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THE LHX PRELIMINARY DESIGN PROCESS

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ABSTRACT

The Army has initiated concept formulation of the new family of light rotorcraft (LHX) to replace an aging and increasingly obsolescing light helicopter fleet. This effort involves a comprehensive interaction between the Army combat development community, the Army Materiel Development Command, and industry. Trade-offs must be made between design requirements and available technology to arrive at an operationally effective system at an affordable cost. Naturally, this must be an iterative process using parametric sizing and analysis to obtain point designs that can be evaluated against cost and design requirements. While industry follows this same procedure, the Army must conduct its own independent analysis. This paper will present the methodology that is being used for LHX concept formulation and explain the emphasis placed on interaction between the combat developer, materiel developer, and industry during the preliminary design process.

1. Introduction

LHX is the Army's next generation light rotorcraft which will incorporate the latest in air vehicle and mission equipment technology focused on the pilot, the mission and cost effective operations. LHX will extend the performance, agility, survivability, sustainability, and supportability of the future Army fleet to meet the challenges of the 1990's and the AirLand Battle 2000 concept. LHX signals a new direction for Army Aviation and heralds the arrival of high technology in the fleet (See Figure 1).

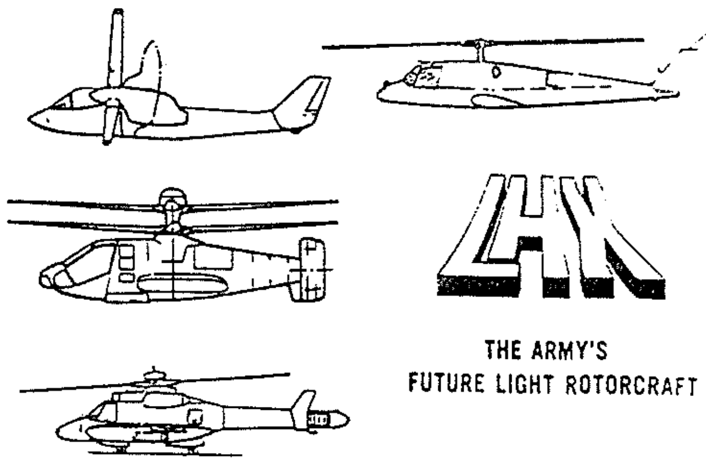

Figure 1

The current fleet of Army helicopters, with the exception of BLACK HAWK, APACHE and AHIP, was fielded during the Vietnam era and is aging both physically and operationally. This aging process has been further compounded by an increasing threat, an expanded US global commitment, and evolving AirLand Battle tactics and doctrine. In direct contrast to the aging problem of our light fleet, has been the extraordinary advances made in microelectronics technology during the same period. New opportunities have been created by the explosion of the microprocessor industry that offer tremendous operational advantages to the Army.

By the mid 1990's, the UH-1, AH-1, OH-58 and OH-6 will be approaching 30 years of service and will need either replacement or major modifications. Complete fleet modification might well exceed the cost of replacing the original system, and, when accomplished, survivability and performance may only be marginally improved. LHX therefore will become the applied technology vehicle for the future of Army Aviation. By pursuing an aggressive acquisition schedule, the LHX can cost effectively bring these new capabilities, new standards of reliability and new mission effectiveness into the Army's light fleet by the early 1990's.

The LHX will meet its challenge by capitalizing on Army aviation's maturing technology base. Advances in lightweight composite materials, dynamic components and fly-by-wire/light flight control systems, will reduce the empty weight of the aircraft and greatly improve its performance and survivability. Voice actuated controls and subsystems, automatic target recognizers, and advanced communications and navigation equipment will reduce the LHX pilot's workload, thereby increasing productivity. Highly reliable, fuel efficient engines will further increase the LHX's overall effectiveness and productivity. Adding to the LHX's high technology mission equipment will be new design concepts for reliability, availability, and maintainability to reduce the cost of ownership to the Army. There is even potential for LHX to meet its mission requirements in a single pilot configuration, expanding the operational flexibility of the total system.

