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Aeronautical Systems Cost Control

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AERONAUTICAL SYSTEMS COST CONTROL

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AERONAUTICAL SYSTEMS COST CONTROL

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THESIS

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ABSTRACT OF THESIS

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ABSTRACT

Addressed is the control of the rising costs of aeronautical weapon systems; aircraft and missiles with operating regimes within the atmosphere. Specific emphasis is on cost control within the Air Force, however, thoughts and conclusions of a general nature may be applied to the Army and Navy systems acquisition processes and operational procedures as well. Cost reduction possibilities are studied with relation to definition of concept, generation of mission requirements, in-house preliminary design, request for contractor proposals, evaluation of proposals, contractor selection, a buy of a limited number of production articles, testing, and pilot training.

High costs, current attitudes, changing priorities, and level budgets have made the task of developing and procuring weapons of adequate capability in sufficient quantities extremely difficult. The purpose of this study is to identify and document ways to reduce the costs of aeronautical weapon systems to affordable levels.

A historical review of systems' acquisition approaches and operational procedures is made. These are compared, and their advantages and disadvantages assessed. A new planning organization for systems development is presented; and based on study findings, the advantageous aspects of past approaches are incorporated. The organization is detailed including

structure, position within the hierarchy, functional aspects, and size. In addition, innovative management approaches, proven effective and documented in the literature, are incorporated. Finally, specific possibilities for cost reduction are presented.

The body of knowledge assembled in this work has not been fully exploited and utilized. It can be applied to the aeronautical systems' acquisition process and operational procedures of the Air Force resulting in the most capable weapons at the least possible cost. The following recommendations are made:

1. Initiate an exhaustive program within the Air Force aimed at making the cost problem and potential solutions known.
2. Implement an efficient planning and development organization for aeronautical systems.
3. Specifications be improved and used as guidance only.
4. Life cycle costs be considered in the conceptual and development phases of systems.
5. Simplification and standardization be practiced.
6. Contracting methods be improved.
7. Greater use of scale, wind tunnel models and mathematical simulation models be used for some aspects of testing.
8. Simulators replace actual flying for some aspects of pilot training.

9. A select group of public administration and organizational theory personnel be established to improve efficiency in the Air Force.
10. A program be developed whereby selected development engineers are afforded the opportunity to spend ten percent of their time participating in high level systems decision making.
11. Provisions be made for senior decision makers to spend approximately five percent of their time touring development facilities and being briefed on development methods and problems.

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INTRODUCTION

THE PROBLEM OF RISING COSTS

> The principal responsibility of Defense Department managers is to provide the necessary military strength to support the President's strategy for peace--strength, partnership and a willingness to negotiate. The challenge to the Defense Department is to provide this strength in an era of rising prices, shrinking budgets and changing priorities.[1]

This thesis addresses itself to this challenge. Specific emphasis is on aeronautical systems, and cost control within the Air Force, however thoughts and conclusions of a general nature may be applied to the Army and Navy systems acquisition processes and operational procedures as well.[2]

Aeronautical systems costs are rising, not only because of inflation, but because of increased sophistication. Technology has allowed increasingly complex and better weapons to be built. In addition, increased concern for pilot safety over the years has resulted in the use of redundant systems, armor plating, and other safety features which contribute to complexity and cost. Consequently, aeronautical systems costs are rising considerably faster than that caused merely by inflation. In a recent issue of the

Defense Management Journal, Dr. John S. Foster, Jr., a past director of the Department of Defense's Defense Research and Engineering, commented on the problem:

> Within the past twenty years the cost of defense weapon systems and manpower has been rising at more than five times the rate of inflation. The extra money to pay for these rising costs is unavailable because at the same time all the growth in the Gross National Product (GNP) within this same period has gone into the non-defense sector.
>
> The need for national security forces continues to grow with the increasing size and sophistication of the arms of potential adversaries. The reduction of the defense procurement dollars raises the question, how do we get more for less? The answer is not simple, but we must make a strong effort to reach some kind of a solution before we're out of business.
>
> . . . The Defense Department, to continue to acquire weapons systems, must design to a cost, utilize greater standardization and require greater supplier responsibility for field reliability.[3]

Dr. Foster continued, and suggested some possible solutions:

> The key to implementing these new concepts lies in Government and industry management. We must demand more discipline on both sides in controlling costs and that ever present human frailty of trying to acquire those last few percentage points of performance. Cooperative management demands the best efforts of all of us.[4]

High costs, current attitudes, changing priorities, and level budgets makes the task of developing and procuring weapons of adequate capability in sufficient quantities a challenging one indeed.

