MATERIEL ACQUISITION MANAGEMENT OF U.S. ARMY ATTACK HELICOPTERS

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE

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The Army has produced attack helicopters without any clearly defined concept as to useful life. Until the publication of the Army Aviation Modernization Program (AAMP), the Army had not attempted to define an attack helicopter's useful life nor did it possess a strategy by which to modernize its attack helicopter force. Without a definition of useful life and a modernization strategy, the Army has had a difficulty in justifying valid operational requirements to the legislature. This thesis investigates methods to aid in program clarification and analysis permitting more concise analysis and justification of the Army's requirements.

This thesis historically defines the life cycles of existing attack helicopter programs. This is essential in determining the useful life of these helicopters and may bear on the requirement to procure a new system.

Second, the thesis identifies criteria that are common to many acquisition programs that may be useful in model design which can be used to evaluate an attack helicopter program. This could aid in the determination as to whether or not to procure a new system or upgrade an existing system.

Finnally, a comparison of the existing system versus the model is made to determine what benefits there may be in use of the model and its utility.

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

MATERIEL ACQUISITION MANAGEMENT OF U.S. ARMY ATTACK HELICOPTERS; by Major Patrick J. Becker, USA, 105 pages.

The Army has produced attack helicopters without any clearly defined concept as to useful life. Until the publication of the Army Aviation Modernization Program (AAMP), the Army had not attempted to define an attack helicopter's useful life nor did it possess a strategy by which to modernize its attack helicopter force. Without a definition of useful life and a modernization strategy, the Army has had difficulty in justifying valid operational requirements to the legislature. This thesis investigates methods to aid in program clarification and analysis permitting more concise analysis and justification of the Army's requirements.

This thesis historically defines the life cycles of existing attack helicopter programs. This is essential in determining the useful life of these helicopters and may bear on the requirement to procure a new system.

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Finally, a comparison of the existing system versus the model is made to determine what benefits there may be in use of the model and its utility.

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CHAPTER ONE

INTRODUCTION

Introduction

The Army did not have a definitive strategy on which to base requirements for further research, development, and fielding of new attack helicopter systems until the publication of the Army Aviation Modernization Program (AAMP). Even with the AAMP, life cycle analysis models are not used to determine when to product improve or retire attack helicopter programs.[1] The Army's planning focused on keeping an attack helicopter system operational until its replacement was fielded or to accomplish whatever activity was necessary to meet Program Objective Memorandum (POM) requirements. Analysis of life cycles should lead to the development of criteria used to determine when to add or drop specific procurement program.[2]

The Department of Defense must justify to the legislature operational requirements that necessitate procurement activity. A procurement strategy is a key aspect of the justification process to the legislature. This strategy should have practices and procedures that stand the scrutiny of Congress. The AAMP now allocates resources to continue current production aircraft, saves multiyear funds, continues the development of the LHX, and funds programs to support and sustain all aviation programs.[3] Yet the decisions in the AAMP are not empirically based. This has caused the Deputy Chief of Staff for Operations to have the Concept Analysis Agency to develop an evaluative trade-off model that can quantify these factors.

Within an aircraft procurement strategy should be some definable point at which work must be undertaken to develop a replacement attack helicopter. This replacement helicopter should be available prior to the point of diminished usefulness for the current attack helicopter.[4]

Department of the Army must have a strategy that clearly establishes definable time-phased requirements. This strategy will ensure the allocation of resources among stiff competition within the Department of Defense. Analysis of civil aviation and sister service procurement strategies may show similar program strategies.

Technology change may necessitate a constant evaluation of a program's utility. For example, Soviet innovation in tank technology seriously degraded US antitank technology and, although an airframe may last for a period of time, the utility of its tank killing systems may become obsolete faster than the airframe.[5] A model with specific analysis criteria which focus on the threat could indicate when aircraft changes may be required due to threat technology.

a. Background. During the early 1960's the Army conducted studies into the application of helicopters and heliborne forces initially under the direction of LTG Gordon B. Rogers and later GEN Hamilton H. Howze. The Army Aircraft Development Board, or the Roger's Board, was established on 15 January 1960 to consider ways to build the aviation force structure identified in a Continental Army Command (CONARC) study titled "Development Objectives for Army Aviation 1959-

1970."[6] Whereas the CONARC study focused on organization, doctrine, and type aircraft requirements, the Roger's Board reviewed proposals by industry as to how to manufacture those aircraft identified in the CONARC study.[7] The most significant finding of the Roger's Board pertinent to this study was the recommendation to replace aircraft every ten years and to consider technological advances and operational requirements as some evaluative criteria in the decision to replace those aircraft.[8]

The Army's Tactical Mobility Requirements Board or the Howze Board, as it later became known, was directed by Secretary of Defense Robert McNamara to examine Army requirements for aircraft and force structures.[9] The essential task for the board was to create a tactical force with improved mobility. GEN Howze made recommendations about aviation force structure and the use of helicopters on the modern battlefield. By incorporating the recommendations of the Howze Board, substantial progress was made concerning the application of helicopters as supporting air maneuver units to enhance the mobility of the ground maneuver force.[10]

Arming of helicopters in support of this highly mobile force was one of the board's findings. Although a formal request for proposal (RFP) for an armed helicopter was not immediately released, the first qualitative materiel requirement (QMR) for only a helicopter weapon system was approved in May 1960, yet industry anticipated the requirement for armed helicopters.[11] Industry, using company funds, had designed specialized armed (attack) helicopters and had even developed several prototypes (OH-13 and later the AH-1G). The AH-1G (Cobra) was fielded based on the operational requirements developed in Vietnam.[12]

The Cobra and subsequent attack helicopters have been produced without any clearly defined concept as to useful life as was recommended in the Roger's Board Findings.[13] This being the case, it is apparent that the Army has not had a definitive strategy on which to base requirements for the conduct of further research and development and fielding of new systems. Without a life cycle analysis model, all procurement activities will not be based on a stated procurement strategy.

Significance of the Study

The Army has produced attack helicopters without any clearly defined concept as to useful life. Thus the Army has not had a definitive strategy on which to base requirements for the conduct of further research and development and fielding of new systems. It is essential to define an attack helicopter's useful life and develop an evaluation model to help determine its useful life. Without these being defined or developed, all force modernization activities will be without a stated procurement strategy and therefore difficult to justify to the legislature even though valid operational requirements may necessitate this procurement activity.

There should be a life span for attack helicopters, as with any product, in which the helicopter is useful and which, after this prescribed period of time, the helicopter is no longer useful.[14] If this life span is determinable, there must be some definable point at which work must be undertaken to develop a replacement attack helicopter so it may be available prior to the point of diminished usefulness for the current attack helicopter. If replacement is not the result of the decision at this point, then a plan for fleet modernization should be formulated.

This study will not undertake the task of designing an evaluation model to determine an attack helicopter's useful life. I have discovered that the Army has recently begun work on developing one. The intent is rather to identify a comprehensive listing of evaluation criteria developed by studying the programs of other Department of Defense services, the Soviet Union, and the commercial airlines, in particular Trans World Airlines. Furthermore, an effort has been made to identify those criteria that are common to a program and to the decision-making and funding programs that support a program during its product life.

Discussions with participants in the acquisition process have indicated that they perceive benefit from a more empirical approach to their activity. Any modelling effort that helps in making decisions concerning their programs would be of significant value.

Assumptions

Attack helicopters have a finite useful life. After this prescribed period of time, the helicopter is less useful and should be replaced. The factors affecting useful life include: airframe deterioration, personnel training, trained population maintenance costs, repair parts availability and costs, test, measuring, and diagnostic equipment (TMDE) availability and costs, training aids support, ammunition procurement and maintenance costs, and technological or battle obsolescence. Additionally, the cost and utility of product improvement program (PIP) or multi-stage improvement program (MSIP) upgrades should be considered.[15]

If there is a determinable life span, there must be some point at which a decision must be made to determine if work should be undertaken to develop a replacement attack helicopter. This decision should be made so that the replacement helicopter is available prior to the point at which the current attack helicopter is no longer useful.

Life span calculation will include the fleet being upgraded at least once in its life due to fleet replacement costs and the relatively low production rates for newly fielded systems. Upgrades have historically occurred in every aircraft fielded to date. The Army has directed that all product improvements be consolidated and engineered into a MSIP.[16]

A model can be developed that identifies critical analytical considerations that indicate a method to evaluate the utility of an attack helicopter from an operational and economical perspective. This model should be used to evaluate the existing helicopter program periodically in order to determine utility in reference to all evaluation criteria.

Defintion of Terms

Life Cycle. A characteristic pattern of a product in which stages of growth can be delineated which define a useful life span of a product. This is normally broken into the stages of conceptual, project initiation, operational, and the terminal or disposal stage. The conceptual stage consists of all activity up to a formal request for proposal (RFP). The project initiation phase entails all activities involving detailed program planning and approval. This completed, the project enters the operational phase during which the end product is produced. Finally, the terminal stage terminates the project.[17]

Product Midpoint. A definable point associated with the useful midlife of a product which may be used as a trigger point to initiate like-product replacement.

Obsolescence. The process of becoming obsolete or tending toward a state of disuse either as the result of legitimate functional or design improvements or because of a deliberately planned fixed useful life (planned obsolescence).[18]

Personnel Training. The requirement to train personnel to operate, maintain, and sustain a specific system.

Trained Population Maintenance Costs. The costs associated with maintaining a population trained on a specific system. These costs include fiscal costs, costs to force structure, and available personnel resources.

<u>Limitations</u>

The data collected by industry, commodity managers, or support agency sources may not necessarily be of use to support a total system determination of a life cycle model. There is information available about every aspect postulated, however the information may not be compatible since it was not collected with life cycle analysis in mind. Additionally, all information pertinent to a particular program is not necessarily available to all concerned parties including the commodity manager.

Delimitations

Research will be restricted to five attack helicopters, the OH-13X, AH-1, AH-56, AH-64, AH-58, and the LHX. Other than the OH-13X and AH-56, which were never fielded, no other attack helicopters will be analyzed.

CHAPTER ONE -- END NOTES

[1] U.S. Army, The Army Aviation Modernization Plan, (Washington D.C: Office of the Assistant Secretary, 19 May 1988), p. 1.

[2] Philip H. Francis, Principles of R&D Management, (New York: AMACOM, 1977), pp. 52-55.

[3] U.S. Army, Annex A to the Army Aviation Modernization Plan, (Washington D.C: Office of the Assistant Secretary, 19 October 1988), p. 1.

[4] Ibid., pp. 138-140.

[5] "Armor/anti-armor: National Crisis?," Army Times 49th Year, vol. 10, (October 17,1988), p. 14.

[6] John W. Oswalt (LTC, USA), "Report on the Roger's Board," Aviation Digest, Vol 7, No. 2, (February 1961), p. 15.

[7] Ibid., p. 16

[8] Department of the Army, Vietnam Studies: Air Mobility 1961-1971, John J. Tolson (LTG, USA),(Washington D.C.: Government Printing Office, 1973), p. 9.

[9] John R. Galvin (LTG, USA), Air Assault: The Development of Airmobile Warfare, (New York, Hawthorne Books, 1969), p. 276.

[10] Tolson, pp. 51-53.

[11] Charles O. Griminger (LTG, USA), "The Armed Helicopter Story Part III,) Aviation Digest, Vol 17, No. 9, (September 1971), p. 10.

[12] "Bell's AH-1 Cobra Series," Defense, Vol. 11, No. 5, (May 1980), p. 294.

[13] Tolson, p. 9.

[14] Francis, p. 136.

[15] U.S. Army, Materiel Acquisition Management Course Cost Management and Technique Reference Book, (Washington D.C.: Government Printing Office, 1985), pp. 21-24.

[16] Annex A to the Army Aviation Modernization Plan, p. 2.

[17] Francis, pp. 138-140.

[18] Francis, pp. 135-137.

CHAPTER TWO

SURVEY OF THE LITERATURE

Review of Literature

There were three areas in which the majority of my research effort was spent. First, I wanted to investigate the history of our attack helicopter programs. I then wanted to see if there was any overarching strategy that guided the development and procurement of our attack helicopter programs. Finally, I investigated how acquisition decisions are made and by what method.

Analysis of this study's bibliography illustrates the lack of previous research in this area. I believed that I would find studies that would show a historical analysis of attack helicopter life cycles that would assist decision makers in making decisions that would affect those programs and be used in an empirical based product management analytical framework. This would require an overall strategy from which to define life cycles and programs. Also, it would require some sort of empirical based analytical model that could quantify various alternatives for managing a program. Particular emphasis would be warranted in the historical analysis of previous and present attack helicopter programs, thus permitting a definition of life cycles. An analysis of these life cycles may determine a program life span, mid-point, and consideration for the development of a program evaluation model.

The most significant information I discovered was through interviews from people in the acquisition/materiel management system and from two critical documents, the Army Aviation Modernization Program and the Army Aviation Modernization Trade-off Requirements Study. Although discussed in greater detail later in this study, these sources clearly indicated that the Army now has a aviation acquisition strategy and has begun work on an evaluation model and most importantly, that the community felt there was a requirement for both of these programs.

Methodology

The methodology used in this study is based on historical analysis, primarily documentary research. The historical analysis was necessary in order to analyze existing attack helicopters in terms of a life cycle and to identify the current manner by which decisions are made and when.

Interviews were conducted with people now influential in the decision making process, to provide insight into the reality of the Army's procurement program since there has been relatively little research in this area.

Previous Research Efforts

The Army is currently attempting to model aspects of the decision process in support of aviation program management decisions. This modeling effort is needed in support of the Army's Aviation Modernization Program which provides aviation force users and developers a modernization strategy.

The Army's attack helicopter fleet is predominately a mixture of

Vietnam vintage helicopters. The sentiment of much of the aviation community is that these aircraft are approaching the end of their useful life. The age of the majority of the Army's aircraft are at or beyond 15 years. These aircraft were produced for use in Vietnam in large quantities over a relatively short period of time. The reality of today's resources is that the aviation industry can not produce that many aircraft in that short of time. Additionally, the Army is not allocated a budget large enough to support a one-for-one replacement of these older aircraft.[1]

As will be discussed in Chapter Three, Army procurement planning is limited to actions needed to fulfill program objective memorandum (POM) requirements. Fleet modernization has had no long-range fleet goals and consisted of piecemeal modifications to selected aircraft. It was not until 1987 that the Army established a strategy to modernize the fleet with a mixture of new aircraft and service life extension programs (SLEP) of several model airframes.[2]

The Army is cognizant of the complexity of developing, procuring, and sustaining its aviation fleet. The Deputy Chief of Staff for Operations and Plans was particularly concerned with evaluating the effect of the Army's aviation modernization policy over the long term.[3,1] The Deputy Chief of Staff for Operations and Plans requested that the Army Concept Analysis Agency (CAA) develop a decision support system to aid in evaluating aviation policy. The CAA has developed a prototype automated planning model named the "Phoenix".[3]

The Phoenix model assists force developers in evaluating tradeoffs in the areas of requirements, resources, and policy. Through the use of a mixed integer linear programming model, the Phoenix model has demonstrated the potential to assist in the analysis of strategic and operational issues in helicopter acquisition and management.[4]

The principal limitations of the Phoenix model as noted in the study, are that the operations and maintenance (O&M) costs are modeled as a function of aircraft age rather than from historical data and that the effects of production learning and lot size on unit costs are approximated.[5]

The Phoenix model considers various requirements policies and resources concerning aircraft production and retirement. This information is used to derive management reports that have utility to force planners. A summary of the model is indicated in figure 2-1.