Designed as a family of light helicopters in the 8000 lb. class, LHX will center around two separate airframe designs; a utility version will augment the UH-60 and replace the outdated UH-1 and OH-58 helicopters in those units where a full squad carrying capability is not required. Furthermore, by standardizing its utility and administrative fleet with the UH-60 and LHX-Utility, the Army will improve its overall logistics posture and become more sustainable, efficient, and productive.

The second version of LHX is the scout/attack or SCAT. LHX-SCAT uses a common airframe for both its scout and light attack missions and shares common dynamic components with the LHX utility (see Figure 2). By adding or deleting weapons and other mission equipment, the unit commander can quickly tailor his aircraft to perform either the scout or attack mission. While the AH-64 and AHIP fill the heavy attack force structure, LHX-SCAT will replace the UH-1 and AH-1 series of attack helicopters. Standardizing the force with AH-64, AHIP and LHX-SCAT will reduce the number of individual types and models of scout/attack helicopters in the current fleet by more than 50 percent. This standardization will consequently improve aviation's overall sustainability, supportability and deployability of its light scout/attack units.

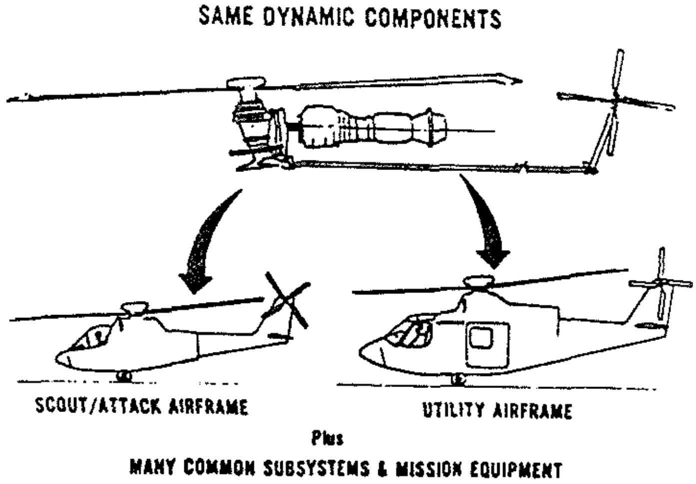

Figure 2

2. Concept Formulation

All systems begin as a gleam in the eye of someone and undergo many different phases of development before being deployed, made operational, or marketed. This is true for weapon systems, transportation systems, or new products. The U.S. Department of Defense (DOD) uses a system life cycle concept in the management of the development of weapon systems and the first phase is concept formulation. The LHX is in the conceptual phase. The justification for a major system new start (JMSNS) has been approved by the Army and it contains documentation on why the LHX is needed, what technology makes it happen, what constraints should be applied, and what initial acquisition strategy will get you there. Approval of the JMSNS allows you to enter concept formulation, provided adequate funds are made available. The fundamental purpose of the conceptual phase is to conduct a feasibility study of the requirements in order to provide a basis for further detailed evaluation. Table 1 shows the details of these efforts[1]. The LHX Special Working Group (SWG) is drawing expertise from the entire Army community and is interfacing with the other military services and industry to insure state-of-the-art technology is available to produce a lightweight, low cost, and reliable weapons system.

CONCEPTUAL PHASE

- DETERMINE EXISTING NEEDS OR POTENTIAL DEFICIENCIES OF EXISTING SYSTEMS.
- ESTABLISH SYSTEM CONCEPTS WHICH PROVIDE INITIAL STRATEGIC GUIDANCE TO OVERCOME EXISTING OR POTENTIAL DEFICIENCIES.
- DETERMINE INITIAL TECHNICAL, ENVIRONMENTAL AND ECONOMIC FEASIBILITY AND PRACTICALITY OF THE SYSTEM.
- EXAMINE ALTERNATIVE WAYS OF ACCOMPLISHING THE SYSTEM OBJECTIVES.
- PROVIDE INITIAL ANSWERS TO THE QUESTIONS:
  - WHAT WILL THE SYSTEM COST?
  - WHEN WILL THE SYSTEM BE AVAILABLE?
  - WHAT WILL THE SYSTEM DO?
  - HOW WILL THE SYSTEM BE INTEGRATED INTO EXISTING SYSTEMS?
- IDENTIFY THE HUMAN AND NONHUMAN RESOURCES REQUIRED TO SUPPORT THE SYSTEM.
- SELECT INITIAL SYSTEM DESIGNS WHICH WILL SATISFY THE SYSTEM OBJECTIVES.
- DETERMINE INITIAL SYSTEM INTERFACES.
- ESTABLISH A SYSTEM ORGANIZATION.

