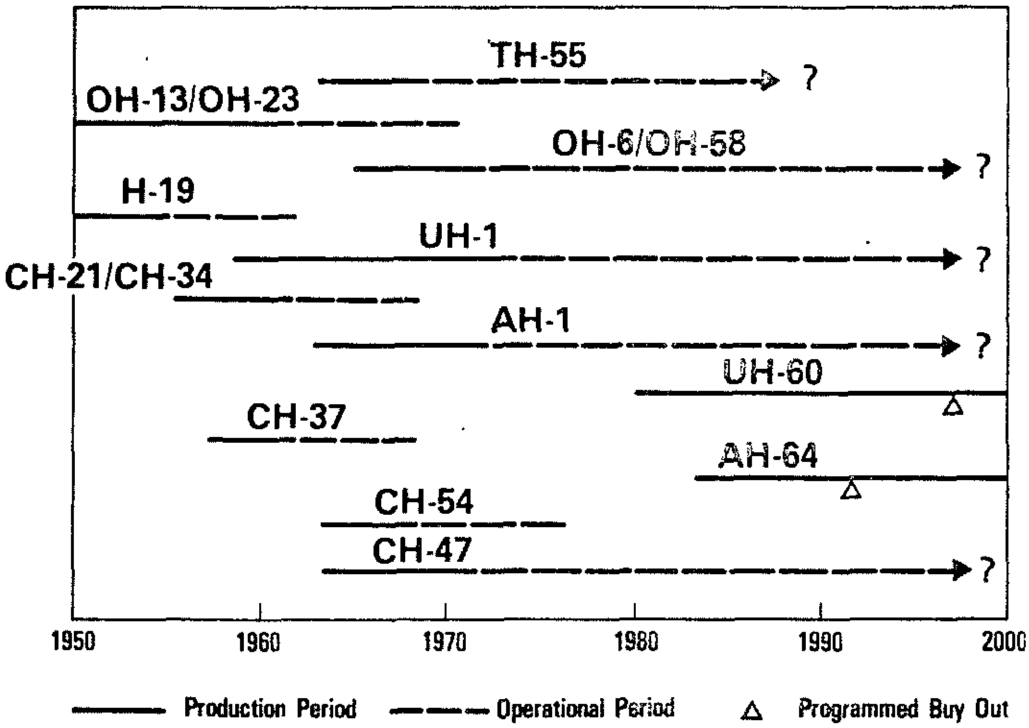

Figure 1. Army Helicopter Acquisition

It is a matter of concern that this aging fleet could become an operationally deficient and economically unsupportable force. This condition is expected to be relieved through implementation of the Advanced Helicopter Improvement Program (AHIP) and introduction of the AH-64 and UH-60 helicopters during the 1980s. However, the high capability AH-64s and UH-60s may be too costly to field in sufficient quantities to meet the threat; and the AHIP is considered only a near term solution to the actual requirement.

The problem is further aggravated by evolving tactical concepts which envision operation over wider ranges in highly dynamic battlefield settings. These scenarios place an increased emphasis on such factors as mobility, sustainability, and control measures. Deployment options to various trouble spots around the world is also a major factor; and the ability to conduct operations at night, under adverse weather conditions and in the presence of battlefield obscurants such as smoke, haze and dust is considered essential.

Survivability on the battlefield is expected to become increasingly difficult with the use of improved conventional weapon systems and potential for the introduction of nonconventional weapons. For the helicopter this means surface-to-air guns with higher rates of fire, better fire control, and more lethality; surface-to-air missiles with advanced guidance and higher flight velocities; and threat aircraft - both rotary and fixed wing. Two major areas on which the Soviets are placing a great deal of emphasis are their air defense and electronic warfare capabilities. They apparently recognize these two areas provide a high payoff for increasing their overall combat effectiveness and are rapidly expanding their capabilities in both areas. Other areas of concern are represented by their attention to developing rotary wing, air-to-air tactics, employment of chemical agents and development of tactical lasers as well as more exotic systems.

Projecting the US Army helicopter fleet into the 1990s time frame and comparing its capability to that of the forecast threat produces the following list of perceived needs, deficiencies and technical opportunities:

a. Numerical threat parity.

b. High target servicing rate.

c. Adverse environment operation.

d. NBC and EMP tolerance.

e. Deployment capability.

f. Pilot workload reduction.

g. Improved speed, range, endurance and dependability.

h. Precise navigation and target location.