The current trend of increasing costs and decreasing numbers of systems bought, exemplified by the procurement of the F-111 fighter/bomber and the C-5 transport, has led Dr. Foster to say, ". . .We are entering an era when we cannot compete with our major rivals on numbers and performance."[5] If our national security is not to suffer, the military services must seek and find solutions. If acceptable solutions are not found, the Department of Defense will be forced again and again to choose among buying a small quantity of very sophisticated and costly weapon systems, buying sufficient numbers of less capable systems, or allowing our forces to remain equipped with aging, obsolescent hardware. None of these alternatives are acceptable. Relative to this problem, Senator Barry Goldwater, in a recent talk to the Wings Club of New York said, "The sobering realities are that we have not designed and fielded new air-superiority fighters in the last fifteen years, and we have not added any advanced strategic bombers in the last twenty-two years."[6] The Senator continued to say, "Our world leadership in both military and commercial aviation is in dangerous jeopardy. . . ."[7]

It must be understood that the current situation is critical. The trend of increasing weapons system cost must be arrested. Dr. Foster has said, "We can no longer continue to buy adequate qunatities of needed weapons if the unit procurement and lifetime costs of those weapons continue to soar."[8] It is imperative that a solution to the problem of rising systems cost be found. Congress has been scrutinizing the actions of the Department of Defense in increasingly greater detail in recent years, both directly, and through the use of the General Accounting Office. Congress has informed Dr. Foster that the Taxpayers will not pay an open-ended bill. If costs per unit are high, the public--through the Congress--will restrict the numbers of units; and already numbers of essential systems are barely marginal.[9] The Honorable Kenneth Rush, Deputy Secretary of Defense, has stated the systems acquisition dilemma very succinctly:

> . . . The pressure on the Department of Defense to reduce expenditures is strong, partly because of poor performance on several large programs. We see new pressures on Defense to maintain the current world wide posture in a time of rapidly expanding technological capability without creating significant new demands on financial resources. Over the past few years, except for Vietnam-related costs, we have received almost no real increase in financial support. Stated in constant dollars, we have been living with a level budget. I see little reason for us to expect a change during the next decade.[10]

There is a way out of this dilemma--a way to get both adequate quality and sufficient quantities of weapon systems at an affordable cost. The objective of this thesis is to develop an organizational plan for Air Force aeronautical systems design in the conceptual phase with the supposition being to reduce systems cost.[11] In addition, implementation and operational aspects of the organization are discussed. System specifications, standardization of components, life cycle costs, contracting methods, simulators for pilot training, and weapons carriage certification testing are also considered in relation to their impact on costs.

SYSTEM SOPHISTICATION AND COMPLEXITY

Sophistication, and its attendant complexity, is a major cause of increased weapons' costs. Sophistication is generally attributed to advances in technology by the layman. While Technology advances have made increased sophistication possible, four general areas can be stated as the actual cause: (1) a necessity to counter the threat; (2) operational reliability; (3) pilot safety and aircraft survivability considerations; and (4) unnecessary refinements.

The Air Force Chief of Staff, General George S. Brown, in a recent exclusive interview with Alan Horton of Scripps-Howard Newspapers said in response to a question, "Weaponry has become more sophisticated because defenses have become more complicated."[12] Each new weapon built is designed to defeat a threat. If we as a nation desire to continue the policy of being militarily strong, using deterrence as a means for peace, then a weapon must be developed to counter each new threat. In fact, it is wise and desirable to anticipate new threats, and to be prepared in advance of their operational readiness.