Table 1

The concept formulation package for a major DOD weapon system consists of a Trade-off Determination (TOD), Trade-off Analysis (TOA), a Best Technical Approach (BTA), and a Preliminary Quantitative Analysis (PQA). Figure 3 illustrates the interelationships of these elements as well as the lead organization for each element. The term "user" refers to the combat developer, TRADOC, while the term "developer" refers to the material developer, DARCOM. Products from one element are fed to another element as depicted in Figure 4 for the TOD outputs which become the TOA inputs.

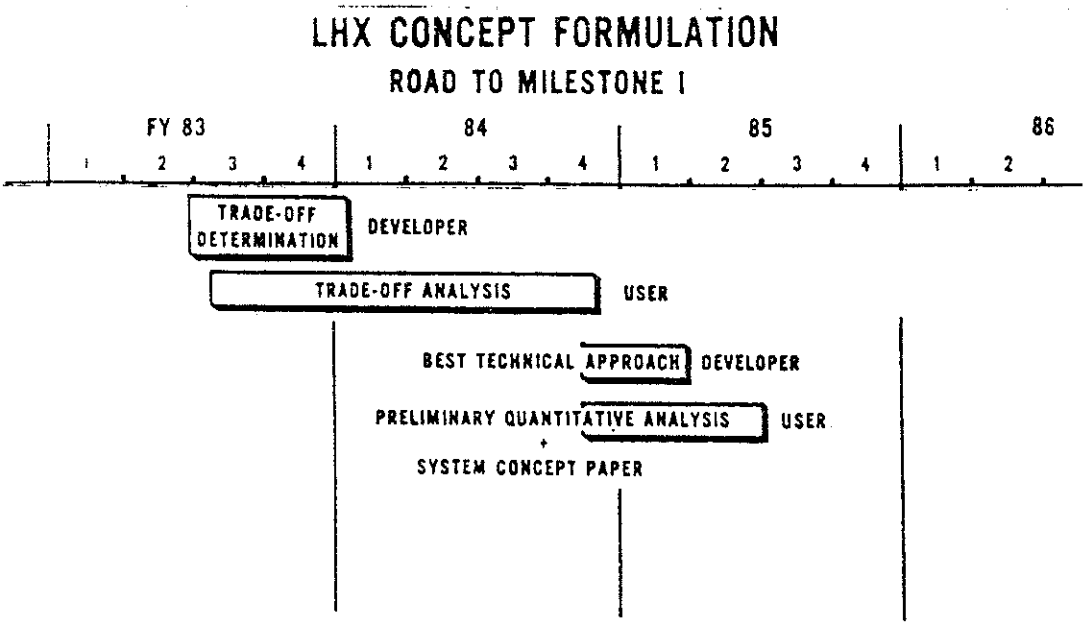

Figure 3

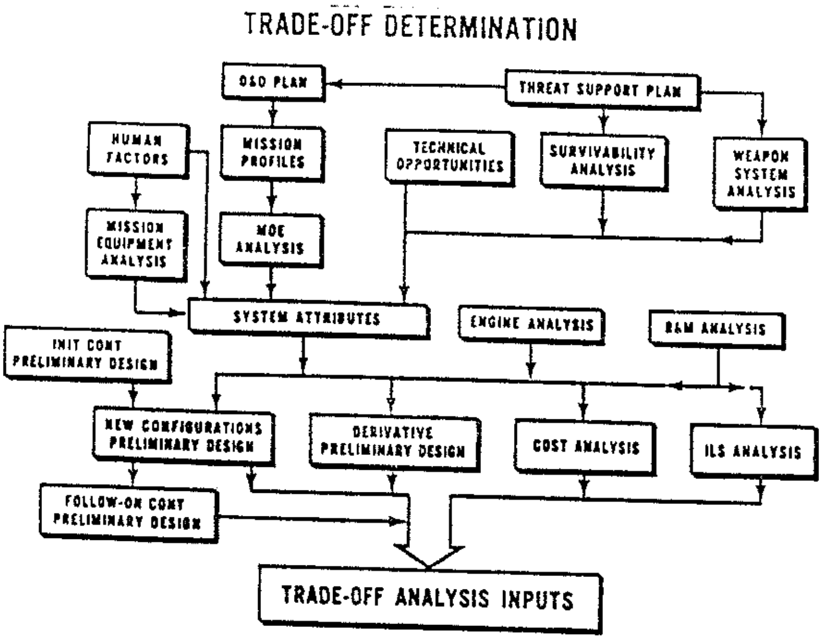

Figure 4

3. <u>The Preliminary Design Process</u>

The engineering analysis at the heart of concept formulation is the preliminary design process as depicted in Figure 5. The need for new weapon systems in the Army is generated by the concept based requirement system, which assesses Army operational capability against a proposed threat. The Army has recently completed a mission area analysis (MAA) in each of its operational functional areas. The Army Aviation Mission Analysis (AAMAA) identified major deficiencies in its light helicopter fleet that established the need for LHX as illustrated in Figure 6. In addition to the AAMAA, which addressed the Army's near term Airland Battle "How to Fight" Doctrine, the Army has developed on Airland Battle 2000 (ALB2K) concept which projects operational concepts on the future battlefield. These two areas, the MAA and ALB2K, have generated the concept based requirements which have driven the LHX design requirements as illustrated in Figure 5.