Certainly the benefit of such modeling, if it were comprehensive and successful, would do much to reduce the degree of uncertainty in the materiel management of our attack helicopters. The Phoenix model permits a variety of variables and options to be analyzed simultaneously permitting a thorough comparison of all possible courses of action. The Phoenix model also permits constraint penalty values to be assessed and folded into total cost formulation (eg if you had a requirement to modernize 100 AH-1s and due to fleet attrition there were only 97 available, then you would have to buy three older models from some source to modernize).[6]

The initial findings of the CAA is that they can design a comprehensive model for helicopter modernization. Although the original intent was to design an evaluation model with a thirty year evaluation period, the prototype model can only be used for a twenty-five period problem. This may limit the model's usefulness by our cargo and utility (they both have a thirty year lifespan) force designers but it is adequate for an evaluation of attack aircraft with their twenty year lifespan. The Phoenix model can also be used to evaluate different modernization courses of action to include the useful life of an

Phoenix Model Data Flow

INPUT DATA		OUTPUT		
Policies				
Aircraft Size				
Technological Classification				
High Tech Goals				
Residual Life Goals				--- Fleet Size
Flying Hour Program				
Resources				
Budget				
Current Aircraft Inventory				
Production Line Data				
Min & Max sustain rate --	Phoenix	Procurement/	Annual Force	
Earliest Opening Year	Model --	Retirement ---	Composition ---	Residual Age
Latest Closing Year		Schedule		
Requirements				
Force Structure				
Min # of Aircraft per Fleet				
Max # of Aircraft per Fleet				
Programmed Buys				
Costs				--- Technology Mix
Unit Production				
Retirement				
Start-up				
RDT&E				
Flying Hour				
Aviation Overhead*				

* Aviation overhead includes the cost of air traffic control, ground support equipment, and aviation life support equipment.

Figure 2-1 [7]

aircraft, comparisons versus SLEP and fielding new aircraft, trade-offs between goals for average useful life, and trade-offs concerning the mix of high technology and low technology aircraft in the different mission fleets.*

A curious aspect of the efforts of the CAA is the many agencies that CAA didn't effect direct coordination. This was due to the limited time that they had to develop the model. Noticeably lacking is the Aviation Support Command in St Louis, Missouri. Most PM's that I spoke with on the phone concerning the Phoenix model were unaware of its existence. Certainly these people may have keen insight into the development of a comprehensive model to evaluate the long term effects on their programs. Most recipients of the study were R&D activities, sister services, or TRADOC schools.*

The Army Aviation Modernization Plan (AAMP) is the Army's master planning document for future aviation requirements. The AAMP is a guide for aviation force users and developers that will template a strategy that will achieve fleet modernization and provide an aviation force structure that is responsive to the current and projected roles on the AirLand battlefield. It is in support of this plan that an evaluation model is needed in order to facilitate force integration.

Personal Interviews

Free study format interviews were conducted with the following people influential in the acquisition/materiel management system.

Dr. Wolfe Elber is the director of the Aerostructures Directorate, U.S. Army Aviation and Research and Technology Activity. Dr. Elber provided insight into the more technical aspects of the evaluation process of either existing or proposed systems.

COL Larry D. Holcomb is the project manager for the AH-1 Cobra. COL Holcomb described the current decision making process and assisted me in analyzing the AH-1 in respect to a life cycle model.

MAJ R. Scott Mair is an aeronautical engineer in the Apache program. His office is responsible for the compilation of programs providing for the multi-stage improvement of the AH-64.

MAJ Terry Thompson, of the U.S. Air Force Tactical Air Command, is assigned to an office that translates deficiencies noted during their mission area analysis into statements of system operational requirements documents.

Mr. Joseph East is an instructor at the Army's Logistics Management Center. Mr East described the defense acquisition process and provided a different perspective on the process from what I obtained from people at Aviation System Command.

Mr. Veldon B Clark is the director for aircraft development for Trans World Airlines, Inc. and is a position in which he is primarily responsible for the compilation of information pertinent to the decision to procure new aircraft.

Mr. Frederick L. Troutman, also of Trans World Airlines, Inc. is the director for materials control and is concerned with spares and repair parts stockage and acquisition.

Additional agencies that have been helpful in developing this thesis are:

Total Army Personnel Command (TAPC). TAPC has been asked to attempt to identify the costs for maintaining a population of program trained (eg AH-1 distinct air and ground personnel) personnel.

Trans World Airlines (TWA). In order to compare our procedures with the civilian community, TWA has been asked for information concerning the criteria they use to assist them in making the decisions to purchase their aircraft. TWA was selected due to their historical long-term success and their availability to me for the purpose of conducting interviews.

Training and Doctrine Command (TRADOC). TRADOC has been asked to provide information concerning the costs associated with training the force as it applies to the attack helicopter and with simulations and training devices. Additionally TRADOC has been asked to comment on the impact of program distinct ammunition requirements.

The National Aeronautics and Space Administration provided information pertinent to an analysis of the effects of composite materiels on airframe fatigue life. Composites are being used more frequently in aircraft constrution.

Information from the U.S. Army Aviation Center is essential whereas they are the TRADOC system manager for matters pertinent to aviation matters.

Bell Textron Helicopters and McDonnell Douglas Helicopter Division were asked to provide information concerning the AH-1 an .. 64.

Study Layout

The sequence for the remainder of the study is oriented initially to describing the current Army and sister service programs, a historical analysis, the identification of evaluation criteria, and conclusions and recommendations.

Chapter Three describes the current policy, procedures, and models used to make procurement decisions with the intent of identifying criteria that may be useful in a modelling effort.

Chapter Four discusses the relative merit of other military and civilian systems in making procurement decisions and provides criteria useful in development of an Army evaluation model.

Chapter Five conducts a historical analysis of attack helicopter life cycles and its impact on attack helicopter procurement.

Chapter Six identifies criteria that should be used in an evaluation model that may be used during the life span of an attack helicopter program. This criteria should help indicate the optimal strategy at a decision point which should indicate whether it is more cost effective to product improve an existing attack helicopter or to initiate procurement activity for a follow-on program.

Chapter Seven reviews the information for the purpose of drawing conclusions and formulating recommendations.

CHAPTER TWO -- END NOTES

[1] Department of the Army, The Army Aviation Modernization Trade-off Requirements (AAMTOR) Study, (Bethesda, Maryland: U.S. Army Concept Analysis Agency, August 1988), p. 1-1

[2] Ibid., p. 1-1.

[3] Ibid., p. Report Document Page.

[4] Ibid., p. iii.

[5] Ibid., p. iii.

[6] Ibid., p. v.

[7] Ibid., p. 5-2.

[8] Ibid., p. 1-3.

[9] Ibid., p. 6-1.

[10] Ibid., pp. D-1-D-12.

CHAPTER THREE

CURRENT SYSTEM ANALYSIS

Introduction

This chapter will explain the current system used to ensure that the Army maintains a balanced, modern, sustainable, and ready force. An explanation of this system requires a fundamental understanding of the concept based requirement system, the biennial planning, programming, budgeting, and execution system, the life cycle system management model, and military construction acquisition. This study is oriented towards the materiel solution of deficiencies identified during concept based requirement system analysis.

Concept Based Requirements System (CBRS)

CBRS is based on an analysis of future Army needs. It analyzes the current umbrella concept (a broad definition of expected capabilities), current and future missions, current and projected world threats, historical experiences, and technological forecasts. The result should be a balanced, modern, sustainable, and ready force.[1] This system is the cornerstone to any strategy or model that may be developed in managing our attack helicopter programs.

CBRS begins with the formulation of an operational concept one that describes a future battlefield function which may warrant a change in the Army.[2] The CBRS coordinates the development of doctrine, training, force design, and new or improved materiel systems.

Operational concepts are developed considerating to the umbrella concept, Army missions, threat, and technological forecasts. Analysis of the threat investigates the capabilities and vulnerabilities of potential adversaries against programmed U.S. forces using input from intelligence sources. This information is analyzed from a regional perspective and documented in a mission area threat (MAT) document and, in conjunction with analysis of the mission area concept, provides the basis for the developer's analysis.[3] The threat should be the foremost consideration in the management of our attack helicopter programs. Technological forecasts examine current and projected technologies to ensure that the developers are aware of emerging technologies and their possible impact on concept and materiel development.[4] Threat and technological forecasting may be the two most influential considerations in the premature obsolescence of our attack helicopters.

The operational concept then undergoes definition in terms of what, why, how, when, and where to accomplish the task. Once a concept is defined, it is analyzed in respect to the programmed force, mission area analysis, and the mission area threat.[5]

The mission area analysis (MAA) analyzes the Army's ability to execute its wartime mission. There are thirteen mission areas, of which aviation is one.[6] The MAA compares the operational concept against the capabilities of the programmed force and the MAT. The MAA identifies deficiencies and evaluates the areas of doctrine, training, force structure, and materiel for proposed corrective actions. The intent of the corrective actions is to produce solutions prior the time projected deficiencies become acute problems.[7] The MAA evolves into the mission area development plan which is used to integrate, time-phase, and synchronize corrective actions in doctrine, training, force structure, and materiel to overcome the identified deficiencies.[8] The entire program is then subjected to the scrutiny of a senior program review (SPR).

On completion of the SPR, deficiencies are integrated and prioritized in an ordered list of battlefield deficiencies in a document called the battlefield development plan (BDP).[9] This plan focuses the Army's research, development, and acquisition efforts. The BDP provides the format which feeds the planning, programming, budgeting, and execution system, the vital appropriations aspect of attack helicopter management.[10] The BDP is incorporated into the DA long range research development and acquisition plan (LRRDAP) and coordinates the efforts of TRADOC and DARCOM.[11]

The approved MAA, MADP, and BDP trigger the development of new doctrine, training, changes in the force structure, and the procurement of modified or new materiel systems.[12] If no corrective action is possible in the first three categories then a materiel solution is investigated.[13] Materiel solutions, normally the most costly and least timely, should be undertaken only if other methods are ineffective. Materiel activity may be manifested in product improvement of an existing system, evaluating sister service systems, foreign systems, improving systems in development, or developing a new conceptual system.[14] Materiel solutions not only involve cost and time, but may also involve a change, in organization, force design, training, and doctrine.[15]

The major analysis of a materiel solution is conducted under the auspices of the TRADOC system manager (TSM), a subordinated program manager, and the particular project manager(s). A deficiency identified to be corrected in the attack helicopter arena may involve activity by program or project managers with the AH-64, AH-1, Army helicopter improvement program (AHIP), or LHX activities.

One of the products of CBRS is the identification of need for a new materiel system. The materiel acquisition process used by TRADOC and DARCOM is a sequenced phased program of activity and decisions. The process is depicted in the life cycle system management model which outlines the life cycle of system acquisition from the conceptual through terminal phases.[17]

CONCEPT BASED REQUIREMENTS PROCEDURES

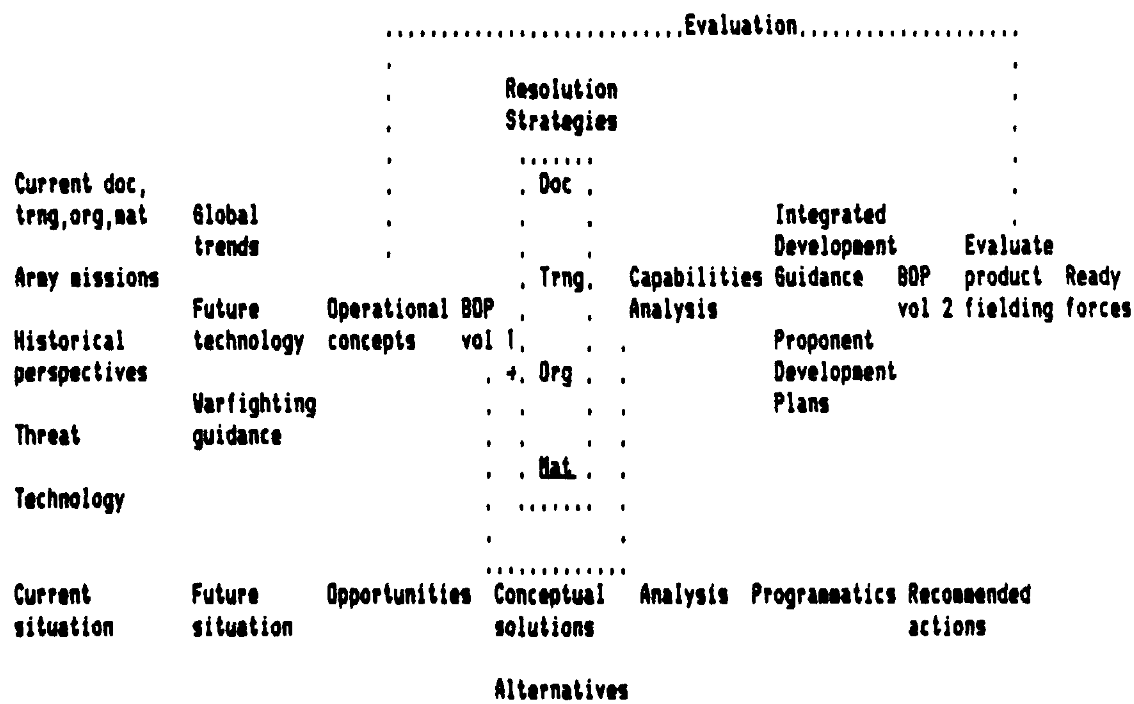

FIGURE 3-1[16]

Life Cycle System Management Model (LCSMM)

The LCSMM sees the system through to the terminal stage, and LCSMM is broken into four phases which coordinate system developers. These are the concept exploration, demonstration and validation, full-scale development, and production and deployment phases. A system must transition through each phase before going into proceeding to a subsequent stage. No transition is made without a decision being made at the conclusion of a preceeding phase.[18]

LIFE CYCLE SYSTEM MANAGEMENT MODEL (LCSMM)

Phase -	Milestone 0	Milestone I	Milestone II	Milestone III	Milestone IV	Milestone V
Action -	Concept exploration	Concept definition & validation	Concept demonstration development	Full scale operational support	Production/ deployment/ replacement decision	Major upgrade or system
Document -	O&O Plan documents	O&O Plan documents	Required Operational Capability documents			

FIGURE 3-2[19]

The objectives of the LCSMM are to guide the acquisition process, provide the basis for the program structure, and speed the materiel acquisition process.[20] The LCSMM is adaptable based on the program, lesser programs being permitted to bypass events and abridge phases provided there are adequate safeguards and the risks are acceptable.[21]

The LCSMM is used when a materiel solution is indicated based on CBRS analysis. The LCSMM takes the developer through a series of milestones that have been established to provide a standard measurement for cost, performance, schedule, readiness and supportability.[22]

Milestone 0 involves activities associated with program initiation and the mission need decision. Primary considerations include the MAA, affordability and life cycle costs, the ability to modify existing U.S. or allied systems, and an operational utility assessment.[23]

Concept demonstration and validation decisions are an aspect of milestone I. Program alternative trade-offs, performance/cost trade-offs, and the appropriateness of the acquisition strategy are considered. These decisions are based on the recommendations of a special task force (STF) or special study group (SSG). The STFs and SSGs are a group of senior officers that direct the program until the designation of a materiel developer, if required, and consider the affordability and life cycle costs, prototyping of the system, potential common use solutions, and cooperative development opportunities.[24]

Milestone II are decisions that concern full-scale development. Considerations most pertinent to this study are the affordability of the program versus its military value, program risk versus benefit, program stability, risk assessments, procurement strategy appropriate to cost and risk, and affordability and life cycle costs.[25] Many of these factors can be incorporated into a system evaluation model.

Milestone III involves the decision to go to full production. Major considerations involve production, operation, and support.

Logistic readiness and supportability requirements are addressed in milestone IV decisions. Consideration is given to many logistic requirements, the most applicable for this study being facilities, training and manpower, disposition of displaced equipment, and affordability and life cycle costs.[26]

Milestone V is the decision point most pertinent to this study and encompasses those decisions associated with system major upgrade or replacement. Evaluation considerations involve the estimate of the system's ability to evolve to perform a new mission or still perform its original mission, potential necessity of modifications and upgrades to perform its mission or to extend its useful life, changes in the threat that require a corresponding change in system parameters, technological changes that increase the system's capabilities, and disposition of displaced equipment. Critical to this analysis are the decisions whether or not identified deficiencies are so critical as to warrant modification, retirement, or a new start.[27]

Although the LCSMM is an entirely different process from the CBRS, there is a transition that occurs where the idea is changed from a concept to hardware. The ease with which this transition occurs can be facilitated by analysis of the information requirements needed at this point being already fulfilled at the onset in the CBRS.