2. CONCEPT FORMULATION STUDIES.

To meet these needs and enhance the future force structure, the US Army Aviation Research and Development Command (USAAVRADCOM) has been conducting concept formulation studies for a new aircraft system known as the Family of Light Helicopters (LHX). These studies are designed to provide information to assist in structuring the Command's technical base program and support an advanced development (AD) program beginning in mid-1983. Engineering development (ED) would start in 1986-1987 with first delivery to units in the field scheduled for the mid-1990s.

A primary consideration for the LHX is to design an affordable aircraft which can be produced in large numbers. A scout version is planned for initial development with attack and utility derivatives to be evolved around a common set of dynamic components. It is envisioned that both the scout and attack variants would use the same airframe and that a different airframe would be required for the utility model. Along with low cost, a small air vehicle in the 6000-8000 pound gross weight category is desired. Other general characteristics to be incorporated in the LHX are the "ilities": reliability, maintainability and survivability. For the LHX, however, these common descriptors are meant to carry a new dimension of meaning. Through the use of composites and advanced design techniques, the LHX will be able to continue operation in a damaged mode; and, while the mission equipment package, flight control system, radios, etc., may be degraded, the basic mission can still be performed. Survivability is to become more a matter of not being hit or destroying the enemy first rather than the mere ability to withstand a certain number of hits. Crew workload reduction is of paramount importance and will be accomplished through a planned series of investigations which have already begun in the concept formulation stage and will continue into engineering development.

INTEGRATED COCKPIT.

With the preceding framework of postulated requirements and desired aircraft characteristics for the 1990s, initial studies have focused on the feasibility of a one-man crew, lightweight weapon systems, performance/survivability trade-offs and integrated chemical, biological and laser protection. Of these, a preliminary avionics architecture study conducted by AVRADCOM shows the potential for dramatic weight savings up to one-third of that achieved using current state-of-the-art technology. It would enable the LHX to perform the scout and attack missions with a one-man crew by employing automation of communications; navigation and target acquisition; identification, radar warning, and missile detection; fire control; and flight control. The electrical power subsystem is described as a modern avionics power generation and control system using lightweight, high voltage direct current (270 HVDC) generators. Other results from the study are: (1) The power required for all avionics is estimated to be 4000 watts. (2) The unit cost for avionics, based upon 1981 dollars, will be approximately $500,000. (3) The volume required for avionics will be approximately 10 cubic feet.

Based on these very promising results, the following tasks are now being pursued:

a. Expand on a statement of mission functions.

b. Refine a baseline conceptual system.

c. Synthesize a conceptual control and display specification.

d. Determine conceptual system arrangement to assure adequate dependability.

e. Assess technological opportunities for improvements.

f. Describe mission capabilities and weight attainable as a function of cost.

In item c above, one or more critical workload phases will be selected for simulation and the simulator used to refine control and display layout as well as determine the validity of concepts.

A top level baseline system, Figure 2, has been assumed for this study. In this system, many pilot controls can be effected through a voice actuated control system. Pilot's night vision is assumed to be presented via a helmet mounted display; however, the baseline system does not show allocation of functions between helmet, heads up, or panel displays or tactile, audible, or synthesized speech systems. The main quantities to be displayed are functionally grouped, but final grouping and means of display are to be determined. A "computed map" has been included as one of the display elements where the term means a plan view of a shaded relief map both with and without terrain elevation contours and having cultural features, known air defense systems and targets, navigational waypoints and checkpoints, and terrain type designation (urban, open, forrested, etc.) shown. Other modes would institute intervisibility maps and contours of probability of survival in place of the terrain elevation contours. It is assumed that important locations can be labeled in such a way that they can be used in verbal commands to the navigation, target acquisition, flight control and weapon control systems. The "computed scene" would be a complementary display computed from the same data base, showing the scene in horizontal perspective. It is noted that the resulting baseline system may not contain all the functions described above since final configuration will be tempered by cost/weight trade-offs.

A second level baseline navigation and target acquisition subsystem, Figure 3, is also considered. The navigation system is an integrated hybrid system which uses a miniature strapdown inertial attitude and heading reference system, a precision doppler velocity sensor and a global position satellite system (GPS) for absolute position sensing. The doppler data, together with the attitude data, are furnished to the GPS for rate aiding. Position updating can be accomplished by the TV, FLIR and radar systems without requiring overflight of checkpoints. An alternate method of updating would use the radar altimeter terrain clearance data and the digital terrain data base to determine location from the terrain. An air data system with low speed, 3D air speed sensor provides input to the navigation and fire control system. Both of these systems should provide near-optimum combination of these data in an adaptive fashion so that degradation of some data will be compensated by increasing dependence on other data. Adequate precision for hover control should be provided by the doppler sensor so that no pattern correlation system is included. As can be seen, there are numerous opportunities to derive data from different sensors for validity comparison and to operate in various substitute and degraded modes. The system is therefore believed to be quite robust and relatively immune to external vagaries.