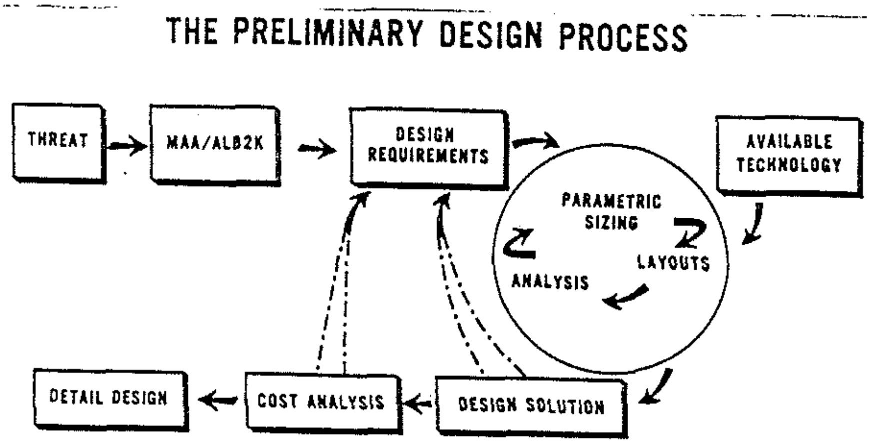

Figure 5

Figure 6

POTENTIAL IMPROVEMENTS IN CRITICAL CHARACTERISTICS DUE TO GENERIC TECH BASE PROGRAM

CRITICAL CHARACTERISTIC	SOURCE OF IMPROVEMENT
SMALL LIGHTWEIGHT	ADVANCED COMPOSITE STRUCTURES, INTEGRATED COCKPIT CONTROLS AND DISPLAYS, ADVANCED ROTOR SYSTEMS, LIGHTWEIGHT INTERCOM, ADVANCED PROPULSION
HIGHLY MANEUVERABLE, AGILE	ADVANCED ROTOR SYSTEMS, ADVANCED FLIGHT CONTROLS, AIR VEHICLE CONFIGURATION
SIMPLE TO OPERATE	INTEGRATED COCKPIT CONTROLS AND DISPLAYS, VOICE INTERACTIVE CONTROLS, ADVANCED FLIGHT CONTROLS, VHSIC
LOW LIFE CYCLE COST	ADVANCED COMPOSITE STRUCTURES, ADVANCED ENGINES, ADVANCED ROTORS
RELIABLE, SUSTAINABLE	ADVANCED COMPOSITE REPAIR TECHNIQUES, COMBAT MAINTENANCE, FAULT TOLERANCE, REDUNDANCY, GROUND SUPPORT EQUIPMENT, VHSIC
SURVIVABLE	ADVANCED COMPOSITE STRUCTURES. ADVANCED FLIGHT CONTROLS LOW OBSERVABLES, REDUCED VULNERABILITY
MISSION EFFECTIVENESS	NIGHT NAVIGATION AND PILOTAGE SYSTEM. ADVANCED FIRE CONTROL SYSTEMS, ADVANCED TARGET ACQUISITION SYSTEMS. VHSIC

Table 2

Determining available technology and engines in the preliminary design process requires a detailed technical assessment. For a complex weapon system, such as LHX, this assessment must be across the complete range of aviation technologies (aeromechanics, structures, propulsion, survivbility, RAM/LOG, avionics, and weaponization). Fortunately, there are emerging technologies in ongoing technology base programs that will provide potential improvements in critical LHX characteristics. The potential improvements are summarized in Table 2 against the critical characteristics. The synergism of these technologies make LHX possible and support the program in a timely manner as illustrated in Table 3. The detailed technical assessment must evaluate these technologies and determine technology factors that can be used in the preliminary design computer codes, which are illustrated by the circle in Figure 5. Since the configuration for the LHX, i.e., helicopter, compound helicopter, Advancing Blade Concept (ABC), tilt rotor etc., has not been determined, preliminary design computer codes must be available for a variety of configurations, each with its own peculiarities. The conventional helicopter preliminary design program is described in Reference 2, as well as how it was utilized in the Advanced Scout Helicopter (ASH) concept formulation efforts.