TRANSITION FROM CBRS TO LCSMM

Concept Based Requirements System // Life Cycle System Management Model

Pre-Concept Exploration/definition // Milestone 0 // Milestone I

MAA--→ O&O Plan --→ Mission need statement ---------→ // Program objective memorandum -→ Program decision memorandum -→ // Development contract

// STF or SSG -→ Program manager

// - Phase transition points

FIGURE 3-3[28]

Biennial Planning, Programming, Budgeting, and Execution System (BPPBES)

An important aspect of BPPBES is that there is an attempt to form a "coherent bureaucracy", that is, a bureaucracy "in which the activities of subordinate units are consistent with the objectives of the superior organization."[29] This does not mean that the subordinate unit has to blindly follow the dictates of the superior. It does mean that these activities must contribute to the objectives of the superior unit.[30] From a fiscal perspective, a subordinate unit must be able to justify its budget requests in terms of how well its output will support higher level goals.

Considering some of the goals of BPPBES indicated above, a great deal of information is logically required in order to communicate how a subordinate's budget request supports the goals of the higher unit. Successful budgetary development has always stressed the evolution of budgetary formats.[31] In other words, the subordinate who most clearly describes the content of his budget and relates it to the goals of the higher unit normally fares better than a subordinate who does not do this well. It is in justifying these requirements that the Army has not done as well as the other services; and in this area, the overarching strategy and empirical modelling may help better state our needs.

BPPBES translates needs into reality through resources. The first phase of the BPPBE system is planning and it is this phase that the CBRS initially interfaces.[32]

The programming phase is where funds and manpower are programmed towards the concept. Program requirements are documented in the Army's program objective memorandums (POM). After reviewing the POM, the defense resource board (DRB) may identify issues or alternative courses of action. These alternatives are reviewed with the appropriate service and approved exceptions are documented in program decision memorandums (PDM).[33] These are associated with milestone 0 activities in the LCSMM.

The budgeting phase involves the distribution of programmed funds. The decision of the Secretary of Defense for the services programs are transmitted to the services in the program budget decision (PBD). CBRS identified projects that do not have programmed funds must be deferred unless funds can be made available through internal service trade-offs.[34]

System Integration

The concept based requirements system, planning, programming, budgeting and execution system, and the life cycle system management model are not separate independent systems. They are interdependent, relying on information and decisions from one system in the operation of another.[35]

Requirements generated by the CBRS must be integrated into the Army's critical decision-making process and resourcing cycles.[36] It is essential to understand that requirements generate work, work is managed by the LCSMM, and the work must be resourced through the BPPBES.

This model shows that some requirements may involve solutions that are not materiel oriented and yet are subject to actions with the LCSMM and in BPPBES. Materiel solutions involve activity in all related systems. One source of confusion in the TRADOC model is caused by the fact that some systems are event driven (eg CBRS and LCSMM) and some are time driven (eg BPPBES and military construction).[37] This relationship sometimes hinders a system's progress in that a delay in one area impacts on another. A delay in military construction may affect efforts to field the materiel system.

The Acquisition Players

The responsibility for the acquisition process is a defined tiered structure in which actual program decision authority rests in the chain of leadership. To more clearly identify responsibility, DOD has limited program management from one to four management tiers, depending on the scope of the program.[38]

The foremost player in the Army acquisition arena is the Army acquisition executive (AAE). The AAE is the senior procurement executive and the service acquisition executive. He is charged with discharging responsibilities defined in DOD directives for service acquisition executives, establishes a streamlined acquisition process for managing major and non-major Army programs, and formulates overall guidance for policy and programmatic aspects of acquisition consistent with DOD policy.[39]

The program executive officer (PEO) is an executive for the AAE and administers a defined number of programs stipulated by the AAE and is charged with ensuring that all Army agencies are responsive to the needs of a program or project manager.[40].

The PEO supervises assigned program and project managers (PM) and provides planning guidance, direction, and control and support necessary. The PEO helps the PM's maintain their costs, schedule, and performance baselines.[41] He is responsible for providing information concerning his programs to HQDA, the AAE, DOD, and Congress. The PEO must justify assigned programs to the legislature.

PEOs are influential in developing data to be used by the AAE to support programmatic decisions in support of the BPPBES and the LRRDAP.[42] Their responsibilities involve providing technical, operational, and functional integration of his programs, extending the AAE's management oversight to PM's, interfacing with combat and materiel developers, chartering and rating assigned PM's, monitoring PM and contractor performance, and tracking and enforcing assigned programs.[43] An empirical evaluation model could assist the PEO in rechartering and program analysis by quantifying alternatives.

The primary decision-maker in the day-to-day operations of a program or project is the program/project/product manager. The PM is established by the AAE but chartered by the PEO, and is assigned full line authority for the centralized management of a specific program.[44]

PMs are charged with compliance of DA acquisition policies, commitment to the program baseline and reporting actual and imminent breaches to the SECDEF, identifying materiel, personnel and functional management shortfalls to the PEO, and must prepare periodic program performance reports. Requisite acquisition planning is the overall responsibility of the the PM.[45]

The PM has the unenviable task of interfacing with over twenty-nine Army commands, agencies, or activities. These activities range from health services to strategic defense, however the Army's Legislative Liaison Office and Public Affairs Office are not indicated in their coordination list.[46] All these impact in some manner on the initial decisions to initiate a project or may need to comment on an operational concept. Many may have some input required in milestone V decisions to product improve or retire a project.

Summary

The materiel acquisition process is a very complex system. The deficiencies identified in CBRS are resourced and resolved through interface with the LCSMM, for program development and management, PPBES, for funding, and military construction Army (MCA), for facility support. All these systems require information that decision makers must have in order to analyze the full complexity and interrelationship of all the systems. To add further complexity to the problem, CBRS and LCSMM are event driven whereas PPBES and MCA are time driven systems. Decision-makers, concerning materiel acquisition, should have information pertinent to decisions to made in all systems. This will give a better indication of total costs, timing, and complexity and enables a collective evaluation of a program.

CHAPTER THREE -- END NOTES

[1] Department of the Army, TRADOC Regulation 11-15, (Fort Monroe, Va: Training and Doctrine Command, 4 August 1986), p. 2-1.

[2] Ibid., p. 2-2.

[3] Ibid., p. 2-4.

[4] Ibid.

[5] Ibid., p. 2-5.

[6] Department of the Army, TRADOC Primer, (Fort Monroe, Va: Training and Doctrine Command, 11 April 1984), p. 80.

[7] Ibid., p. 80.

[8] Ibid.

[9] TRADOC Regulation, p. 2-9.

[10] TRADOC Primer, p. 81.

[11] Ibid., p. 81.

[12] TRADOC Regulation, p. 2-9-2-10.

[13] Ibid., p. 2-11.

[14] Department of the Army, TRADOC Regulation 11-15, (Fort Monroe, Va: Training and Doctrine Command, 4 August 1986), p. 2-11.

[15] Ibid., p. 2-11.

[16] TRADOC Regulation, p. 2-2.

[17] Department of the Army, TRADOC Primer, (Fort Monroe, Va: Training and Doctrine Command, 11 April 1984), p. 89.

[18] Ibid.

[19] Department of the Army, " Army Acquisition Executive (AAE) Policy Memorandum #88-7, Revision of AR 70-1, Systems Acquisition Policy and Procedures," (Washington D.C.: Office of the Under Secretary Research, Development, and Acquisition, 13 July 1988), p. 37.

[20] Ibid., p. 3-1.

[21] TRADOC _Primer_, p. 89.

[22] Department of Defense Instruction 5000.2 "Defense Acquisition Program Procedures," (Washington D.C.: Deputy Secretary of Defense, 1 September 1987), p. 2.

[23] Ibid., p. 2.

[24] Ibid., p. 3.

[25] Ibid.

[26] Ibid., p. 4.

[27] Ibid., p. 89.

[28] Department of the Army, ALM 31-4784-LC (G), _The Life Cycle Model_, (Fort Lee, Virginia: U.S. Army Logistic Center, 1988), p. 31.

[29] Fremont J. Lyden and Ernest G. Miller, _Planning-Programming-Budgeting_, (Chicago: Rand McNally Publishing Company, 1972), p. 2.

[30] Ibid., p. 3.

[31] Ibid., p. 7.

[32] TRADOC _Primer_, p. 122.

[33] Department of the Army, Student Text 25-1, _Resource Planning and Allocation_, (Fort Leavenworth, Kansas: Command and General Staff College, 15 July 1988), pp. 5-4-5-5.

[34] Ibid., p. 5-5.

[35] Ibid., p. last page foldout.

[36] Ibid.

[37] Ibid.

[38] Army Acquisition Executive Memorandum #88-7, p. 2-1.

[39] Ibid., p. 2-1.

[40] Ibid.

[41] Ibid., p. 2-2.

[42] Ibid.

[43] Ibid.

[44] Ibid.

[45] Department of the Army, ALM 31-4754-H1, Acquisition Planning, (Fort Lee, Virginia: U.S. Army Logistic Center, 1988), p. 31.

[46] Army Acquisition Executive Management Memorandum #88-7, p. 2-2.

CHAPTER FOUR

ALTERNATE PROCUREMENT METHODS

Introduction

A comparison of other agencies responsible for aircraft procurement would be beneficial in indentifying either the need for an aircraft procurement model or the evaluation criteria for such a model. The problem of procuring aircraft that enable an organization to accomplish its mission and yet live within fiscal constraints is not a problem unique to the Army. Both the Navy and Air Force are faced with a similar problem in terms of procuring aircraft for the defense of the nation while doing so in a constrained fiscal environment. Like aircraft operators in the Department of Defense, Trans World Airlines must be able to quickly analyze the market situation and procure the optimal aircraft for that market. This procurement must be done while minimizing the economic cost of the procurement in terms of the corporation's profits. A another player, the Soviet Union, maintains a sizable air capability and has a definite program for aircraft procurement.

The two major competitors for the diminishing Department of Defense dollars are the U.S. Air Force and the U.S. Navy. They, like the Army, must make intelligent informed decisions concerning aircraft procurement. They too must be able to articulate these decisions to the legislature for funding. Analysis of their acquisition and procurement programs may lead to considerations useful to the refinement of the Army program.

Aircraft acquisition is not unique to the the military nor America. The Soviet Union has built and operated the world's largest fleet of helicopters. Analysis of their program may provide an insight into a more technological and fiscal independent perspective. Although more centralized in execution and in overall perspective, the organization of the various design bureaus and technical institutes provide the Soviets variety in the developmental stage.

Trans World Airlines (TWA) has long been a leader in the world's civilian aviation community. It is because of this experience, their success in the market, and close proximity to Fort Leavenworth for interviews that I selected them for comparison. TWA operates in an industry that has been deregulated and is extremely competitive. This competition becomes even more acute in difficult financial times when the cost for aircraft procurement is also more of a financial problem. Despite these fiscal conditions, TWA must still pursue aircraft modernization. Unlike the government, TWA can not pursue an aircraft acquisition strategy that involves the loss of income to the corporation or they would cease to exist. The corporate decision makers in the civilian sector must quickly realize a change in the market situation and rapidly initiate an appropriate procurement strategy to service that market before a competitor does so.

The United States Air Force

The U.S. Air Force Tactical Air Command has a procurement and acquisition problem very similar to the Army's program for procuring attack helicopters. The Air Force has a overarching plan similar to the Army's Aviation Modernization Plan called the Fighter Road Map. The Fighter Road Map prescribes a management plan that will ensure that the average age of their fighter aircraft will be eleven years (the optimal average is ten years with a useful life of twenty years). This plan also ensures the replacement of 1/22 of their fighter force thus providing the replacement rate to modernize and sustain their 35 tactical fighter wings over a twenty year period.[1]

Historically the useful life of a fighter has been twenty years. At the twenty year point, technical obsolescence has driven the fighter into either a less demanding role or into retirement. Furthermore, reliability and maintainability degradation eventually dictate retirement.[2]

Air Force planners have defined four major categories as critical realities which can influence aircraft procurement: the threat, technology, the fiscal environment, and politics.[3] Key to understanding a successful flexible strategy is that anyone or all these factors can change.

Technology plays an important role in air-to-air warfare. Reliability and maintainability, safety, survivability and technical improvements update the vital technologically important areas of avionics, engine, airframe, and munitions.[4]

The fighter road map acknowledges that quality improvements for their fighter fleet are necessary to extend the useful life of their fighter force, an extension they deem essential. Additional to useful life extension, the Air Force attempts to extend utility in the fighter's primary role, provide capability in their secondary role, and enhance their reliability and maintainability.[5]

The Air Force identifies requirements subsequent to their equivalent to Mission Area Analysis in a system operational requirements document (SORD). As in the Army process, the Air Force identifies an operational need that initiates the procurement process.[6]

The basis of need documents a change in either the threat, technological opportunity, or expanded mission requirements. The Air Force examines existing or planned DOD and allied capabilities for performing the identified deficiency.[7]

The Air Force identifies wider criteria in their needed capabilities. The Air Force's general operational requirements identify required system operational characteristics, which specify desired standards for performance, reliability and maintainability, integrated logistic support elements, other design considerations, and related support considerations.[8]

Integrated logistic support elements include: maintenance planning, supply support, support equipment, packaging, handling, storage, and transportation, technical data, facilities and land, manpower and personnel, training and training support, and computer resources which include design and needed support.[9] These considerations are very similar to those requirements identified in an Army operational and organizational plan (O&O) but are more comprehensive. These factors could be quantified in a modeling effort.

Other design considerations are evaluated. These include communications-computer systems support, safety, energy management, survivability for the system and its infrastructure, operational environment, threat assessment, unique weather support, security, and mapping, charting, and geodesy.[10] These considerations relate to the system and how it is to exist in its environment. Again they are not greatly different from an O&O plan but more comprehensive particularly in consideration for weather support, security, and mapping, charting, and geodesy. Related support factors are those factors that are important but are not considered elsewhere in the document.

Candidate solutions are considered up front, as in the Army, and are forwarded to their senior leadership for decision. Upgrading an existing system is their initial option for a candidate solution. Upgrade evaluation must include the impact on general employment, mission scenarios and tactics, mobility, force structure, basing, command and control structure, computer resources integral to the system, communications-computer systems, operational intelligence support, standardization, interoperability and commonality, and other system unique support considerations. New system designs and "other solutions" are considered using the same considerations as for upgrading an existing system.[11]

The proposed program is finally evaluated in the areas of acquisition strategy, schedule, and funding profile. This evaluation looks at the program in terms of success in meeting the Air Force's needs and the likelihood of the program's success both operationally and with justification for funding.[12]

The U.S. Navy

The U.S. Navy Air Systems Command has problems similar to the other services for procuring attack aircraft. The Navy also has a overarching plan similar to the Army's Aviation Modernization Plan called the Fighter Road Map. Their plan ensures that the fleet is equipped with technically and operationally suitable, supportable, and affordable aircraft. Their bottomline is "to provide the fleet aircraft on a more timely, efficient, and effective basis.".[13]

Naval planners have also identified four major categories as critical realities which can influence aircraft procurement: the threat, technology, the fiscal environment, and politics. Key to understanding a successful flexible strategy is that anyone or all these factors can change.

One criterion that influences aircraft programs that the Navy emphasizes more than any other service is that of politics. The threat still is the foremost consideration, however the Navy understands the requirement to gain consensus for a program and the requirement to manage that consensus throughout the life of that program. The requirement for consensus has been verbalized by one of the Navy's deputy program managers when he said: "Good ideas have no practical value until their merits are recognized by those with the authority to approve and support them."[14] When the question was asked of a Navy program manager about a decision-making model that could be used in aircraft procurement, he replied that he thought it would be of limited use due to the real manner by which decisions were made. The captain said that once the Navy determines what it desires, the real issue was winning the support of the Congress. He revealed their target audience, "The people that have to be convinced about a program is not a

Congressmen but their congressional staffers." and their basic strategy, "We put together a briefing that explains what we want and to some extent why we want the program. We gather the staffers together and take them someplace nice (eg,. the Bahamas). We then present our information and usually do quite well in getting for what we've asked."[15].