To constitute a truly deterrent force, military weapons must be developed to be used. That is, the military force must be ready at any moment to respond to aggression anywhere in the world. Consequently, operational reliability is given serious consideration. For instance, aircraft developed since the early sixties have built-in test equipment. By interrogating this equipment, in maintenance or prior to a mission, any malfunction aboard the aircraft is immediately noted. Modularization allows the faulty component to be removed and replaced in a matter of minutes. This sort of equipment is computer based and costly, but mandatory for quick response.

Concern for pilot safety and aircraft survivability have resulted in the use of redundant systems, armor plating, and other safety features which contribute to complexity and cost. However, there is a trade-off here. The ability to recover a damaged aircraft results in a considerable savings.

Sophistication and complexity, resulting from unnecessary refinements, presents the development engineer with a challenging area for possible cost reductions. Unnecessary refinements occur throughout aeronautical systems, and are the result of years of precedents. Specifications, for instance, have been modified over the years, incorporating general rules, many of which are unnecessary constraints for specific purpose systems. Also, engineering thinking has been conditioned to strive for the best possible performance, often without regard for cost implications. Of this problem, Jacques S. Gansler, the Pentagon's Assistant Director (Electronics), has said, ". . . demands for increased performance have led to equipment sophistication and, therefore, increased costs."[13] He attributes part of this problem to the requirements process by saying, "Uncertain of exact needs, we frequently err on the safe side, i.e., ask for maximum potential performance."[14] While still committed to the development of superior weapons, engineers must be indoctrinated to be constantly aware of cost implications during the conceptual design of aeronautical systems, thus avoiding small, costly performance increases. Cost must be elevated to a principal system design parameter. The engineering attitude of, "We've always done it that way," can no longer be tolerated. Admiral I. C. Kidd, Jr., Chief of Naval Material, stressed the need for innovation by saying, "The old ways of doing things are no longer good enough to meet the current budgeting and technical stresses placed upon us. We must seek out and implement new ways that will provide us with the efficiency and economy we need."[15] In any successful cost reduction effort, the Air Force must reevaluate the majority of past practices in aeronautical systems design, acquisition, and operation.

THE DEFENSE BUDGET

In recent years, the Department of Defense's share of total Federal spending has been declining, while, since 1965, there have been tremendous increases for non-military functional categories such as education and manpower, health, and income security.[16] With regard to the current status of the defense budget, the Secretary of the Air Force, John L. McLucas, has said, "No matter what yardstick one uses, percent of Federal budget or percent of Gross National Product, defense spending is at its lowest point in real terms--people and hardware--since the Korean War."[17]