ONGOING TECH BASE PROGRAMS SUPPORTING LHX

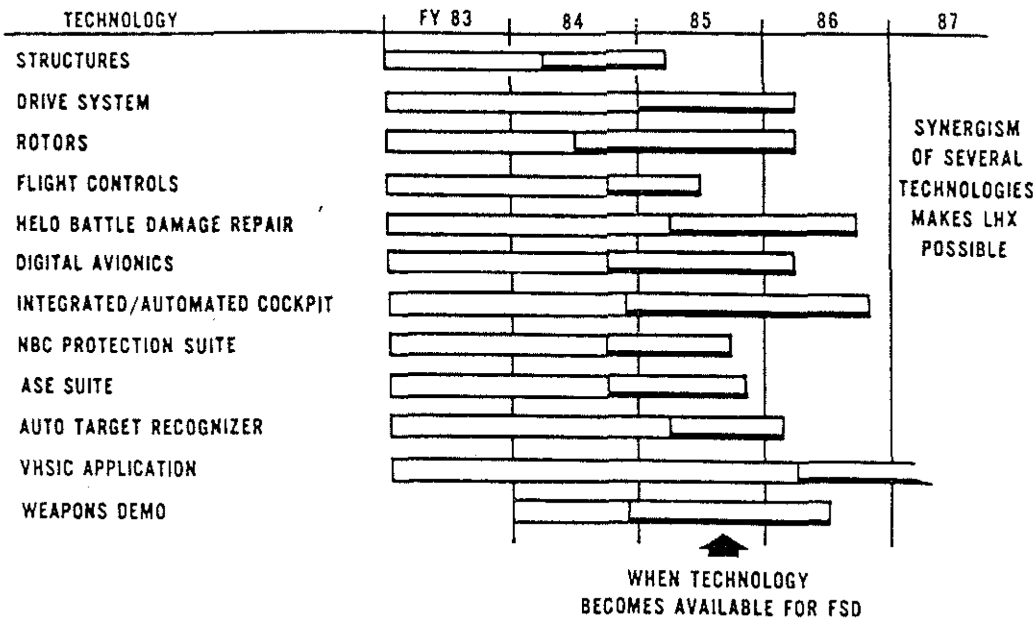

Table 3

While Table 2 listed potential improvements in critical LHX characteristics, the technology assessment also identified voids. The analysis of LHX technology voids is provided in Table 4 and revealed the need for parametric sensitivity analysis of critical design parameters. These are the products of the TOD that will be provided to the user for his trade-off analysis (TOA) (see Figure 4). For many of the critical design parameters, these products are sensitivity variations from a baseline configuration plotted against size, weight, and cost. For some mission equipment, sub-system and weapon parameters a sensitivity variation may not be feasible and selected values are provided based on other rationale such as risk. As illustrated in Figure 5, design solutions and cost analysis are iterated with design requirements in a trade-off fashion to reduce the range of design requirements to that considered achievable and affordable.

ANALYSIS OF LHX TECHNOLOGY VOIDS

CRITICAL CHARACTERISTIC	VOID
SMALL LIGHTWEIGHT	SENSITIVITY OF SIZE AND WEIGHT TO INCREASE IN SURVIVABILITY, MANEUVERABILITY, AND WEAPONS CAPABILITIES NOT QUANTIFIABLE
HIGHLY MANEUVERABLE, AGILE	SENSITIVITY OF SIZE, WEIGHT, AND COST TO IMPROVEMENT IN SURVIVABILITY ACHIEVED THRU HIGH MANEUVERABILITY AND AGILITY NOT QUANTIFIABLE
SIMPLE TO OPERATE	ACCEPTABLE TECHNICAL/COST RISKS OF REDUCED WORK LOAD HAVE NOT BEEN DEMONSTRATED. TWO CREW COCKPIT RISKS ARE MODERATE. SINGLE CREW RISK IS HIGH
LOW LIFE CYCLE COST	EFFECT OF INTEGRATION/AUTOMATION, PERFORMANCE, SURVIVABILITY FEATURES AND WEAPONS ON COST NOT PREDICTABLE.
RELIABLE SUSTAINABLE	EFFECTS OF INTEGRATION/AUTOMATION ON DIAGNOSTIC APPROACH, REDUNDANCY REQUIREMENTS, AND SUPPORT COSTS NOT KNOWN.