Naval program managers are more actively involved in matters of other than a technical nature than their Army counterparts. Program managers interface with their bosses, contractors, Naval Operations, the Secretary of the Navy, and GAO/audit services, as do Army managers, but they are also primary interfaces with the Congress, press, and others.[16]

Reasons for the Navy to establish and/or modify a program include fleet inputs and experience, threat studies and analysis of mission areas, threat strategy that encompass deficiencies of existing capabilities, technology opportunity, cost reduction opportunity, change in national defense policy, identify emerging requirements, tenative operational requirements, development option papers, assess alternative system concepts, and the decision to pursue and fund new systems.[17]

<u>Trans World Airlines</u>

Trans World Airlines has a vested interest in making the appropriate decision in reference to procuring new aircraft. The incorrect decision can be extremely costly and seriously effect the well-being of TWA.

Requirements in the civilian sector are a function of analysis of the airlines themselves and the marketing analysis and efforts of the aircraft industry. The airlines primarily analyze their market opportunities, passenger and freight load factors, flight environment and distances, the utility of their fleet to support these markets, and lastly the age of their fleets (normally measured in terms of take-off and landing cycles). Aircraft manufacturers carefully monitor the activity of the airlines and enter into frequent dialogue with the airlines presenting their aircraft for consideration. Often the airlines approach the aircraft industry for aircraft recommendations to a market situation that the airlines have defined.[18]

New aircraft are not always the solution to the requirements of a new market or aging aircraft fleet. Although not feasible for the military, the airlines are sometimes able to purchase smaller competitors and merge the best of both fleets to resource deficiencies. [19] If a corporate purchase will not produce the desired results, then the purchase of new aircraft may be the only answer to a fleet shortfall or an aging fleet.

TWA currently possess aging L1011 and DC-9 fleets that they will soon need to replace. With the current media exposure of the problem of aircraft age, the airlines are very sensitive to the number of cycles and age of their fleet. TWA has just recently conducted an analysis of their current situation in this regards and conducted an evaluation of the market and some potential new aircraft.[20] Information must be continually reevaluated and, if a board decision is necessary, any decisions made by the board of TWA must be made in a timely manner for the airline industry is extremely competitive.

Repair parts are an important economic factor for the airlines. Unlike the military that has a requirement to maintain repair parts and spares, the airlines negotiate a program that places the responsibility for maintaining repair parts with the manufacturer. The airlines maintain a limited inventory of high use items at maintenance hubs (like Kansas City International Airport in the case of TWA). Airlines are able to supply a problem aircraft from the hubs rapidly and are assured of manufactured supply parts almost as quickly. The problem of inoperative aircraft is more acutely felt in the airlines than even the military. If an aircraft can not fly then it does not earn money.[21]

Soviet Design, Development, and Production.

The Soviets' procedures for the procurement of their helicopters is quite unlike anything comparable in the west. Helicopters are designed to fulfill requirements of the Minister of Defense. These helicopters are then adapted for civil or commercial use. This frees the Soviets from having to do market research, extensive contracting, or bidding. The Soviet economy, as it is centrally planned and organized, delegates tasks to the various helicopter producers and avoids the duplication of effort within the industry.[22]

All research, design, development, testing and production of all aircraft is controlled by the Minister of Aviation Industry (MAI). The Ministry has three main elements: the Military Air Force (V-VS), the Naval Air Arm (AV-MF), and the Civil Air Fleet (Aeroflot). The Ministry controls the V-VS, AV-MF, and the Voluntary Society for the Assistance to the Army, Air Force, and Navy, which is responsible for recreational aviation.[23] It is the MAI that sets the priorities of the Central Aero-hydrodynamic Institute (TsAGI), Central Aero-engine Institute (TsIAM), Central Design Bureau (TsKB) and other design bureaus, and the production plants. [24]

The Soviet General Staff coordinates the action of their Scientific-Technical Committee, the State Planning Commission (GOSPLAN), and the services' Scientific-Technical Committees. [25] Scientific Research Institutes are proliferated throughout the services and Aeroflot. These research institutes are supported by the Academy of Sciences and some higher education laboratories. Institutes deal with pure and applied research dealing with the theoretical and the development of hardware. In aviation one of the institutes is responsible for the acceptance trails for all aircraft, military and civilian. [26]

Soviet helicopter designers have the advantage of an independent budget and a stable workforce. Unlike his western counterparts, his design teams stay together for years and do not disband when a new helicopter is introduced. Particularly for military helicopter designers, who earn more money and enjoy more benefits, the workforce stability is extremely stable. [27]

Design bureaus exist to design and construct new helicopters. They are not exclusively devoted to pure research or production and act independently of research institutes and the factories. They accept the material from the institutes, design, oversee prototype construction, and then test the prototype. [28]

The helicopter design bureaus in the Soviet Union are unburdened of the problems of their western counterparts in that they do not have to recoup their R&D or production costs nor even make a profit. [29]

Design bureau chiefs still must compete to get their designs into full production. Since the design bureaus are able to develop prototype hardware, the ability for the Soviets to analyze a new system is made easier than having to make a decision on the basis of a paper proposal as is the predominate manner in the west.[30]

Military helicopter procurement is initiated when the V-VS issues a requirements document specifying tactical and technical requirements. The design bureaus themselves can submit proposals if they perceive a military advantage by introducing advanced technology. Proposals are submitted to the Council of Ministers and then to the MAI for an analysis of feasibility and need. On approval of the Council of Ministers, based on the recommendations of the MAI and the results of intensified flight testing, the program is forwarded to the production capability for full-scale production.[31]

System Comparisons.

The Air Force and the Navy consider the aspect of politics in their decision criteria concerning aircraft procurement. They realize the importance of that aspect of a program and unlike the Army, have formalized it into their decision process at the onset whereas the Army has not. The approach of these two services is more in line with that of civil industry in that, unless a program can enjoy the support of the "controller of the purse strings", the program will be doomed from the start, no matter how important the program.

The Army realizes the importance of politics for a given program but does not analyze its impact until the technical aspects of the program have been well defined. The Army's approach is that the utility of the program will demonstrate its need and therefore compel the

Congress to fund the program. Presumably this precludes the Army from having to "soil" itself with "lobbying" another federal agency of patriotic Americans (the Congress).

The Soviet's procedures for the procurement of their helicopters are quite unlike anything comparable in our military establishment. All helicopters are designed to fulfill requirements of the Minister of Defense and then adapted for civil or commercial use. The Soviets are freed from having to do market research, extensive contracting, or bidding keeping developmental costs down and always lead to the "financing" of a flyable prototype. We could not achieve this level of initiative in our constrained fiscal environment.

Trans World Airlines' success in the airline industry is largely due to their analysis of the market and their ability to weigh alternatives in aircraft procurement issues. New aircraft are not always the solution to the requirements of a new market or aging aircraft fleet, the airlines are sometimes able to purchase smaller competitors and merge the best of both fleets to resource deficiencies. If a corporate purchase will not produce the desired results, then the purchase of new aircraft may be the only answer to a fleet shortfall or an aging fleet. TWA, like the military, must pursue aircraft modernization in order to keep the fleet at a manageable age and for their purposes, to keep the right type of aircraft on the right route (load factor rationale). The age of the fleet is important to TWA in respect to aircraft safety, maintenance, and improved technology (navigation aids, fuel economy, crew reduction, etc.), these criteria are not unlike criteria pertinent to the military. The corporate decision makers in the civilian sector must quickly realize a change in the market situation and rapidly initiate an appropriate procurement strategy to service a market before a competitor does so. The ability to rapidly procure the appropriate aircraft is even more critical to TWA than for the military for financial and procurement lead times for them are not as protracted as for our military.

The Air Force and Navy have overarching plans similar to the Army's Aviation Modernization Plan. Their plans prescribe management plans that ensure that their fleets have an optimal age for their fighter aircraft. The Army's and Air Force's attack aircraft optimal average is ten years with a useful life of twenty years. The Navy's average is less due to the degenerative effects of carrier landings and salt water corrosion. These plans ensure the replacement of their attack force prior to the end of their useful age thus providing a replacement rate that modernizes and sustains their force structure.

Air Force and Navy planners have defined four major categories as critical realities which can influence aircraft procurement: the threat, technology, the fiscal environment, and politics; the Army has not formally recognized the political factor in their procurement instructions. Both the Air Force and Navy understand the requirement to gain consensus for a program and to manage that consensus throughout the life of that program.

All services appear to have commonality in reasons to evaluate aircraft retention and procurement although the Navy has added the criterion "a change in national defense policy." The analysis of the threat is weighted heavily by all services although there does not appear to be any generic Department of Defense directed analysis for use in materiel evaluation. This is in line with actions in the civilian sector, in that not all participants have the same interest in an identical market situation.

Although there is a great deal of commonality in service programs, emphasis on the importance of fiscal and political environments is calculated at the onset by the Air Force and Navy. This may explain their success when compared to that of the Army. All services have problems determining the actual cost of a program. Consequently, none of the services analyze total costs when investigating candidate materiel solutions for mission area identified deficiencies. The Army has taken the lead in an attempt to quantify these costs and evaluate alternatives with the development of the Phoenix model. This model however, is fairly rudimentary at this stage of development. Information concerning the Phoenix model has been passed to a Navy program manager.

CHAPTER FOUR -- END NOTES

[1] United States Air Force, Briefing, "Fighter Road Map," (Langley AFB, Virginia: Tactical Air Command, 1988), slide, "Maintaining the Force Average Age."

[2] Ibid., slide, "Force Average Age."

[3] Ibid., slide, "The Fighter Roadmap."

[4] Ibid., slide, "Quality Improvements."

[5] Ibid., slide, "Quality Improvements (continued)."

[6] United States Air Force, TAF 3XX-87-I-A, System Operational Requirements Document, (Langley AFB, Virginia: Tactical Air Command, 1987), p. 1.

[7] Ibid., p. 2.

[8] Ibid., p. 3.

[9] Ibid., p. 4.

[10] Ibid., pp. 4-5.

[11] Ibid., pp. 6-8.

[12] Ibid., pp. 8-12.

[13] Robert Glomb, Briefing, "Program Management Overview," (Washington, D.C.: Naval Air System Command, Defense Suppression Systems Program Office, 1988), p. 8.

[14] M.F. Steiner, Briefing, "Program Management Overview," (Washington, D.C.: Naval Air System Command, Air-to-Air Missile Systems Program Office, 1988), slide "Conclusions".

[15] Telephone Interview, James Vaccia (Captain, U.S. Navy), 28 November 1988, F-14 Program Office (PMA-241), Naval Air System Command, Washington, D.C.

[16] Gary T. Pursel, Briefing, "NAVAIR Program Management," (Washington D.C.: Naval Air System Command, Anti-Ship Weapon Systems Program Office, 1988), slide, "Congressional and Press Interfaces".

[17] Robert Glomb, Briefing, p. 32.

[18] Interview, Weldon B. Clark, 26 January 1989, Aircraft Development, Trans World Airlines, Inc., Kansas City, Kansas.

[19] Interview, F.L. Troutman, 26 January 1989, Materials Control, Trans World Airlines, Inc., Kansas City, Kansas.

[20] Interview, Weldon B. Clark, TWA.

[21] Interview, F.L. Troutman, TWA.

[22] John Everett-Heath, Soviet Helicopters, (London, United Kingdom: Jane's Publishing Company, 1983), p. 106.

[23] Ibid., pp. 107-108.

[24] Ibid., p. 107.

[25] Ibid., p. 108.

[26] Ibid.

[27] Ibid., p. 109.

[28] Ibid.

[29] Ibid., p. 108.

[30] Ibid., p. 109.

[31] Ibid., p. 119-111.

CHAPTER FIVE

HISTORICAL ANALYSIS OF ATTACK HELICOPTER LIFE CYCLES

INTRODUCTION

The Requirement For an Armed Helicopter

Both the Rogers and Howze Boards made recommendations in the 1960's about the use of helicopters on the modern battlefield.[1] One of these proposals included the manufacture of a specialized armed helicopter. Although substantial progress was made concerning the application of helicopters to enhance the mobility of the maneuver force, little priority was given to the manufacture of a specialized armed helicopter in support of this highly mobile force.[2]

Despite official endorsement, there remained a great deal of resistance about the application of these new concepts or even a willingness to experiment.[3] There were, however, some helicopter-minded senior officers who attempted to develop new doctrine to employ the findings of the Howze Board to include the arming of some of the force.

Improvisation

Armed with the findings of the Rogers and Howze Boards and experiences gained in the Korean War, some far-sighted officers attempted to deal with the problem of providing fire support capable of keeping pace with the heliborne forces identified by the Howze Board. In June 1956, Colonel Jay Vanderpool attempted to come to grasp with the problem by the improvisation of a force of helicopters armed with machine guns and rockets. He then formed an organization which he designated a "Sky-Cavalry Platoon" that proceeded to engage in spectacular field tests at Fort Rucker, Alabama.[4] The makeshift tests demonstrated that the supposedly fragile helicopters, even if armed with modified ground weapons, could be transformed into mobile platforms for delivering devastating firepower to protect the heliborne assault force.

Vanderpool's "Sky-Cav" gradually earned official recognition and evolved into a company size element for further experimentation. Critics persisted that the helicopter was too slow to satisfy the requirements of a heliborne force.[5] The results of the "Sky-Cav" or "Vanderpool's Fools", although informative, did not result in a specific requirement being identified for an armed helicopter. The issue would become more than a hypothesis in combat during the helicopter war in Vietnam.

Factory Converted Gunships

After our first year in Vietnam, it became apparent that there was a tremendous requirement for some type of armed helicopter escort. The early efforts of pioneers during the Korean conflict and Vanderpool's "Sky-Cav" were soon to bear results. The Army began a concerted program to produce an armed helicopter by taking an off-the-shelf UH-1B, putting weapons and a fire control system on it, and series typing it as the UH-1C or the "Charlie model gunship".[6] This was later upgraded to the UH-1M after the development of the UH-1H. Although the UH-1M was an adequate gunship, the UH-1M could not operate in all required tactical environments due to its limited payload capability and lack of power for the existing environmental conditions.[7]

The previously innovated helicopters, although adequate for escort work with similar model helicopters, could not keep pace with the other participants in the air war (eg. CH-47 or the CH-54). Additionally, their reaction time for strip alert missions was not satisfactorily responsive nor was their ordnance delivery system that accurate. The Army quickly identified the requirement for a heavily armed escort for vulnerable troop-carrying helicopters operating at low altitudes over hostile armies. Other capabilities such as the delivery of antitank missiles, armed reconnaissance, and the support of day or night missions was required.[8] In the later stages of 1964 the Army formulated the requirements for the Advanced Aerial Fire Support System (AAFSS). In that year the Army released its Request for Proposal (RFP) to 128 organizations, of which 12 responded with the preliminary designs. Two of these, Lockheed and Sikorsky, were selected for the construction of flyable prototypes.[9]

The Interim Solution

The nation now had a solution to the problem literally on the drawing board, but the need for the gunship was a reality without immediate solution. The Bell Helicopter Textron Inc., although unsuccessful in its bid for the AAFSS, had gained a great deal of experience in the development of an armed helicopter in its attempt to sell the OH-13X gunship prototype from the popular OH-13.[10] That program was not a successful bid, however, it did place the company on a footing that enabled it to quickly produce a marketable interim substitute for the AAFSS, the Model 209 which eventually was produced as the AH-1G, the Huey Cobra.[11] The other leading rotary wing aircraft manufactures, although conducting research with arming helicopters, had been out maneuvered by Bell Helicopters.

SECTION TWO...THE HUEY COBRA

Development

After its lack of success with both the Sioux (OH-13X) project and its bid for the AAFSS program, Bell made the corporate decision to initiate a company funded program, the Model 209. Begun in March 1965, the development of the Model 209 progressed rapidly. It borrowed the transmission and rotor system from the UH-1B/C and the Lycoming T53-L-13 engine from the UH-1C. These components were placed into a streamlined fuselage inspired by the Sioux endeavor. The two crewmen were seated in tandem, to give them the best possible field of vision, while the low profile and narrow silhouette ensured it would have a small visual signature. Sub wings (they provide no lift) were for armament, together with an Emerson Electric TAT Type 102b minigun.[12]

The first prototype Model 209 flew on 7 September 1965, only six months after inception. In December 1965, the prototype Model 209 was delivered to the Army's Flight Test Evaluation Board at Edwards Air Force Base, Ca. The prototype was rapidly accepted and by 4 April 1966, nine Model 209s were evaluated and designated the AH-1G. On 13 April 1966, the Army ordered 110 AH-1Gs. The number of AH-1 aircraft produced eventually exceeded 2,500.[13] Although the Army obtained a gunship of great utility, the AH-1 still did not fulfill the requirements specified in the AAFSS program in that it could not keep pace with the CH-47 when fully armed, operate in the meteorlogical environment defined for the AAFSS, nor possess the navigational or armament capability identified for the AAFSS.