The overall effort is being performed for the LHX-Scout since it will be the first version fielded; and further, it appears that a baseline scout configuration can be reviewed to provide a suitable configuration for light attack and light utility/observation models. The final report on the above effort will be published in October-November 1982 and is timed to provide input for a follow-on advanced development effort.

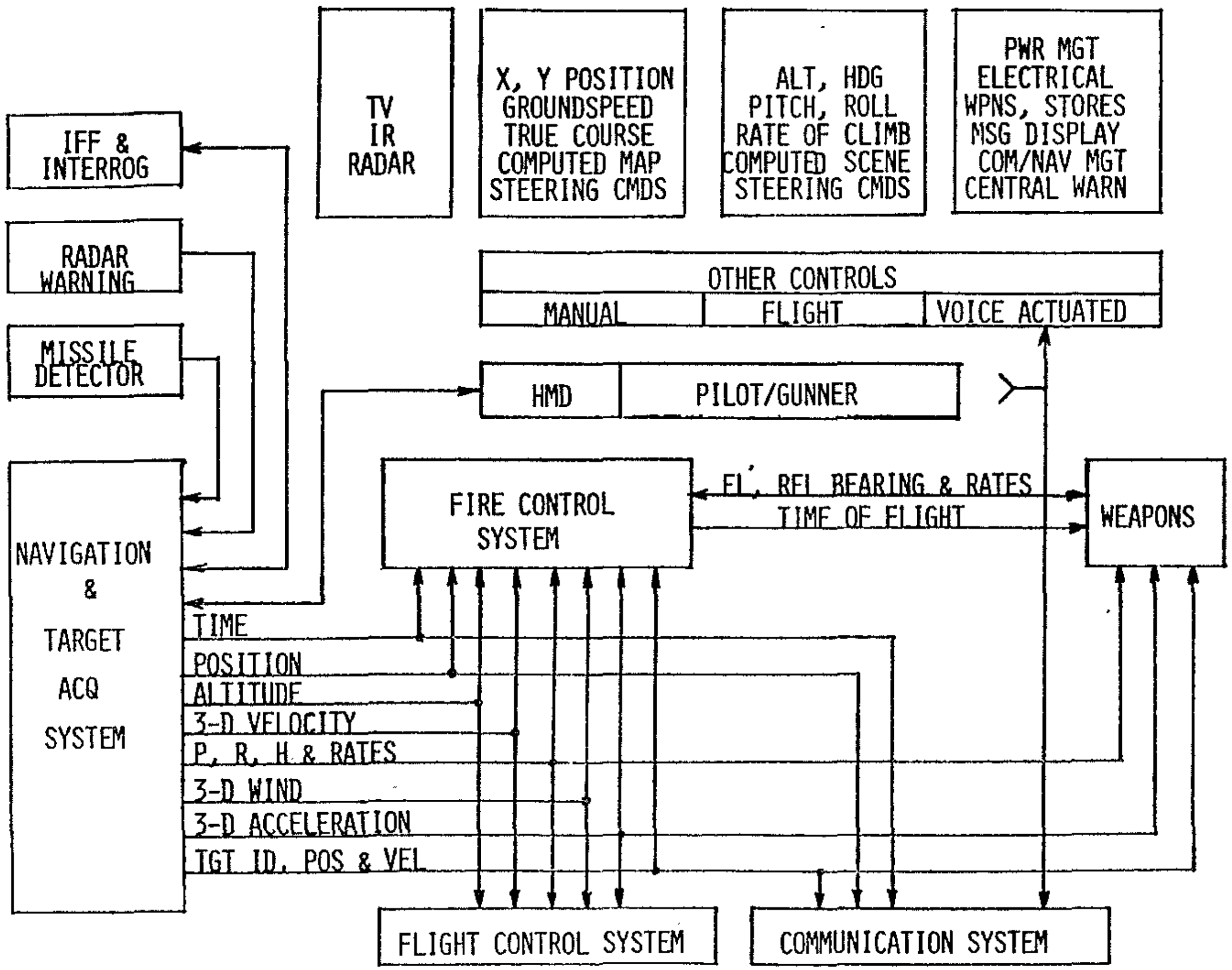

FIGURE 2. TOP LEVEL SCHEMATIC BASELINE SYSTEM

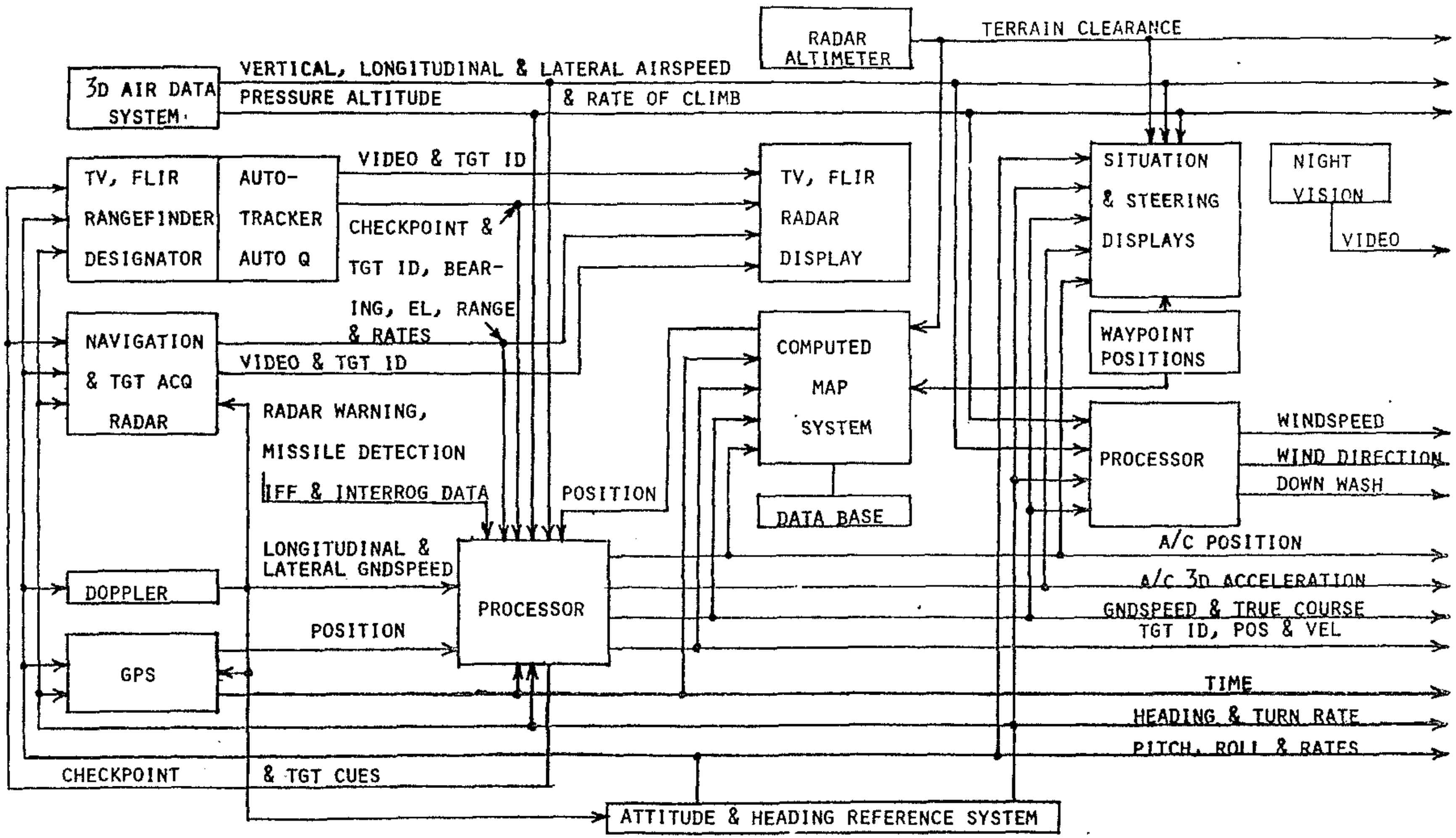

FIGURE 3. SCHEMATIC BASELINE NAVIGATION AND TARGET ACQUISITION SUBSYSTEM

WEAPONIZATION.

Turning to other areas in which technical concentration is being applied to realize a high payoff in capability, weapon system development has been selected for special emphasis. Here, the small size and low gross weight desired for the LHX dictate significant weight reduction measures over current systems while maintaining or improving performance characteristics. This task is made even more difficult by the expanded roles foreseen for each of the LHX models. Since the enemy's helicopter force is sizeable, it is expected that it will be used to impair our own helicopter operations. Also, the more successful our own attack helicopters become at killing tanks, the more they will become high priority targets for close air support fighters. Therefore, a primary function for all models, even to include the utility version, is to provide a self-protection capability against opposing helicopters and fixed wing aircraft. Due to the extensive air defense umbrella to be presented by threat forces, an equally important function for the LHX-Scout and LHX-Attack is to defeat ground based air defense systems in order to accomplish their primary missions.