SURVIVABLE	CRITERIA FOR SELECTION OF DETECTABILITY AND VULNERABILITY FEATURES AND THEIR INTEGRATION FOR SETS OF THREATS, MISSION, AND AIRCRAFT PERFORMANCE.
MISSION EFFECTIVENESS	ALL ABOVE VOIDS MAY ADVERSELY INFLUENCE MISSION EFFECTIVENESS UNLESS ELIMINATED.

Table 4

Once this range of design requirements is achieved, the preliminary design computer codes are exercised to obtain point design solutions. A point design solution is a specific LHX system configuration adequately defined to assess performance, supportability, availability, survivability, and cost. The development of LHX system characteristics, are guided by the measures of effectiveness (MOE's) and life cycle cost. MOE's provide the bridge between operational and engineering characteristics, as illustrated in Figure 7 for survivability. A summary of some critical MOE's for LHX are illustrated in Figure 8. Determining life cycle cost is a complicated and difficult job. A life cycle cost analysis must provide research and development, investment, and operation and support cost information for the major issues associated with design requirements, acquisition management, and logistics support. Its accuracy must be sufficient to permit evaluation of LHX System point design variants. After conducting initial point designs, a best technical approach (BTA) to meet the LHX concept must be determined. The BTA is then provided the user for use in his Preliminary Quantitative Analysis (PQA) to determine the most cost and operationally effective LHX concept. The PQA uses MOE's in a force-on-force role. Completion of the PQA ends concept formulation, and if the LHX requirement for a new start development program is validated, detail design, as illustrated in Figure 5, can begin.