What is particularly noteworthy of the AH-1 program is that it was a program born out of necessity. The traditional R&D program procedures were seriously abridged or eliminated in order to get the product to the troops. The AH-1G went from concept into the hands of the troops in less than fifteen months, versus the usual eight to ten years.[14] How many aviators were lost due to this reduced R&D period may never be discerned, however there are yet in the ranks many Vietnam experienced Cobra pilots. The Army experienced some significant "teething" problems which were cured by up-gunning the chin turret to accommodate both a 7.62mm minigun and a 40mm grenade launcher (previously it could handle only one of these or a machine gun), installing the 808 tail rotor system, and by rethinking the emergency procedures, for never had a helicopter flown so fast and there is a definite aerodynamic response with the AH-1 at high speed.[15] The AH-1G was deployed to Vietnam by August 1967 and served with distinction during the Tet Offensive of 1968 and the Laotian Spring Offensive of 1971.[16]

Generally the AH-1G emerged from Vietnam with an excellent reputation from both the aviation and ground elements of the Army. The AH-1 has earned a role on the modern battlefield. The AH-1 will eventually earn a place in history comparable to the B-52 or the UH-1, in that if the life cycle goes according to plan, the airframe will be older than its pilots. Even considering their age, there is still talk that the AH-1 could be modified to operate well into the next century.

The AH-1 Life Cycle

The AH-1 is an excellent example of the product life cycle that Philip Francis describes in his book Principles of R&D Management. Figure 5-1 illustrates the product life cycle of the AH-1 to date. This has enabled Bell to maintain the AH-1 project in continuous utilization from inception.

U.S. ARMY MODEL AH-1 CUMULATIVE LIFE CYCLE TREND

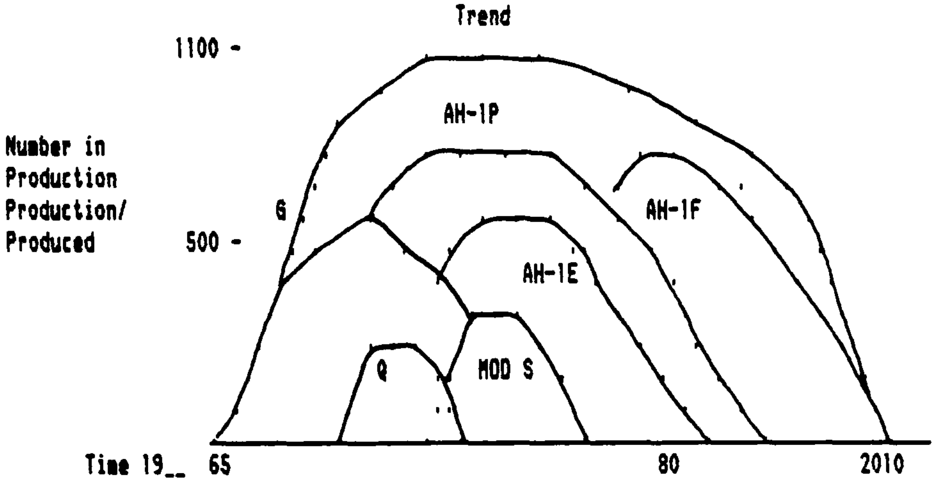

Figure 5-1[20]

The first modification came about in direct response to the needs of the United States Marine Corps who, although satisfied with the performance of the AH-1G's, desired the safety of having twin engines for their extensive over water flight environment.[17] The Marines additionally replaced the M28 turret with the superior General Electric 20mm turret. These newly designated "J" model Cobras made their appearance over the fleet in 1971. Additionally this model was released for sale to friendly foreign nations.[18]

The next large scale modification to the Cobra fleet occurred in 1973 when selected AH-1's were converted to AH-1Q's. The AH-1Q was basically a G model that could fire the Hughes produced tube-launched, optically tracked, wire guided (TOW) missile system. The Sperry Univac helmet sight system (HSS) was additionally incorporated into the airframe, and a total of 92 AH-1G's were converted to the Q configuration.[19] It became apparent that the additional weight of the TOW missile system and the HSS required more power than the old G model power trains were able to deliver. Helicopters were also undergoing drastic revision in order to survive in a high air defense weapon-prolific environment. This required gunships to remain at or below treetop level in an effort to reduce either optical or radar line-of-sight tracking. This dictated the requirement for a more powerful power train which was achieved by incorporating the Lycoming T53-L-703 engine and a transmission modifcation to accommodate 1290 shaft horsepower (SHP). This new Cobra became known as the Modified S or Mod S.[21]

One year later in 1975, the Marines and Bell introduced a variant type classified as the "T" model Seacobra. The Seacobra had a lengthened fuselage, new T400-WV-402 engines, and provisions for the TOW missile system.[22]

The Army in March 1977 committed itself to modernizing the Cobra fleet to meet the needs of the nineties with the introduction of a three phase program to update the AH-1S fleet to AH-1F (originally designated the AH-1 S (Modernized)) standards.[23]

As illustrated in Figure 5-2, the Army has called for the procurement of 100 AH-1P (originally called Production S).[24] The AH-1P has a flat plate canopy, nap of the earth (NOE) cockpit configuration, a radar warning device, a push-pull anti-torque system, and a continental United States (CONUS) navigation package.[25]

Phase two consisted of buying of 98 more Cobras in the AH-1E or as the S (ECAS)(Enhanced Cobra Armament System) as it was originally designated. The AH-1E is basically an AH-1P that has an improved weapons suite with the introduction of the the M197 20mm gun turret, a 10 KVA alternator, a composite main rotor, and provisions for a wing stores management system.[26]

AH-1S MODERNIZATION PROGRAM

```
1975 / 1976 / 1977 / 1978 / 1979 / 1980 / 1981 / 1982 / 1983 / 1984 / 1985 /

   /---AH-1S (MOD)---/ 290
            /--AH-1P--/ 100 - Step 1
                      /-AH-1E-/ 98 - Step 2
                             /--AH-1F--/  99 - Step 3
                             /--AH-1G conversion to--/  372 ‡
                                  AH-1F standards
                                               /Recycle Mod S/ 290 ‡
                                                      /Step 1/ 100 ‡
                                                        to 3
                                                           /Step 2/ 98 ‡
                                                             to 3
```

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
AH-1G	671	487	409	400	397	294	137	0	0	0	0
AH-1S	28	184	331	416	488	488	488	421	257	93	
AH-1F	‡				15	192	362	566	730	894	987

‡ May vary due to attrition

Figure 5-2[27]

An additional production and conversion of 99 AH-1's to the AH-1F configuration began in October 1979. The AH-1F upgrades included a full solution ballistic computer, laser range finder, pilot heads-up-display (HUD), a low airspeed data system, an infrared (IR) jammer, IR suppressor, Doppler navigation system, and FM secure voice. During the final stages of phase three, all remaining Mod S were to be upgraded to

AH-1F standards, then all AH-1P, and finally all AH-1E were to be converted to AH-1F standards.[28]

Cobra 2000

Cobra 2000 was an effort by the Army to gain AH-64-like capabilities integrated into its Cobra fleet. There was not one aspect of the AH-1 that was not evaluated for either increasing efficiency or reducing weight. The weight of the mission-distinct systems had taken a heavy toll on both the payload capability of the Cobra and its maneuverability.

Cobra 2000 expanaed every capability of the AH-1F. However, to enjoy these capabilities, even with the extensive use of composite materials, there evolved a hybrid Cobra that weighed more and could carry less. The growth potential of the airframe to accommodate any additional power was achieved with the advent of the Mod S. Any improvement in the area of power train would necessitate the design of a new airframe.

The expensive Cobra 2000 program was cancelled due to the program cost and the belief that the Cobra would be predominately replaced by the AH-64. Selected options such as the blue-green cockpit lighting, wire strike protection system, radar jammer, have been incorporated into the current fleet.[29]

The AH-1W SuperCobra

During 1983-84 the Navy evaluated a hybrid Cobra under development by Bell Helicopter Textron which was initially designated the AH-1T+. This is now designated the AH-1W. In the AH-1W the Marines have extended the life of the Cobra with the procurement of 22 AH-1W

SuperCobras. Subsequent success has warranted the follow-on purchase of 34 new SuperCobras and a block conversion of 40 AH-1T's to AH-1W configuration.[30]

The AH-1W is designed to fit any environment. It is a powerful, dependable, and proven airframe that can face the challenge of a radar and hostile missile environment and is also the fist production rotary wing aircraft designed for air-to-air combat.[31]

The SuperCobra is a flying arsenal that can fire TOW or hellfire antitank missiles, 20mm cannon, the AIM-9 sidewinder air-to-air missile, 2.75" folding fin aerial rockets, or fire Zuni rockets, CMU-55B fuel air bombs, flares, or smoke grenades.[32]

The powerful AH-1W is as capable a player on any battlefield as the Army's AH-64 except during darkness. With all its potential, the AH-1W does not have the sophisticated night vision devices of the AH-64. The AH-1 has a future in the Marines beyond the AH-1W. A hybrid of the AH-1W is being developed by combining the AH-1W with Bell's 680 bearingless rotor system. This aircraft, to be classified the AH-1V (Viper), is expected to dramatically improve the AH-1W's capabilities in air-to-air and air-to-ground engagements.[33]

The Cobra Future

Although Cobra 2000 was cancelled, there is still tremendous interest in maintaining a Cobra fleet that will complement the AH-64 through to the year 2007 where it will be replaced by either the LHX or the AH-58 (an armed AHIP). The LHX would replace all remaining AH-1's or the AH-58 would be purchased to replace AH-1's in air cavalry if there is a delay in the LHX program.[34]

There are contingency plans in the project manager's office to upgrade the AH-1 program as the Army did with the CH-47 in the event that the LHX and/or the AH-64 programs aren't procured as defined in the Army Aviation Modernization Plan. This modernization would include the modification for the provisions for two T 800 engines (designed for use in the LHX program), a weapons suite that can fire the Hellfire antitank missile, a four blade rotor system and a night sight and night flight capability.[35] This plan is only a conceptual one in the minds of the AH-1 PM's leadership and would involve the allocation of additional R&D funds in order to redesign the airframe to accomodate these new capabilities.

THE CHEYENNE

The Cheyenne is a classical example of a project whose phase II ended without the move to full scale production. Only the SGT York division air defense system has surpassed it in the arena of unrewarded R&D effort. After the project failure, Lockheed removed itself from the rotary wing arena and there started a period in which the Army had no strategy for procuring a replacement attack helicopterfor the Cobra.

Advanced Aerial Fire Support System (AAFSS).

The RFP of 1964 for the AAFSS quickly received response from twelve competitors. Only two of these emerged to compete for phase I development and the operational test (OT) 1; these were Sikorsky with its Blackhawk and Lockheed with the YAH-56A Cheyenne.[36]

Basically what was required was an armed helicopter that could keep pace with the Boeing Vertol Chinook (while making sorties along the flight route) and to destroy enemy personnel, equipment, and armor.

This helicopter had to have a dash speed of not less than 220 knots, hover out of ground effect at 6,000 feet and 95 degrees, and a ferry range of 2,100 nautical miles. The aircraft had to be able to accurately fire rockets, 30mm bullets, 40mm grenades (which could be substituted by a 7.62mm minigun), and be able to fire the TOW missile. Additionally the Army had plans for making great advances in fire control, communications, navigation, and automatic terrain following.[37]

The Lockheed prototype quickly emerged as a rigid rotor "airplane" that could hover with a pusher propeller on the tail. Lockheed had learned extensively from its development of the XH-51A, another rigid rotor aircraft. The Cheyenne with its rigid rotor, which was unloaded in forward flight, could achieve unheard of forward airspeeds and yet handle with great agility at a hover and in other flight regimes. During fast forward flight, the wings of the Cheyenne produced all the lift required for flight and completely unloaded the main rotor system which then functioned like the flaps on an airplane. The wings also functioned as armament stations.[38] Lockheed won the right to continue into phase 2 development due to the fact Sikorsky could not manufacture a tail rotor with durability that could pivot ninety degrees to help its winged helicopter achieve the forward airspeeds possible with the Cheyenne.[39]

The Cheyenne used a rigid rotor stabilized by a gyro mounted above the main rotor hub. This was to be the Cheyenne's greatest asset and downfall. The rigid rotor and wings enabled the Cheyenne to achieve unparallelled forward airspeed and maneuverability. After the initial flight test conducted in September 1967, the flight envelope was expanded.[40] Generally there were problems encountered that required only minor modification. There were two major problems associated with the rigid rotor that required considerable investigation, but whose fixes were quite simple. The first problem resulted in the death of a test pilot after its first occurrence. The gyro manifested a phenomena at high speeds called "half p hop". This is basically the variation of rotor thrust that occurred every other revolution. In the aircraft, the "half p hop" is manifested as feedback through the flight controls that set up a classic resonance situation that caused the pilot's left arm to operate the collective control lever to an ever increasing amplitude against his will. This divergent flapping motion caused the blade to enter the cockpit, destroying ship 1003. The problem was quickly remedied by stiffening the blades, incorporating a collective pitch lock, and modifying the geometric parameters of the rotor.[41]

The second problem was associated with dynamic wind tunnel testing conducted after the crash of aircraft 1003. During the test, the rotor began to flap back, indicating that the blade bending feedback to the gyro was being overpowered by other unstable forces. The result was a severe gyro input that caused the rotor to sever the tailboom, sweeping aircraft 1010 down into the vanes of the wind tunnel. There is still contention today that the accident that aircraft 1010 was involved in was a phenomena of the wind tunnel and would never have happened in actual flight. Lockheed found a fix for the wind tunnel accident by lowering the stabilizing gyro below the transmission. This procedure was actually developed before the "crash" of 1010, and its application followed shortly thereafter.[43]

The Death of the Cheyenne Program

By November 1970 the program was completed. The Cheyenne could fly 215 knots in level flight, demonstrated excellent weapons accuracy, pulled up to 2.6 positive G's and up to 0.2 negative G's; could identify a target, mask behind terrain, fly three miles up a valley, and still point the gunner toward the target after masking. The problem was it took too long for the project to achieve these results and at an expense much higher than the anticipated price.

There were some interservice arguments as to who should have the Cheyenne. The Air Force believed close air support was its mission. It contended that at the airspeeds possible with the Cheyenne the Army was stepping into its realm. Additionally, the Air Force saw the AH-56A as a direct competitor to its soon to be fielded Fairchild A-10.[44]

The high forward airspeed achieveable with the Cheyenne and the very advanced but expensive subsystems became the Cheyenne's worst enemies. Although a contract was let for the procurement of 375 Cheyennes, this contract was cancelled in August 1972 in favor of new parameters of the advanced attack helicopter (AAH).[45]

Lockheed then had an excellent helicopter with no marketplace. The Cheyenne program was disbanded after Lockheed unsuccessfully attempted to modify the Cheyenne to fulfill the requirements of the AAH program. Lockheed helicopter experts were released to seek new horizons, and Lockheed placed its study of rigid rotor in storage.[46]

THE ADVANCED ATTACK HELICOPTER

Development

Based on the findings of a task force report in July 1972 and the subsequent cancellation of the Cheyenne program in August of that year, Hughes Helicopter and Bell Textron began developing company funded prototypes for the soon to be defined AAH. Largely due to their efforts and rapid response to the RFP let for the AAH, both Bell and Hughes were selected to compete in phase 1 development for the AAH. Two years later, in September 1975, the first YAH-64 made its maiden flight. This was followed one day later by the maiden flight of the Bell prototype YAH-63.[47] One year later flight tests were completed at the Army Engineering Flight Activity. Based on the results of the fly-off, the Hughes YAH-64 was selected to participate in a 56-month phase 2 development with a three month OT II to validate the helicopter and its maintenance program.