To determine candidate systems for engineering development in the 1986 time frame, AVRADCOM has recently completed a preliminary survey of weapon technology. In assembling the report, concept options for gun type weapons were submitted by the US Army Armament Research and Development Command (ARRADCOM); missile, rocket and other advanced system concepts were provided by the US Army Missile Command (MICOM); and recommendations were received from various industry sources. For study purposes, a 500 pound weight goal was established for a system to defeat heavy armor (tanks), 400 pounds for the light armor and anti-personnel missions, and 250 pounds for anti-aircraft and anti-air defense systems.

By investigating selected gun armament weight distributions of current developmental helicopters, the report projects future trends. The table below shows three such systems.

HELICOPTER GUN SYSTEMS WEIGHT DISTRIBUTION (LBS)

	AH-1S Cobra 20mm/M97E2	AH-1T Cobra 25mm/GAU-12	YAH-64 30mm/XM230
TURRET	416	301	447
FEEDER	23	28	-
GUN	139	293	118
AMMO BAY	(750 rds)	(435 rds)	(1,200 rds)
Empty	(93)	(107)	(191)
Loaded	520	564	924
	1,098	1,186	1,489

Obviously, the development trend of the 1980s cannot meet the LHX weight allocation of 400-500 pounds; and innovative techniques must be used for ammunition, turret and gun systems.

Several departures from current design convention were considered by ARRADCOM: First, assuming a high agility LHX, a limited flexible mount was used instead of the conventional turret; Second, an interchangeable armament module was proposed to allow several armament options; and Third, new technological developments in ammunition and gun componentry were exploited. An example of one of the designs is shown in Figure 4.

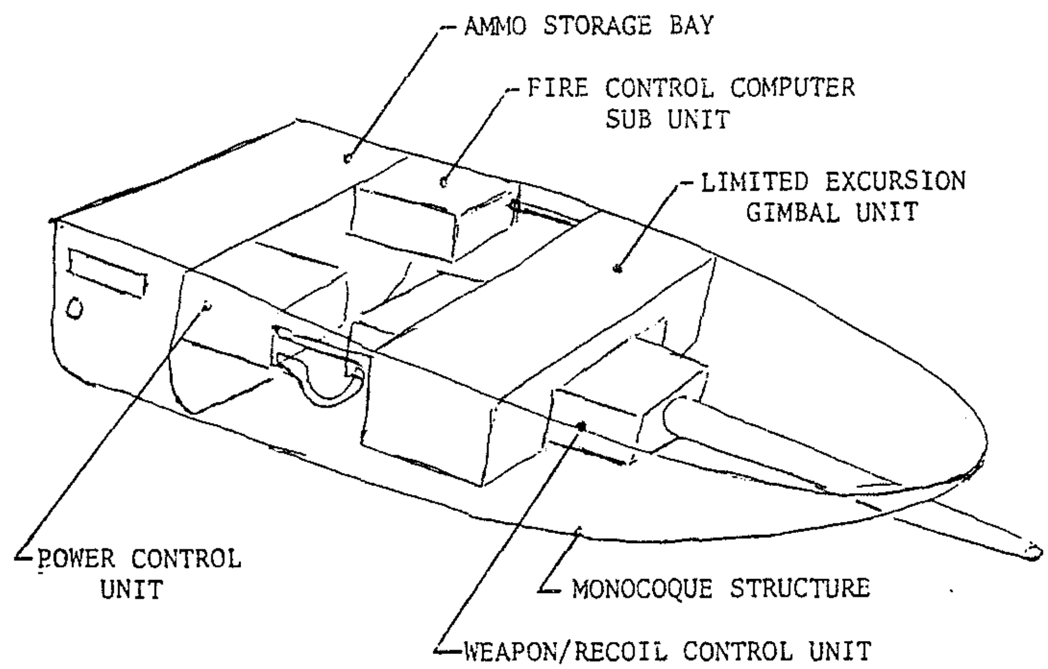

Figure 4. Advanced Armament Module

From these advanced concepts, the following component technologies were defined as requiring immediate impetus:

a. Lightweight material.

b. Precision control.

c. Multi-purpose ammunition.

d. Target sensing and maneuvering projectile.

While the proposed designs provide valuable new gun options for the LHX, the technical risk in attaining the higher capabilities in the specified time frame is considered very high. Funding levels for each of the technical areas will have to be established and maintained at relatively high levels throughout the development cycle, and these will have to be carefully protected.