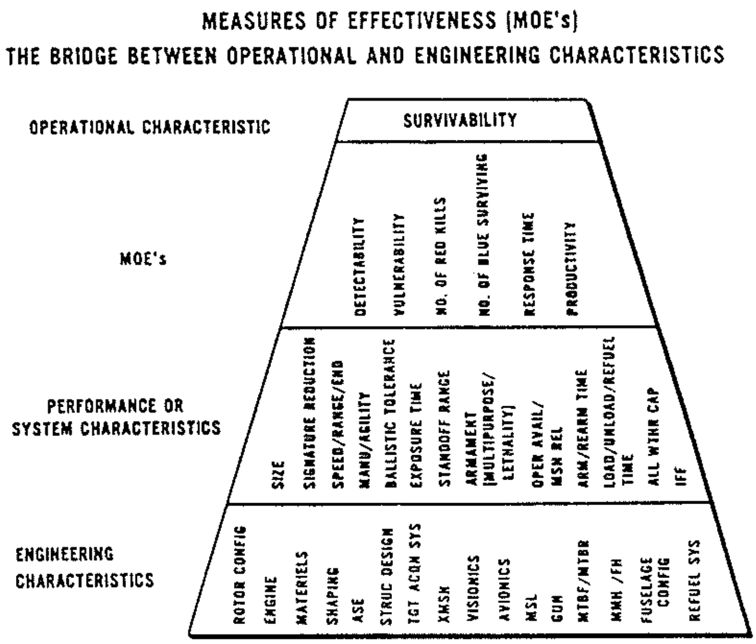

Figure 7

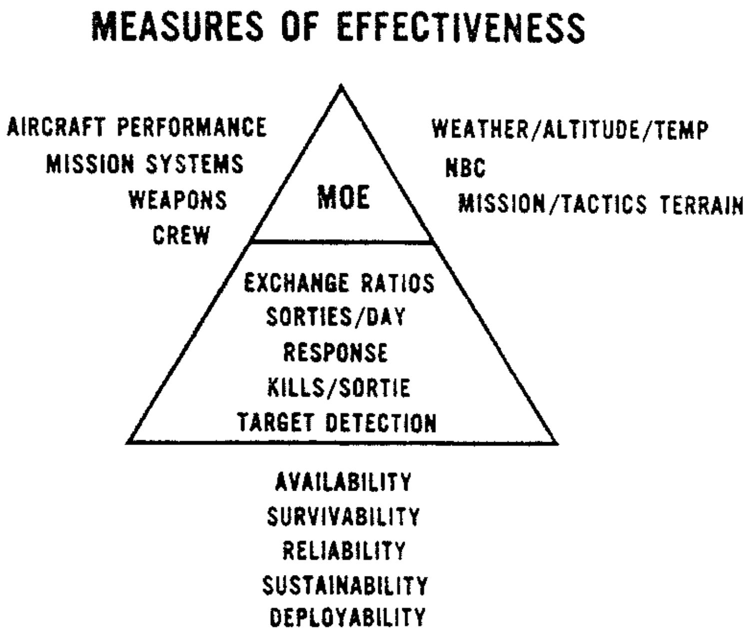

Figure 8

4. Summary

The LHX Program is to provide Army Aviation a bridge to the Twenty-First Century. It is to marry the pilot, the aircraft and the mission with state-of-the-art technology to produce a light weight, affordable, lethal, survivable and reliable weapon system that will meet the challenge of the future battlefield. Concept formulation has begun and the preliminary design process is being utilized to trade-off technology, cost, and design requirements in a timely manner. While the Army must conduct its own independent analysis to reach unbiased solutions, industry is involved by conducting technology base efforts and conducting its own preliminary design analysis against similar requirements.

References

1. D.I. Cleland, and W.R. King, Systems Analysis and Project Management, Third Edition, McGraw-Hill Book Company, Copyright 1983.

2.. M.P. Scully and R.A. Shinn, Rotor Preliminary Design Trade-Offs for the Advanced Scout Helicopter, Proceedings of the American Helicopter Society (AHS) National Specialists' Meeting "Rotor System Design," Philadelphis, PA, October 1980.