By January 1982 funding was authorized for the first eleven Apaches. The program was officially launched in March 1982 with the first production Apaches due to the Army by early 1984.[48]

The AH-64 Future

The AH-64 is scheduled to take the Army well into the twenty-first century. Apache 2000 will involve the AH-64 and a multi-stage improvement program (MSIP). The LHX (Attack) will supplement the AH-64 in our attack formations in air cavalry units and will be the primary attack helicopter in light divisions.[49]

ARMY HELICOPTER IMPROVEMENT PROGRAM (AHIP/OH-58D)

The Army has been involved in procuring an observation helicopter that can keep pace and interface with the AH-64 and function as an advanced platform for aerial observation and control of indirect fire support. The initial AHIP is a modified OH-58A with a four bladed rotor system, an acquisition television, thermal imaging system (TIS) and laser rangefinder/designator incorporated into a mast mounted sight (MMS).[50]

The initial OH-58D did not have provisions for a weapon suite. However, with the proliferation of Soviet attack helicopters on the battlefield, the OH-58 was required to be armed with the Stinger anti-aircraft missile system in order to protect our attack helicopters while they destroyed enemy armor.[51]

The AHIP's fate is unavoidably interwoven with the AH-1 and LHX programs. Due to the retirement of the AH-1 and the unavailability of the LHX prior to the AH-1 retirement, the AHIP has been nominated to be more heavily armed and will replace the AH-1 in cavalry units. Currently 375 aircraft have been authorized in the FY90-94 POM for initial deliveries in October 1992.[52]

The arming of the OH-58D will incorporate the ability to fire the Hellfire anti-tank missile, ATAS, Hydra 70 family 2.75 inch rockets, and a 50 caliber machinegun.[53]

The "AH-58" will significantly enhance the warfighting capability of our cavalry squadrons. The "AH-58" is achievable today with hardware that is available today. The funds for the program are in the POM and should provide good operational capabilities at low cost.[54]

CONCLUSIONS

Program Procurement

Although the requirements for an armed attack helicopter existed, the Army did not immediately release a Required Operational Capabilities (ROC) document. Because of tactical requirements in Vietnam, the procurement of an armed helicopter to fulfill requirements was made despite the lack of an ROC. The procurement of these interim aircraft was drastically modified due to battlefield needs.

The requirements for these armed helicopters closely resembled the characteristics of existing company funded developmental considerations. This was possible due to the close rapport between the Army and the manufactures of rotary wing aircraft.

As attested by the quality of product of all three programs discussed, the procurement policies of the Army and its conduct of quality assurance tests are successful.

Life Cycle Analysis

The Army has described the useful life of the attack helicopter as twenty years in the Army Aviation Modernization Plan. A great deal of the AH-1 fleet is now reaching its twenty year mark. Current plans call for the systemic phaseout of the AH-1 from 1990 through 2007.[55] An analysis of the Army's AH-1's life cycle corresponds to its stated useful life. This contrasts with the Marine Corps decision to product improve its AH-1 fleet. Decisions to product improve the Army's AH-1's were made primarily with adapting new technology based on adapting the AH-1G for its new mission as an antitank system and to upgrade its underpowered power train.The costs for these product improvements were more capabilities for the AH-1 at the expense of lowering its operational capability as the AH-1's weight (minus fuel and ammunition) approached its gross weight of 10,000 lbs. The Marines have truly evolved their AH-1 fleet in that all of their model improvement also incorporated changes in their power train, thus providing greater lift capability.[56]

The AH-64 was not designed as a replacement for the AH-1. It was designed as the result of requirements identified for the AAFSS as modified by deficiencies noted in antitank killing capability identified during the later stages of Vietnam, in particular during LAM SON 719.[57]

Due to the delayed fielding of the AAFSS and then the AAH program, the AH-1 was our only attack helicopter program with which to fulfill the requirement for an attack helicopter for the 70's and early 80's. This, coupled with the realization that we clearly led the Soviets in attack helicopter capability, led us to the decision to not only sustain the AH-1 program, but also to product improve the AH-1 to survivability and lethality requirements for the Central European battlefield.

The original concept for the retirement of the AH-1 included the mass replacement of the AH-1 by the attack variant of the LHX. This product will not be available to coincide with the AH-1 milestones. Largely because of this, the Army has decided to modify the OH-58D in order to replace the AH-1 in our cavalry squadrons. Again the Army has implemented a contingency plan to make the OH-58D a viable replacement for the AH-1's in these organizations.

CHAPTER FIVE -- END NOTES

[1] John W. Oswalt (LTC, USA), "Report on the Roger's Board," Aviation Digest, Vol. 7, No. 2 (February 1961), p. 15.

[2] "Rotary Winged Aircraft," Army Aviation Magazine, Vol. 31, No. 12 (December 15, 1983), pp. 12-16.

[3] Warren R. Young, The Helicopter (Alexandria, Virginia: Time-Life Books, 1982), p. 116.

[4] Ibid.

[5] Ibid.

[6] Ibid., p. 148.

[7] Ibid., p. 149.

[8] "Lockheed Tries the Rotorcraft Warpath," Rotor & Wing International, Vol. 15, No. 6 (June 1981), p.48.

[9] Ibid.

[10] Hollingsworth F. Gregory, The Helicopter (Cransbury, New Jersey: A.J. Barnes & Company, 1975), p. 47.

[11] Bill Gunston, An Illustrated Guide to Military Helicopters (New York: Arco Publishers, Inc., 1981), pp. 38-41.

[12] "Bell's AH-1 Cobra Series," Defense, Vol. 11, No. 5 (May 1980), p. 294.

[13] Kenneth Munson, The Pocket Encyclopedia of World Aircraft: Helicopters and Other Rotorcraft Since 1907 (New York: McMillam Company, 1969), p.76.

[14] The Illustrated Encyclopedia of the 20th Century Weapons and Warfare (New York: Columbia House, 1977), Vol. 13, p. 1380.

[15] Young, pp. 148-153.

[16] Ibid.

[17] Defense, p. 294.

[18] Ibid.

[19] Ibid., pp. 294-295.

[20] Ibid.

[21] Ibid.

[22] Bell Helicopter Textron Inc., "AH-1 Armed Helicopter Evolution," (Fort Worth, Texas), poster.

[23] Ibid.

[24] Ibid.

[25] Defense, p. 294.

[26] Bell Helicopter Textron Inc., poster.

[27] "Cobra 2000 Briefing," Bell Helicopter Textron, Vol. VIII, (July 13, 1981), slide, AH-1S Modernization Program.

[28] Ibid., p. 1-3.

[30] Arthur J. Negrette, "The AH-1W: Tougher Cobra with a Deadlier Strike," Rotor & Wing International, Vol. 22, No.9 (September 1988), p. 44.

[31] Ibid.

[32] Ibid., p. 47.

[33] Ibid., p. 49.

[34] Interview, COL Larry D. Holcomb, 16 December 1988, AH-1 Project Manager, Aviation Support Command, St Louis, Missouri.

[35] Ibid.

[36] Army Aviation Magazine, Vol. 31, No. 12 (December 15, 1983), p 52.

[37] Ibid.

[38] Ibid., p. 53.

[39] The Illustrated Encyclopedia of the 20th Century Weapons and Warfare (New York: Columbia House, 1977), Vol. 1, p. 18.

[40] Rotor & Wing International, Vol. 15, No. 6, p. 53.

[41] Ibid., p. 54.

[42] Ibid.

[43] Ibid., p. 90.

[44] Ibid.

[45] Weapons and Warfare, p. 18.

[46] Rotor & Wing International, Vol. 15, No. 6, p. 91.

[47] Charles F. Drenz, "U.S. Army Advanced Attack Helicopter Program Summary," (St. Louis, Missouri: USADARCOM, 1983), p. 1.

[48] Jack G. Real, "Apache Team Meeting," Hughes Helicopter, Inc. (Mesa, Arizona: Hughes Helicopter, Inc., 1982), p. 6.

[49] Interview, MAJ R. Scott Mair, 16 December 1988, AH-64 Project office, Aviation Support Command, St Louis, Missouri.

[50] Briefing, COL J. T. Huey to Mr. Robert Ropelewski (Armed Forces Journal,), 1 December 1988, "Army Helicopter Improvement Program," Aviation Support Command, St Louis, Missouri.

[51] Ibid., p. Summary.

[52] Ibid.

[53] Ibid., p. Prime Chance.

[54] Ibid., p. Conclusion.

[55] U.S Army Army Aviation Modernization Plan, (Army Washington D.C.: Office of the Chief of Staff, May 19, 1988), p. 12.

[56] Bell Helicopter Textron Inc., poster.

[57] Keith William Nolan, Into Laos, (New York, New York: Dell Publishing Co., Inc., February 1986), p. 156.

[58] COL Holcomb interview

CHAPTER SIX

ANALYSIS MODEL CRITERIA

Methodology

An analysis of military and civilian information has shown that there is commonality in much of the evaluation criteria used by both in aircraft procurement decision-making. Procurement documents were researched to discern the criteria the military and civilians use in aircraft procurement decision-making. Military and civilian program procurement personnel were interviewed in order learn more about the real manner in which procurement is conducted, assess their attitudes toward the existing system, and ascertain their feelings toward a more empirically based system.

Criteria Useful in Evaluation Modeling

It is not the scope of this chapter or study to design an evaluation model. The Army Concept Analysis Agency has already made significant progress towards defining the requirement for an evaluation model and towards formulating a preliminary evaluation model, the Phoenix model. The effort of the Concept Analysis Agency is an adequate model on which to build an even more complex evaluation model. The evaluation criteria used in the Phoenix model are not as comprehensive as have been identified in analyzing alternate procurement methods. This is because the Phoenix model is still in its infancy and has yet to mature to degree of complexity comparable to the problem. This chapter provides some criteria that could be used to expand the capabilities of the Phoenix model.

All the services must accomplish the difficult task of maintaining the best defense possible in order to ensure the security of the United States. We know that, because of political or fiscal constraints, this does not necessarily mean that the best equipment is procured and in sufficient quantities. It is in an effort to obtain the best equipment or the best mix of equipment, that the services need to improve their procurement procedures. An evaluation model would not only assist the services better articulate their requirements to the legislature, as was originally presented in this paper, but also to aid obtaining the best force affordable. Throughout the conduct of research, I discovered that decisions concerning aircraft procurement were not as scientifically based as I anticipated. All the people I interviewed involved in the procurement arena were interested in developing a more empirically based decision-making process. Not all of these people were convinced that it was possible.

Most of the following criteria are found in the the services or TWA's aircraft program procurement methodologies. Not all of the criteria are common to each of the programs.

Mission Area Analysis (MAA). Although this is an Army term, the Air Force, Navy, and TWA conduct a process similar in nature, although the later would probably refer to it as marketing research. Whatever the name, it refers to an interest that you have (eg. attack aircraft), how it is effected by its environment, and what could be done to keep that interest in a commanding position in that environment. The Army tasks its MAA to identify technological deficiencies and propose corrective actions in a specific commodity area (eg. aviation).[1] This process could be evaluated by computer modeling.

Funding Constraints/Strategies. In a resource-prolific environment (as in the Soviet system) this would not be a consideration. In our system, however, funding constraints do influence procurement strategies. Due to the nature of our budgeting process, this would be difficult to forecast with any degree of reliability. Although the eventual fiscal environment that will influence a program may not yet be decided, funding could be used as a variable in program strategy development.

Airframe Deterioration. Historical records should indicate the airframe's useful life. The aviation community (military and civilian) has been regulated to maintain comprehensive historical records. Historical analysis can identify fleet characteristics, maintenance trends and expected useful life. This information could be readily evaluated and quantified for the purposes of evaluation modeling.

Personnel Training and Trained Population Maintenance Costs. As with any system, trained personnel are the keystone to success. In the military, the impact of technological innovation must be understood by all elements of the organization in order to realize the full potential of this innovation. The following categories of personnel are the TRADOC designated personnel that require training. TWA incorporates these costs when determining program costs.[2]

Leader. A leader must successfully understand the employment considerations for new systems in order to derive the maximum benefit for the system.[3] The costs for retraining the military senior leadership could be based on unit costs for that pertinent block of instruction that would be received during formalized training. TVA develops a training program for their executives and managers based on how different a new system may be from existing systems.[4]

Individual. People are the vital ingredient of any system. Personnel training must include not only the obvious personnel to be trained on the equipment, but also occupational skill personnel who must interface with the new system without having to be system qualified (eg a fuel handler or hydraulics repairer). The costs for training these people is also evaluated by TVA. An aspect of individual training cost that is not readily quantifiable but of equal importance to cost is the psychological impact on the personnel force. Pilot training is one of the most expensive and vital aspects of introducing a new aircraft. Economically, specialized training (eg. trained on one aircraft) for a pilot is more cost effective than training that pilot on all the aircraft in the fleet. Why train someone to fly everything when he will probably only fly a specific aircraft. However, it is being observed that pilots that are left specializing in the older less "desirable" and probably less career enhancing aircraft are becoming a retention problem. This may cause the personnel system to train more pilots in a system going into obsolescence or retrain some of their pilots trained in a more advanced system back into the older aircraft. This is happening to some extent with the Army with its management of its attack helicopter pilots in that it is torn between converting experienced Cobra pilots to Apache pilots or using just training new entry pilots in the Apache. The Army is now having to increase its training of new pilots into the Cobra as many Cobra pilots have transitioned into the Apache or are eligible for retirement. The important economical aspect of this phenomenon is that psychological requirements of the aircrew may be more important in preventing their departure from the trained force versus the immediate training savings involved with specialized training.[5]

Unit. Units that receive new systems must receive unit training in order to properly evolve. This training provides the mechanism with which the unit can experiment and innovate with its new systems. An excellent example of this process is exemplified by the AH-64 (Apache) unit training conducted by the Apache Brigade at Fort Hood, Texas.

Repair Parts Availability and Costs. A major recurring problem that has surfaced in the military's system of procurement and system sustainment has been in the area of repair parts availability and costs. The military is forced, due to operational requirements, to maintain a supply of repair parts in every theater of employment. The cost liability of this practice in underwritten due to the necessity to maintain their equipment combat ready at all times. Unlike the airlines who maintain only the minimum essential stockage and have the aircraft manufacturer maintain the parts overhead, the military must maintain considerable quantity of parts on hand. The military must maintain this type of parts stockage program due to the remote areas whe[illegible] operate, the threat on their lines of communication, and the need to maintain high levels of combat readiness. Figure 6-1 shows that the availability of repair parts is initially low as their availability is in direct competition with parts requirement for the assembly line. As production requirements are met, parts become more available. Over time however, the need for repair parts will eventually consume that supply of parts manufactured for the system.

REPAIR PARTS AVAILABILITY

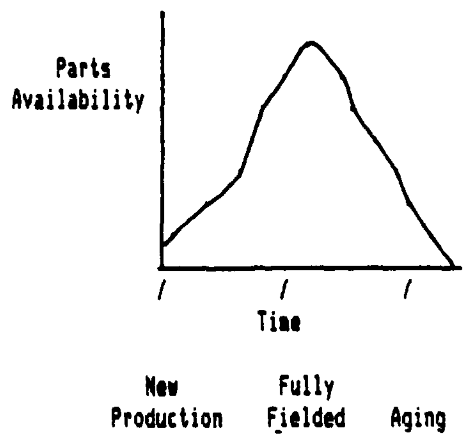

Figure 6-1 Availability of Repair Parts over the Age of a Program[5]

As a program gets older it begins to consume the available repair parts that have been produced. Unless more parts are produced the program will reach a point at which sustained operations can not be continued. Normally the cost of manufacturing new parts is substantial due to the costs of retooling and converting production lines back to producing those parts. The Army is faced with this predicament in its older aircraft, particularly low density aircraft like the OV-1. Sometimes a problem is encountered, as with the OV-1, in which the technical drawings and specifications for the manufacture of a particular part are no longer available.[7] The impact of this phenomenon is that this may drive a program that still enjoys usefulness into early obsolescence. Availability and costs could be incorporated into a decision-making model.

TMDE Availability and Costs. Aircraft distinct tools, measuring devices and equipment are an inherent aspect of any procurement program. Their costs and availability will impact on the fielding and maintenance of a helicopter program and could be incorporated into a decision-making model.