The weapons survey presents a much brighter picture of missile system options and their availability than it does for gun options. The candidate systems described in the report are:

a. Modular Multimode Fire and Forget Missile (M^2F^2M).

b. Close Combat Laser Assault Weapon (CCLAW).

c. Multipurpose Lightweight Missile System (MLMS).

d. Single Penetrator Kinetic Energy (SPIKE).

e. All Weather HELLFIRE Modular Missile System (HMMS).

f. Fibre Optic Guided Missile (FOG-M).

g. 2.75" Rocket variants.

h. Solid Propellant Advanced Ramjet Kinetic Energy Missile (SPARK).

i. Hypervelocity Guided Rocket (HGR).

These weapons represent an extremely wide array of characteristics and performance features available to the LHX with substantial differences in seeker type, range and armor penetration. Nearly all would meet the LHX weight goals with the All Weather HELLFIRE Modular Missile weighing 100 pounds and the SPARK missile at 90 pounds being possible exceptions due to the limitation in number of rounds that could be carried. Other variables represented by these candidates include flight trajectory, time of flight, method of destruction and probability of hit/kill.

In summary, the weaponization study has provided descriptions, analyses, trends and forecasts of threat forces and US countering capabilities as they impact the design of LHX weapon systems. Further effort is indicated to refine the results and to identify optimum weapon suites for the LHX family.

With this survey as a starting point, a one year investigation will be initiated this fall. Tasks to be performed are:

a. Update the threat forecast presented in the original weapons study.

b. Develop an analysis methodology for performing cost, operational effectiveness and trade-off analyses for Army aircraft and Army aviation weapons considered as synergistic systems performing tactical operations in dynamic scenarios.

c. Employ the threat forecast and methodology developed in a. and b. above to identify and evaluate potential weapons systems for each of the LHX models.

The analysis will address system operation in an authentic battlefield environment under the following conditions: day and night, limited visibility, rain and snow, battlefield obscurants, and radio/electro-optical jamming. The effects of terrain shielding on direct view optics, sensors, seekers, etc., will be considered, especially during air-to-air engagements.

Study methodology will permit evaluation of one or more aircraft organized to perform a specific tactical mission. If more than one aircraft is depicted, the aircraft may be of different models (e.g., scout, attack or utility) or they may be the same model with different weapon configurations (e.g., attack with guns and attack with missiles). Consideration will be given to such aircraft attributes as speed, agility and endurance and specific weapon system capabilities to include lethality, ground preparation time and target servicing rate. Measures of effectiveness will be determined through the use of force-on-force simulation in scenarios ranging in scope from small units up to and including division/corps level. As a final product, the methodology will identify those weapon systems for the LHX which best meet Army aviation needs for the 1990s and determine associated acquisition costs.

PERFORMANCE/SURVIVABILITY.

In a related effort, a study which seeks to quantify the aircraft performance contribution to survivability has been underway. A stochastic learning model was used to determine optimal aircraft maneuvers for a wide variety of threat weapon launch conditions. The AH-1G Cobra helicopter was modeled for the base case, and a notional LHX with 250 knot speed capability was introduced for comparison. These two helicopter designs were then played on a one-on-one basis against two threat weapon systems. The threat system consisted of an anti-tank guided missile (ATGM) launched in an air-to-air mode and a surface-to-air missile (SAM) with high performance characteristics. The effects of terrain and obscurants were not considered, and the threat sensor and guidance were credited with perfect operation over the full kinematic range. The aircraft, on the other hand, were assumed to be equipped with a warning system which accurately presented missile location.

Study results identify relevant performance features for different aircraft energy states and demonstrate model capability to perform trade-off analyses between performance and survivability features. More specifically, the study concludes that for the ATGM air-to-air threat, transient turn capability was important at high speed, sustained turn capability at low speed and rudder pedal turn with lateral acceleration was beneficial at the hover condition. To meet the surface-to-air threat, it was found that survivability must rely on seeker sensor jamming in coordination with maneuver and nap-of-the-earth masking maneuvers.

This model is currently being applied to three other threat systems: an attacking helicopter with a turreted gun, a surface-to-air gun system and an improved performance SAM. This study is being complemented by two other investigations which examine the survivability, productivity and cost of small air vehicles in three speed regimes. These speed ranges are 150 to 200 knots, 200 to 250 knots and over 250 knots. The latter two studies are of short duration and when considered with emerging results from the first task, air-to-air, the data will be used to determine a tentative speed band for the LHX. Having postulated this requirement, it will be possible to further define advanced development efforts and focus the Command's technical base program to best facilitate entry into engineering development.