Simulators and Training Devices. The use of simulators and training devices are a potential way of deferring training and operating costs. TWA incorporates their cost into the cost of a program. To be most effective, they must be designed and available at the onset of the production of the system. Simulators were used effectively for qualification training in the UH-60A program.

Airframe Adaptability. During the course of an attack helicopter's lifespan, it is probable that it will be exposed to an unanticipated threat technological innovation. This may be manifested in either a requirement for some aviation life support counter or by attempting to modify an existing airframe for a new mission (eg. air to air). Although this criterion may not be useful in the decision made concerning initial production, it would be useful if quantifiable at a milestone V decision. At this point, it maybe useful in determining to what extent, if any, the airframe has the potential to be modified for its new mission.

Airframe Distinct Ammunition Procurement and Maintenance Costs. There may be merit in investigating ammunition procurement and maintenance distinct to an a particular airframe. This is particularly important if the ammunition concerned is not compatible with any ground based system. If not compatible, it could become a substantial cost not only involving costs for production but also distribution.

Threat analysis.

Ability to Defeat the Threat. Analysis to defeat the threat must look beyond the airframe. The analysis must include weapon subsystem capabilities and the adaptability of the airframe to receive weapon subsystems that can defeat the threat. We have simulations and models that quantify this to some extent now.

Exploitation of Technological Opportunities. When technological breakthroughs are achieved (eg stealth technology), the tactical advantage of fielding this technology should be weighted favorably in consideration. The Soviets weight this criterion when they perceive that a military advantage can be gained by introducing new technology (eg. tank reactive armor kits).

Densities of Threat Systems. The threat may develop a more lethal system than a system of ours. However, until that system is proliferated throughout the battlefield to present a prevalent threat, it should not be considered to render a system of ours totally ineffective.

Interoperability with Other Systems. In order to gain the total synergistic benefit of the system to be fielded, interoperability with other related systems (eg C2, fire support, weapon systems) is essential. If a new system will not be interoperable with other related systems, then it maybe useful at the appropriate decision point of an older system, to prolong an older system than go with the new start.

Technology factors weigh heavily in an aircraft's ability to retain a commanding lead in its operational environment. The Soviets have demonstrated an awareness of this relationship and have regularly begun production on new models of equipment in order to capitalize on the advantage technology may give them. The following factors play a significant role in helicopter technology for the near future. They will be applicable for the current systems in production or under consider-ation. The costs/advantages for these innovations could be readily modeled and used to determine desired program characteristics.

Aeromechanics. Technology provides the means for improvements in the following arenas: aerodynamics, maneuverability, aerodynamics performance, advanced digital/optical control systems, advanced flight control systems, and advanced rotor/control system integration.[8] These upgrades would entail considerable costs in terms of modernizing an existing aircraft. Although systems, like the Marine AH-1W Supercobra is being fitted with a new rotor system that incorporates many of these improvements.

Propulsion. Innovations are now possible in compressor drive technology, high temperature component technology, auxiliary thrust improvements, advanced rotorcraft transmissions, and the development of a multipurpose small power unit.[9] Generally these innovations can be readily accomplished, quantified, and have been incorporated into the AH-1 program as it evolved. Costs for modification and qualification can be calculated.

Structures. Research into structures has indicated new approaches to the manufacture of aircraft structures. Refinements have been made in design criteria, structural dynamics, advanced landing gear, the advanced composite airframe program, vibration reduction, combat sustainable rotorcraft, structural integrity verification, advanced wing structures, and advanced swashplates.[10] Retrofit of an aircraft fleet with new materials technology could be considered at Milestone V decision points.

Aviation Electronics. Fewer areas of modern technology have evolved as quickly as in the field of electronics. Aviation electronics has benefited from progress in general electronics. Research in the following areas will soon be incorporated into these aircraft systems: antenna and electromagnetic communications research, cockpit display technology, fault tolerance computer architecture, voice interactive avionics, advanced communications, audio signalling processing, integrated communications, navigation, identification avionics, command and control, threat C3, systems standardization, navigation technology, miniature global positioning system (GPS) transceivers, and artificial intelligence applications.[11] Many of these innovations could be incorporated on to existing airframes with little difficulty, however as aircraft increase in electronic complexity like the UH-60, more effort will be required to determine suitable system interface. An additional problem associated with electronic system integration include power availability and cooling capability. More electronics mean greater demand for power and the ability to cool electronic components.[12] These costs can be captured and used in a decision-making model for product improvement decisions.

Armaments. Technology has been identified and established for improvements in the following areas: fire control and aerial munitions, advanced missile systems, advanced gun systems, guided munitions, artificial intelligence insertion, air-to-air combat, multisensor fusion, maneuverability, closed loop fire control, fire control 21, air-to-air Stinger, and improved lethality Hellfire.[13] This factor is probably one of the most significant in terms of an attack helicopter being able to defeat an adversary. The decisions involving the incorporation of many these systems would be difficult for many of these systems are programs in themselves.

Aircraft Survivability. The threat continually develops systems for which countermeasures are required. Requirements for increased survivability of Army aircraft in the arenas of NBC protection, hardening against laser and other directed energy threats, and the reduction of the aircraft's signature to enemy detection and tracking capabilities are necessary.[14] As with aviation electronics, these systems also compete for aircraft power and cooling capabilities. Aviation Life Support. Parallel to the requirements for aircraft survivability are requirements to ensure crew survivability. Aviation life support technology has advanced in the areas of NBC protection, laser protection, new aircrew restraint systems, microclimatic cooling, escape systems, and respiration systems.[15] Many of these factors can be incorporated into a program without great cost. The cost for aviation life support normally is associated with adding to the aircraft total weight.

Mission Support. New combat maintenance systems concepts, procedures, and techniques have been developed for incorporation into existing programs. Particular emphasis is directed towards improving maintenance procedures.[16] These factors involve little change to the airframe but do involve increased program costs.

Systems Integration. Emerging and projected technologies must be integrated into aviation programs. Man-machine integration, artificial intelligence, digital avionics, battle management systems, crewstation integration, and a plethora of simulation options affect not only existing or proposed hardware considerations but also impact on personnel and training requirements for the force.[17]

Force Structure Requirements. The impact on force structure should be considered in order to ascertain the relative effectiveness of the force structure fielded with the new system versus the existing force structure.[18] The Army's Phoenix model is demonstrating a model's ability to estimate the impact and costs of these decisions.

Aging and cycle rates are other aspects that should be considered. Airlines are becoming particularly sensitive to take-off and landing cycles as a measure of aircraft use. Closely tied to the costs of repair parts and the deterioration of the airframe due to age or number of take-off and landing cycles performed, are rising maintenance costs. Figure 6-2 shows the relationship between cost and use.

PROGRAM COSTS COMPARED TO AGE OR USE

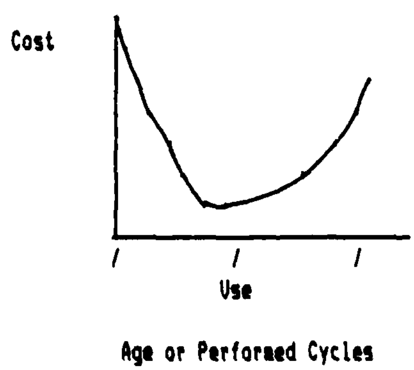

Figure 6-2[19]

Many of the technology factors could be empirically evaluated and a total system approach is the best manner to approach this evaluation. The impact of technology update in terms of their effect on operating weight, power, and cooling can be substantial and contributed to the demise of the Cobra 2000 update. A Multi-Stage Improvement Program approach to aircraft modification better coordinates modification efforts and makes cost calculation simpler.

Politics are an important aspect of any program decision, however, it is the most difficult factor to measure. Political scientists are able to quantify support to some extent but not to the degree that I feel would be useful in our modeling effort.

CHAPTER SIX -- END NOTES

[1] Department of the Army, Army Command and Management: Theory and Practice, (Carlisle Barracks, Pennsylvania: U.S. Army War College, 26 August 1988), p. 11-2.

[2] Interview, F.L. Troutman, 26 January 1989, Materials Control, Trans World Airlines, Inc., Kansas City, Kansas.

[3] FM 22-103, Leadership and Command at Senior Levels, (Washington D.C.: Department of the Army, 21 June 1987), p. 84.

[4] Interview, F.L. Troutman, TWA.

[5] W.A. Stewart and E.S. Warnstein Rapporteur, "RAND Symposium on Pilot Training and the Pilot Career Final Report," (Santa Monica, California: RAND Corporation, December 1970), pp. 124-125.

[6] Interview, F.L Troutman, TWA.

[7] Interview, Larry D.Holcomb (COL, USA), AH-1 Program Manager, U.S. Army Aviation Support Command, St Louis, Missouri, 16 December 1988.

[8] Department of the Army, Army Aviation RDT&E Plan FY 1988-2007, (St Louis, Missouri: Army Aviation Systems Command, FY88), pp. 14-19.

[9] Ibid., pp. 20-35.

[10] Ibid., pp. 36-43.

[11] Ibid., pp. 44-53.

[12] Interview, R. Scott Mair (MAJ, USA), Aeronautical Engineer, APACHE Program Manager's Office, U.S. Army Aviation Support Command, St Louis, Missouri, 16 December 1988.

[13] Army Aviation RDT&E Plan FY 1988-2007, pp. 54-61.

[14] Ibid., pp. 62-79.

[15] Ibid., pp. 80-89.

[16] Ibid., pp. 90-101.

[17] Ibid., pp. 102-119.

[18] ST 25-1, Resource Planning and Allocation, (Fort Leavenworth, Kansas: U.S. Army Command and General Staff College, 15 July 1988), p. 5-3.

[19] Interview, Larry D. Holcomb, AH-1 Program Manager.

CHAPTER SEVEN

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

General

This study was unable to determine the period of usefulness for the Army's attack helicopters based on historical analysis. Life trends could be defined, however a finite period of useful age could not be defined. Within the aviation maintenance community there is not consensus as to when the airframe itself wears out. Some factions say it is when maintenance costs begin to rise and some say it is solely due to structural deterioration.[1] The Army however, in their Army Aviation Modernization Program (AAMP), has finaly defined the useful age of their attack helicopters as twenty years. A telephone interview with a member of the Deputy Chief of Staff for Operations' staff indicated that this period was an arbitrary period borrowed from the Air Force (historically Air Force fighters have demonstrated a useful life of approximately twenty years). This defined period was not a function of any assessment made by the Army. The Army could not ascertain whether or not their existing airframes had reached a point of limited usefulness, either as a function of maintenance reasons or due to utility against the postulated threat. Regardless as to how the period was defined, now defined, it has enabled the Army to formulate a program that provides for a force that should not linger on beyond technical obsolescence nor become degraded due to reliability and maintainability as a function of age. The AAMP has now defined a finite period which now enables system modelers a time period on which to quantify time.

Analysis of the Army's procurement programs, those of sister services, Trans World Airlines Inc., and the Soviet Union has shown that procurement systems are very complex processes. Common to all programs were numerous criteria that would be useful to attempt to quantify. If codified and quantified, a more scientific approach could be made to evaluate aircraft programs. The product of these efforts would be a more scientific basis to determine need and program utility and could therefore be more revealing to Congress.

It is essential that procurement planners and program managers develop an empirical technique to improve the ability to evaluate aviation programs. The function of planning in the past has been to meet POM requirements. Modernization in the Cobra program and initially in the Apache program was accomplished in a piecemeal fashion using block improvements with little regard to long-range goals for the fleet and aircraft useful life.[2]

A total life cycle modernization program can improve a system in planned stages expanding battle capabilities and extending the operational life. The staging will make improvements and apply recently matured technology in an efficient total system approach.[3] MSIP will preclude the shortfalls of the Cobra program in that product improvements will be consolidated and engineered to ensure the adequacy of computer memory, cooling, and electrical capacity.[4]

<u>Discoveries</u>.

The Army Aviation Modernization Trade-off Requirements (AAMTOR)

Study (AAMTOR) is an unrefined prototype decision aid for the Office of the Deputy Chief of Staff for Operations and Plans (ODCSOPS). The process uses the (Phoenix Model) a mixed integer, linear programming model. The Phoenix Model, when refined, will enable force planners to measure the effect of aviation modernization policy.[5]

The U.S. Army Concept Analysis Agency (CAA) is the agency charged with the development of the decision aid. The CAA's efforts in AAMTOR are the most comprehensive efforts toward aiding the Army make complex aviation modernization decisions.[6]

The Phoenix model inputs criteria such as: procurement policies, resources, requirements and costs. Analysis by this mixed integer linear programming model outputs recommendations for fleet size, residual age, and technology mix.[7] Although not all inclusive, the Phoenix model is the "rough draft", on the part of the CAA, towards quantifying those aspects of aviation procurement that can be modeled.

Even in its rough form, the Phoenix model has been received warmly by the ODCSOPS and he has mandated that all Army modernization programs be evaluated using the model. With continued efforts on the part of the other aviation management players, the data used by the Phoenix model will be refined and thus the accuracy of the model improved. The model has already been used to determine several options in regards to aircraft fleet mix and modernization.[8]

Significance to the Field of Study

The Army has procured attack helicopters without any clearly defined concept as to useful life. With the publication of the AAMP, the Army now has a definitive strategy on which to base requirements for the conduct of further research, development, and fielding of new systems. With the introduction of the Phoenix model, force modernization activities now can be evaluated and options formulated and thus a more comprehensive procurement strategy developed. Justification of a program to the legislature or a board of directors will be based on valid operational requirements which may withstand the close scrutiny of those bodies.

RECOMMENDATIONS

Recommendations to the Acquisition Community.

The use of the Phoenix model should be considered in use for decisions made in initial decisions for materiel solutions to MAA identified deficiencies, Milestone V decisions, and charter renewal for program managers. A serious limitation to any ongoing attempt to use a decision aid is that the collateral information required in the decision making process is not being collected in a manner required by the modelers. My investigations indicate that all costs associated with a program are not always attributed back to the program due to the nature of our funding programs. Therefore costs (information) that should be captured in their evaluation of a specific program may be hidden in other accounts.

The Army should take note of the forward attitude that both the Air Force and Navy have in terms of developing a political consensus for a program at the onset. None of the Army documents reviewed indicated the need for such political activity. Practitioners in the Army clearly understood the critical function of politics in the procurement process, however, the Army does not document this process in its procurement documents. Obviously, the combination of a political consensus development strategy and an empirically justified procurement analysis would improve the Army's ability to fulfill its needs. Although the military is legally prohibited from lobbying, a strategy that fits within the framework of acceptable political consensus development need not be manifested by actual lobbying. Rather a technique that provides a comprehensive empirical presentation to key congressional decision-makers early in the evaluation should be considered. As the Air Force and Navy demonstrate, this does not need to be exhaustive or even involve members of the Congress, discussion with congressional staffers early into the decision process is beneficial. After reviewing the evaluation techniques of both sister services, I feel that program evaluation based on a Phoenix model evaluation, could more clearly state our requirements and lessen dependence on a more subjective analysis.

Recommendations for Further Study.

The period of usefulness for its attack helicopters should be based on historical analysis of the fleet, not an arbitrary period adapted from the Air Force. Aviation program managers from the various services belive this structural usefulness is determinable provided the expectations of the user concerning the airframe can be determined. As Dr. Elber indicated, airframes like the Cobra are still structurally useful based on the current mission profile for the AH-1. If the Cobra is to move in to the air-to-air role, the change in flight environment could significantly increase airframe structural stress and therefore effect useful life.

As was discussed in Chapter Three, there is a great deal of complexity to the procurement process requiring activity in several systems. There are common pieces of information in all programs that need to be analyzed. Many of these bits of information can be quantified and probably incorporated into a modeling effort.

The Phoenix modeling effort should be continued and refined. An effort that will effect modeling quality more than any other, would be to improve the quality of information being fed into the model. The original Phoenix model was used after only six months of coordination between the Concept Analysis Agency and the potential model users. The information used was not well refined and formatted and therefore the model was not as accurate as it might have been. More effort is needed to capture better historical information and less assumptions.

CHAPTER SEVEN -- END NOTES

[1] Interview, Dr Wolfe Elber, Director of the Aerostructures Directorate, U.S. Army Aviation Research and Technology Activity, NASA Langley AFB, Virginia, 19 December 1988.

[2] CAA, p. 1-1.

[3] Briefing MSIP "MSIP".

[4] Ibid., slide,"Material Need."

[5] CAA, p. B-1.

[6] Ibid., p. 1-1.

[7] Ibid., p. 1-3.

[8] Tnterview LTC William R. Teufert, Study Director, The Army Aviation Modernization Trade-off Requirements Study, U.S. Army Concept Analysis Agency, Bethesda, Maryland, 13 March 1989.

APPENDIX A

GLOSSARY

(Extracted from U.S. Army FM 1-203 Fundamental of Flight and TM 55-1520-235-10 Operators Manual, Army OH-58C Helicopter)

Antitorque. A method used to counteract torque reaction.

Attitude. The position of a body as determined by the inclination of the axes to some frame of reference. If not otherwise specified, this frame of reference is fixed to the earth.

Autorotation. The action of a turning rotor system by airflow and not by engine power. The airflow is produced by movement through the air.

Collective. The collective is a lever that is controlled in an up or down motion. Movement of the lever up or down will determine the angle of attack and corresponding lift developed by the main rotor system.

Cyclic. The cyclic is a lever that controls movement, primarily in the horizontal axis. Moving the stick in any direction will produce a corresponding movement in that direction as a result of a change in the plane of rotation of the main rotor system.

Dynamic Stability. The property of a body, such as an aircraft or rocket, that causes it, when disturbed from an original state of steady state flight or motion, to dampen the oscillations set up by restoring moments and gradually to return to its original state.

Feedback. The transmittal of forces initiated by aerodynamic action on control surfaces or rotor blades to the cockpit controls.

Flapping. The movement of the rotor blades on an upward (upflap) or a downward (downflap) path during rotation.

Flat Plate Canopy. A canopy consisting of large flat panes of transparent material erected at obtuse angles, in respect to the airframe, to reduce glare from the sun.

Flutter. A vibration or oscillation of definite period set up in an aileron, wing, or the like, by aerodynamic forces and maintained by the aerodynamic forces and by elastic and inertial forces of the object itself.

Ground Effect. The effect of the ground or surface in turning the downwash vortexes, or induced flow from the wings or rotor of an aircraft hovering or flying near it, thus reducing induced drag and increasing lift.

Gyroscopic Precession. A phenomenon in rotating systems that makes all forces react with a movement 90 degrees from the point of force in the direction of rotation.

Heads-up-Display. A device that transfers cockpit instrument information up on to either the canopy surface or a transparent device thus enabling the pilot to continue viewing outside the cockpit environment and yet have access to instrumentation information.

Induced Flow. Flow drawn or sucked in, as the flow induced by the vortex system of a rotor, or the flow of air or mixture sucked into an engine by the action of the pistons.

Lead and Lag. Movement of the rotor blade forward (lead) and aft (lag) of the radial line from the center of the main rotor shaft through the axis of the drag hinge.

Lift. That component of the total, or resultant, aerodynamic force acting on a body perpendicular to the undisturbed airflow relative to the body.

Nap-of the Earth. A technique of flight in which an aircraft is flown in close proximity to the earth to take advantage of terrain masking (concealment). The aircraft is flown without attempting to maintain a consistent airspeed or altitude.

Negative G. In a gravitational field, or during an acceleration, when the human body is so positioned that the force of inertia acts on it in a foot-to-head direction; that is, the headward inertial force produced by a footward acceleration.

Positive G. In a gravitational field, or during an acceleration, when the human body is so positioned that the force of inertia acts on it in a head-to-foot direction; that is, the footward inertial force produced by a headward acceleration.

Rigid Rotor System. A rotor system in which the rotor blades are fixed rigidly to the hub and not allowed to flap or lead and lag. The only action allowed is pitch change.

Semirigid rotor system. A rotor system in which the rotor blades are connected to the mast by a trunnion that allows blades to flap. Pitch change (feathering) is allowed at the hub about the blade grip retainer bearing.

Tail Rotor. The antitorque device of a single-rotor helicopter. Control of this rotor is through the foot pedals.

Tandem Cockpit. A cockpit arrangement in which the aircrew is seated one behind the other.

Wing Stores. Components attached to the wings that are not an integral aspect of the wing for the purpose of producing lift.

BIBLIOGRAPHY

BOOKS

Everett-Heath, John. Soviet Helicopters. London, United Kingdom: Jane's Publishing Company, 1983.

Francis, Philip H. Principles of R & D Management. New York: Amacon, 1977.

Galvin, John, R (LTG, USA). Air Assault: The Development of Airmobile Warfare. New York: Hawthorne Books, 1969.

Gaylord, Edwin H. and Charles N. Gaylord. Structural Engineering Handbook. New York: Mc Graw-Hill Book Co., 1968.

Gregory, Hollingsworth F. The Helicopter. Cransbury, New Jersey: A.J. Barnes & Company, 1975.

Gunston, Bill. An Illustrated Guide to Military Helicopters. New York: Arco Publishers, Inc., 1981.

Habler, Richard, G. Straight Up -- The Story of Vertical Flight. New York: Duel, Sloan and Pearce, 1961.

Kent, James A. Ragel's Handbook of Industrial Chemistry. New York: Von Nostrand and Reinbold Co., 1974

Lyden, Fremont J. and Ernest G. Miller. Planning-Programming-Budgeting. Chicago: Rand McNally Publishing Co., 1972.

Montross, Lynn. Cavalry of the Sky. New York: Harper and Brothers, 1954.

Munson, Kenneth. The Pocket Encyclopedia of World Aircraft: Helicopters and Other Rotorcraft Since 1907. New York: McMillan Company, 1969.

Nolan, Keith, William. Into Laos. New York: Dell Publishing Co., Inc., 1986.

Rasor, Dina. The Pentagon Underground. New York: Times Books, 1985.

Young, Warren R. The Helicopter. Alexandria, Virginia: Time-Life Books, 1982.

The Illustrated Encyclopedia of 20th Century Weapons and Warfare. Vol 1, New York: Columbia House, 1977.

The Illustrated Encyclopedia of 20th Century Weapons and Warfare. Vol 13, New York: Columbia House, 1977.

GOVERNMENT DOCUMENTS

Department of the Army. ALM 31-4754-H1. Acquisition Planning. Fort Lee, Virginia: U.S. Army Logistic Center, 1988.

Department of the Army, The Army Aviation Modernization Trade-off Requirements (AAMTOR) Study, Bethesda, Maryland: U.S. Army Concept Analysis Agency, August 1988.

Department of the Army. Army Command and Management: Theory and Practice. Carlisle Barracks, Pennsylvania: U.S. Army War College, 26 August 1988.

Department of the Army. ALM 31-4784-LC (G), The Life Cycle Model. Fort Lee, Virginia: U.S. Army Logistic Center, 1988.

Department of the Army. Student Text 25-1. Resource Planning and Allocation. Fort Leavenworth, Kansas: Command and General Staff College, 15 July 1988.

Department of the Army. "Army Acquisition Executive (AAE) Policy Memorandum #88-7, Revision of AR 70-1, System Acquisition Policy and Procedures, Washington D.C.: Office of the Under Secretary for Research, Development, and Acquisition, 13 July 1988.

U.S. Army, TRADOC Primer. Army-Fort Monroe, VA: U.S. Army Training and Doctrine Command. April 11, 1984.

Department of the Army. TRADOC Regulation 11-15. Fort Monroe, Virginia: Training and Doctrine Command, 4 August 1986.

Department of the Army. Vietnam Studies: "Airmobility 1961-1971". LTG John J. Tolson, Washington D.C.: U.S. Government Printing Office, 1973.

Department of Defense. Directive 5000.1 "Major and Non-Major Defense Acquisition Programs." Washington D.C.: Department of Defense, 1 September 1987.

Department of Defense. Instructions 5000.2 "Defense Acquisition Program Procedures." Washington D.C.: Department of Defense, 1 September 1987.

Dexter, Benson, H. Composite Components on Commercial Aircraft. Hampton, Va: NASA Langley Research Center NASA TM 80231, March 1980.

Dexter, Benson, H. and Andrew J. Chapman. NASA Service Experience with Composite Components. Hampton, Va: NASA Langley Research Center, Oct 1980.

Drenz, Charles F. U.S. Army Advanced Attack Helicopter Program Summary." St. Louis, Missouri: USADARCOM, 1983.

Farley, Gary L. and Donald J. Baker. In-Plane Shear Tests of Thin Panels. Hampton, Va, U.S. Army Research and Technology Laboratories. May 1982.

FM 1-203. Fundamentals of Flight. Washington D.C.: Department of the Army, 9 September 1983.

FM 22-103. Leadership and Command at Senior Levels. Washington D.C.: Department of the Army, 21 June 1987.

Good, Danny E. ACAP Airframes to Fly in 1984. The ACAP Airframe, Applied Technology Lab, Fort Eustis, March, 1982.

Orlino, Drew, G. and Bruce F. Kay Design and Fabrication of a Composite Rear Fuselage for the UH-60 (Black Hawk). Fort Eustis, Va: Applied Technology Lab, May, 1982.

TM 55-1520-235-10. Operators Manual Army OH-58C Helicopter. Washington D.C.: Department of the Army, 7 April 1978.

U.S. Air Force. TAF 3XX-87-I-A, System Operational Requirements Document, Langley AFB, Virginia: Tactical Air Command, 1987.

U.S. Army. The Army Aviation Modernization Plan. Army-Washington D.C.: Office of the Chief of Staff. 19 May 1988.

U.S. Army. Annex A to the Army Aviation Modernization Plan. Army-Washington D.C.: Office of the Chief of Staff. 19 October 1988.

U.S. Army. Army Aviation RDT&E Plan FY 1988-2007. St Louis, Missouri: U.S. Army Aviation Systems Command. 1988.

U.S. Army, Material Acquisition Management Course Cost Management and Techniques Reference Book. Army-Fort Lee, VA-8480-85-200-C, Washington D.C.: Government Printing Office, 1985

ARTICLES and PERIODICALS

"Apache Inbound." Army Aviation Magazine. Vol. 31, No. 10 (October 15, 1982).

"Armor/anti-armor: National Crisis?" Army Times, 49th Year, vol. 10, (October 17, 1988).

Augustine, Norman, R. "Helicopter Technology and Today's Army." Vertiflite. September-October, 1975.

"Bell's AH-1 Cobra Series." Defense. Vol. 11, No. 5 (May 1980).

Drenz, Charles, F. (MG USA). "Blue Thunder and Airwolf Stand Aside...Here Comes Apache." U.S. Army Aviation Digest. December, 1985.

Griminger, Charles, O. (LTG, USA). "The Armed Helicopter Story Part III". U.S. Army Aviation Digest. September, 1971.

Hirsh, Norman, B. "AH-64--A Total System for Battle." U.S. Army Aviation Digest. July, 1986.

"Lockheed Tries the Rotorcraft Warpath." Rotor & Wing International. Vol. 15, No. 6 (June 1981).

Magnus, R. (CPT USMC). "We'll Soon Need a New Helicopter Gunship." Marine Corps Gazette. May, 1978.

Negrette, Arthur, J. "The AH-1W: Tougher Cobra with a Deadlier Strike." Rotor & Wing International. Vol. 22, No. 9 (September 1988).

Oswalt, John, W. (LTC, USA). "Report on the Roger's Board." U.S. Army Aviation Digest. February, 1961.

Real, Jack G. "Apache Team Meeting." Mesa, Arizona: Hughes Helicopters, Inc., 1982.

Reed, Fred. "Who's Calling the Hardware Shots?" Army Times. April 27, 1987.

RisCassi, Robert, w. (LTG USA). "Army Aviation in the 1980's." U.S. Army Aviation Digest. January, 1986.

"Rotor Winged Aircraft." Army Aviation Magazine. Vol. 31, No. 12 (December 15, 1983).

Shillito, Robert, G.(MAJ, USMC). "The 10-Year Hover." Marine Corps Gazette. September, 1986.

Stockman, Raymond, L. and Willis J. Brown. "AH-64--A Total System for Battle." U.S. Army Aviation Digest. October, 1986.

______. "What the Aerospace Industry is Made Of and Why?" Aviation Week and Space Technology. Vol 116, No 17 (April 26,1982), pg 72.

______. "Rotorcraft Technology Update." Aviation Week & Space Technology. January 19, 1987.

Wagstaff, Bill. "Here Come the KEVLAR Copters." Rotor and Wing. Vol 16, No. 3 (March 1982). pg 65.

REPORTS AND BRIEFINGS

Baker, Donald J. Composite Flight Service Evaluation Program for Helicopters. A Report Prepared for the American Helicopter Society, Washington D.C., May 1980.

Bell Helicopters Textron Inc. "AH-1 Armed Helicopter Evolution," Fort Worth, Texas, 1988.

"Cobra 2000 Briefing." Bell Helicopter TEXTRON. No. VIII (July 13, 1981).

Department of the Army. Briefing, "Apache Multi Stage Improvement Program (MSIP)," Apache Program Manager's Office, U.S. Army Aviation Support Command, St Louis, Missouri, December 1988.

Glomb, Robert. Briefing, "Program Management Overview," Defense Suppression Systems Program Office, Naval Air System Command, Washington D.C.

Huey, J.T. (COL, USA). Briefing to Mr. Robert Ropelewski (Armed Forces Journal), 1 December 1988, "Army Helicopter Improvement Program," U.S. Army Aviation Support Command, St Louis, Missouri.

Pursel, Gary, T. Briefing, "NAVAIR Program Management," Anti-Ship Weapon Systems Program Office, Naval Air System Command, Washington D.C.

Steiner, M.F. Briefing, "Program Management Overview," Air-to-Air Missile System Program Office, Naval Air System Command, Washington D.C.

Stewart, W.A. and E.S. Warnstein Rapporteur. "RAND Symposium on Pilot Training and the Pilot Career Final Report," Santa Monica, California: RAND Corporation, December 1970.

United States Air Force, Briefing, "Fighter Roadmap," Tactical Air Command, Langley AFB, Virginia, 1988.

STUDENT PAPERS AND THESES

Camia, Danta, A. (MAJ USA). "The Evolution of the Advanced Attack Helicopter." (A Master Thesis) Fort Leavenworth, KS: U.S. Army Command and General Staff College, 1975.

Lawson, Albert, P. (MAJ USA). "The Effect of the Concept Based Requirement System on the Corps Support Command's Ability to Sustain AirLand Battle." (A Master Thesis) Fort Leavenworth, KS: U.S. Army Command and General Staff College, 1988.

Throckmorton, Richard, L. (MAJ USA). "Army Attack Helicopters: Can They Survive on the Airland Battlefield?" (A Master Thesis) Fort Leavenworth, KS: U.S. Army Command and General Staff College, 1987.

INTERVIEWS

Interview, Weldon B. Clark, Director of Aircraft Development, Trans World Airlines, Inc. Kansas City, Missouri, 26 January 1989.

Interview, Joseph East, Instructor U.S. Army Materiel Acquisition Management Course, Fort Lee, Virginia, 27 December 1988.

Interview, Dr. Wolfe Elber, Director of the Aerostructures Directorate, U.S. Army Aviation Research and Technology Activity, NASA Langley AFB, Virginia, 19 December 1988.

Interview, Larry D. Holcomb (COL, USA), AH-1 Program Manager, U.S. Army Aviation Support Command, St Louis, Missouri, 16 December 1988.

Interview, R. Scott Mair (MAJ, USA), Aeronautical Engineer, APACHE Program Manager's Office, U.S. Army Aviation Support Command, St Louis, Missouri, 16 December 1988.

Interview, Terry Thompson (MAJ, USAF), U.S. Air Force Tactical Air Command, Langley AFB, Virginia, 19 December 1988.

Interview, F.L. Troutman, Director of Materials Control, Trans World Airlines, Inc. Kansas City, Missouri, 26 January 1989.

Interview, James Vaccia (CAPT, USN), Program Manager F-14 (PMA-241), Naval Air System Command, 28 November 1988.

Interview, William R. Teufert (LTC, USA), Study Director, The Army Aviation Modernization Trade-off Requirements (AAMTOR) Study, U.S. Army Concept Analysis Agency, Bethesda, Maryland, 9 March 1989.

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