With a desire for more extensive analysis of LHX performance requirements, Army researchers are considering further investigations which would examine speed, maneuverability, and countermeasures in a more realistic setting. If undertaken, this effort would use a methodology which closely resembles that of the follow-on weapons study but focuses on aircraft performance and survivability features. The period allotted for this work would be 10 to 12 months with a final report due in November-December 1982.

NUCLEAR, BIOLOGICAL AND CHEMICAL.

Pursuing an increased capability for the LHX in another field, AVRADCOM has explored various alternatives to protect the aircraft and crew from nuclear, biological and chemical (NBC) effects. Present NBC protective gear was first considered for its adequacy to protect the crew against the projected threat. The current aircrew chemical-biological (CB) ensemble consists of a chemical protective overgarment, footware covers, rubber gloves, masks and a hood. These garments must be worn over the standard flight uniform which includes combat boots, Nomex flight suit, flying gloves and SPH-4 flight helmet. The study establishes that the NBC protection of this equipment is satisfactory; however, it is noted that the aircrew CB ensemble is cumbersome and bulky, reduces dexterity, contributes to heat stress, and is not fire resistant. The heat stress problem is highlighted as an area for improvement with the interface between protective mask and visual display/sighting systems being of nearly equal importance.

In assessing technical approaches best suited for the LHX, the study presented five NBC protection options: (1) Ventilated Facepiece, (2) Ventilated Facepiece with Cooling, (3) Liquid Cooled Vest, (4) Collective Protection, and (5) a Hybrid Collective System. A full positive pressure collective system for the LHX would permit normal flight gear to be worn. The advantages of this approach are obvious in that no encumberances of CB paraphernalia would be necessary during flight operations. Major problems arise, however, from ingress and egress in contaminated areas, punctures or ruptures in the skin or canopy and crash/forced landing situations. As a solution, a hybrid system is being considered for the LHX which uses both collective protection and aircrew CB clothing. This system would offer cooled, filtered cabin air at a slight positive pressure; but the equipment would not be sized to meet hit capability and still maintain pressure. A full CB ensemble, complete with mask, would also be worn by the crew; but it would be of a new, lightweight design.

3. ADVANCED DEVELOPMENT PROGRAM.

As mentioned at the outset, an Advanced Development program is scheduled to begin in 1983. It is structured to complement the Command's generic technology base program in areas unique to the LHX and facilitate entry into engineering development in 1986. Three of the concept formulation studies just discussed would lead directly into tasks which have been identified for this effort. These tasks are Single Pilot Automated Demonstrator (SPAD-86), Lightweight Armament System (LAS), and Chemical, Biological and Laser (CB&L) demonstrations. SPAD-86 would expand on previous integrated cockpit work to develop a full simulation capability and flight demonstration vehicle to evaluate the mission potential of a one-man crew. Projects for the simulator include refining control and display layout, examining flight control laws and selecting the proper balance of automation and pilot interaction. The flight demonstration program will provide verification of simulator results, establish a range of missions for which a one-man cockpit is feasible and provide data to establish specification requirements for ED. Approximately 50 hours of flight test will culminate with a limited evaluation by Army pilots. The goal for LAS is to develop a lightweight Target Acquisition Designation System/Pilot Night Vision System (TADS/PNVS) which includes focal plane array technology and auto-cueing as integral functions. Night acquisition capability is expected to be improved by 50 percent and system weight reduced by 100 pounds. A prototype unit would be fabricated, bench tested, and flown in a limited flight test program to verify performance. In the CB&L demonstrations, the proposed hybrid collective system would be refined and trade-offs evaluated to determine the optimum clothing/cockpit protection system for LHX crew effectiveness. A cockpit mock-up would be used to study crew workload, fatigue, heat stress and interface problems, Additionally, investigations will be performed to evaluate and determine specifications for both low and high energy laser protection schemes. In this phase, structural sections and components would be tested against high energy laser weapons; and various eye protective measures would be evaluated for their effectiveness in countering the low energy laser threat.

Other tasks proposed for advanced development include the application of adaptive concepts to electronic fuel control; fabrication and test of a lightweight drive system with 30,000 RPM engines; advanced transmissions and high speed clutches; and research into electric control actuators with attendant elimination of the current hydraulic system and swash plate. A High-Speed Rotor Optimization task will maximize rotor performance for mission profiles and vehicle configuration. Studies will be perfomed for both high-speed pure helicopter and compound configurations. Following the design studies, scale model wind tunnel demonstrations of two candidate systems will be performed. Again, the overall goal of the LHX program is to produce a small, affordable, and effective aerial system for the 1990s through judicious application of advanced technology. Through a continuing process of trade-off analyses, the benefit of technological advances will be carefully weighed against cost and weight.

4. CONCLUDING REMARKS.

Finally, in tracing the LHX program through to completion, only the framework of the engineering development program has been formulated. Scheduled to commence in the 1986-1987 time frame, a two contractor, prototype flyoff is envisioned for the scout model with final selection leading to low rate initial production in the early 1990s. Sequencing of the attack and utility derivatives is expected to follow in two year intervals. As stated earlier, commonality of engines, rotors and drive systems along with other major subsystems is a key driver of the LHX concept. As the program matures, it is even conceivable that the scout and attack models will merge into a single aerial system with modular equipment packages which are interchangeable to accommodate specific missions. Such a vehicle has already been described in some circles of the user community under the name of an air cavalry vehicle. Be that as it may, the US Army is well on its way to developing an aircraft for the future. LHX: a small, fast, fighting machine.

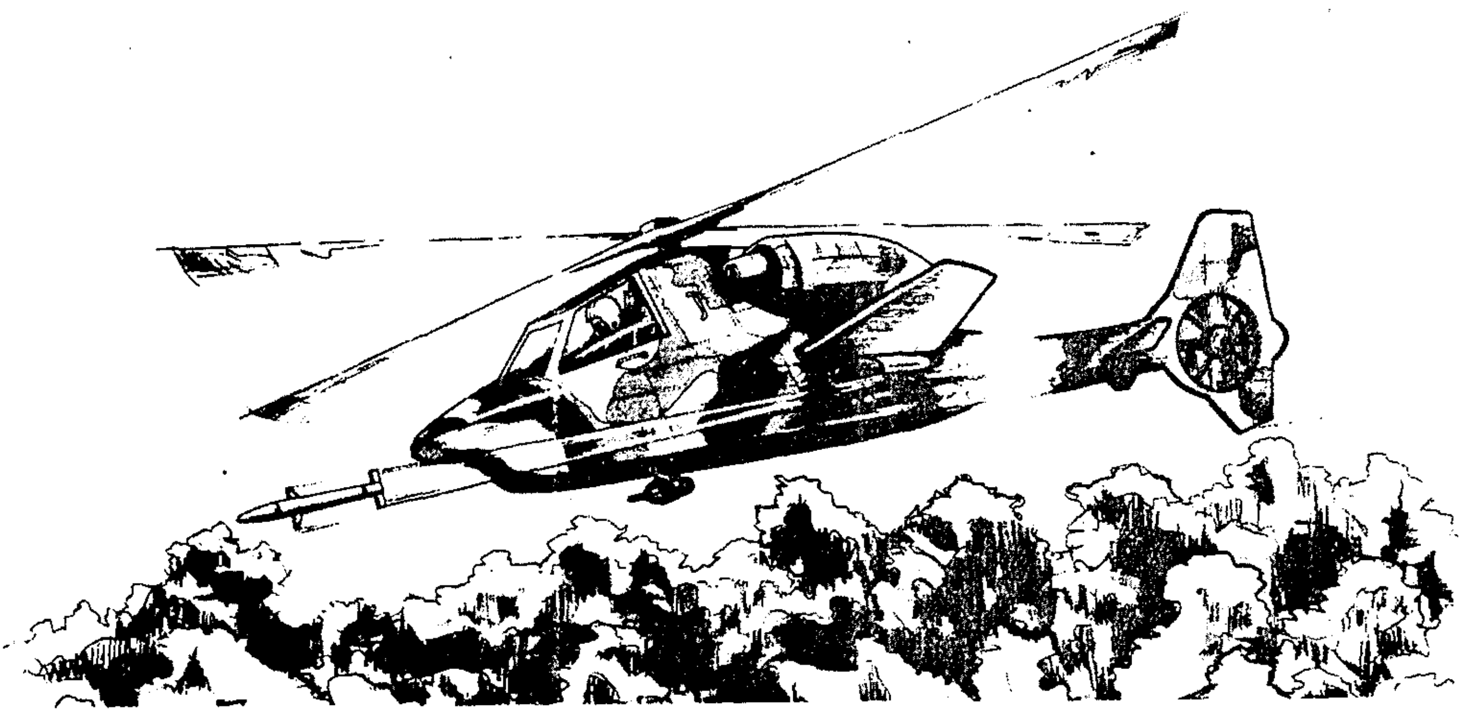

Figure 5. LHX Artist's Concept