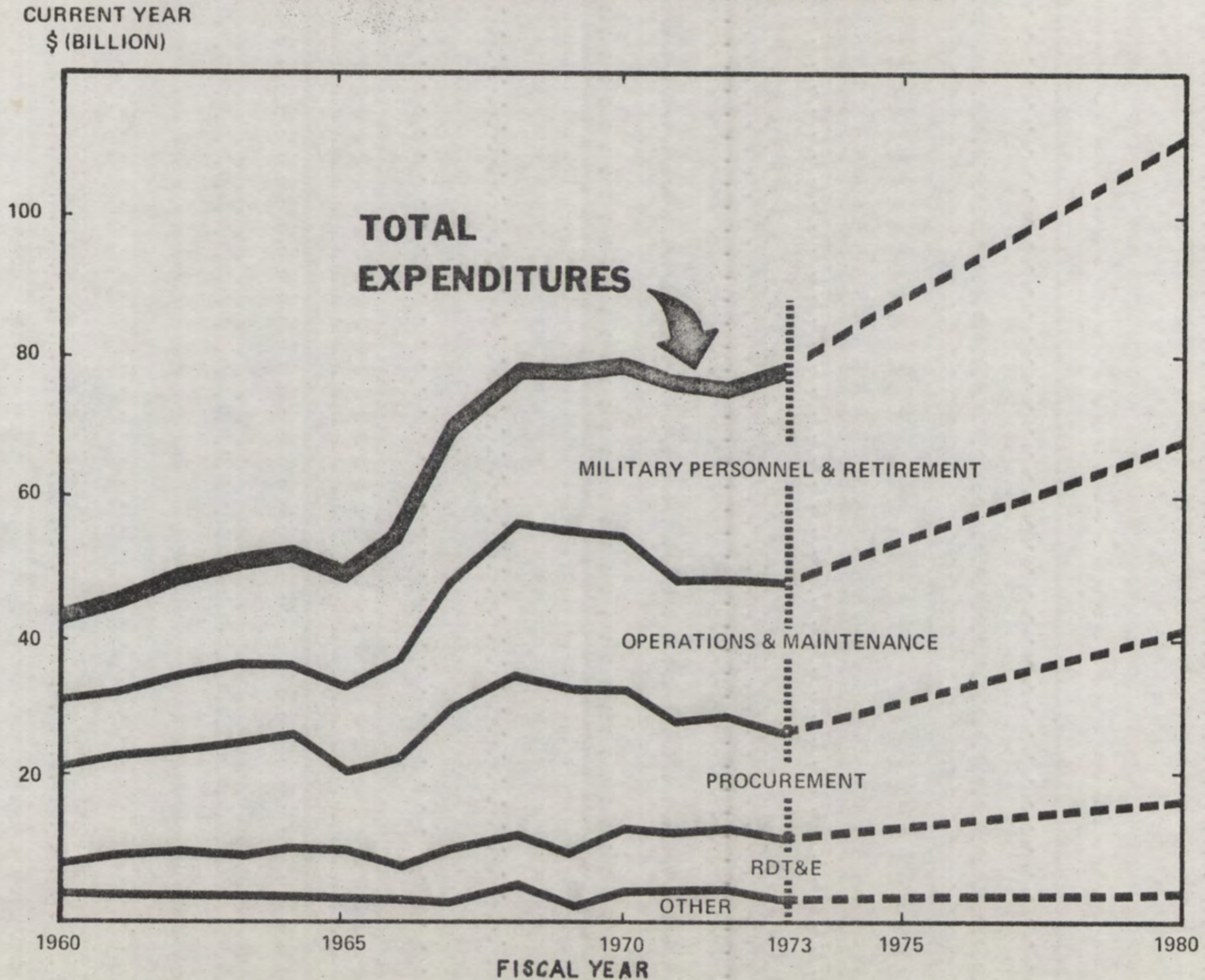
Predictions of the levels of defense spending for the next decade are not encouraging. The most optimistic predictions are for a level budget when the loss of buying power due to predicted inflation is considered. In actuality, however, the levels will more likely decrease, if peace prevails.

Defense budget predictions for the next seven years are quantified in a preliminary study accomplished by the Department of Defense's Defense Research and Engineering.[18] The study makes three key assumptions: (1) that force levels would stay generally constant at the currently planned levels; (2) that the Department of Defense will attempt to maintain a modern force whose average age is half the system lifetime; and (3) that inflation will be held to current levels. The study includes a projection of the Gross National Product, and a projection of government spending. From this is made an allocation for the defense budget based on past trends and projected pressures. The budget is then divided into the usual categories of manpower, procurement, and operations and maintenance.

The Gross National Product is estimated to be $2 trillion in 1980. Non-defense expenditures are projected assuming that the historic growth rate would continue, generally paralleling the Gross National Product growth. This results in about $400 billion non-defense spending annually by 1980. Future defense expenditure estimates result in a $112 billion budget in 1980.

Defense expenditures from 1960 to 1980 by category are shown graphically on Figure 1. It is expected that

Fig. 1. **DEFENSE EXPENDITURES 1960-1980**



military personnel and retirement costs will continue to increase, reaching forty percent of the total budget by 1980. Operations and maintenance costs are expected to increase to about twenty percent of the defense budget. This leaves a maximum of only forty percent for investment in procurement, research and development, and "other" items; such as military construction and military assistance to other countries. The dollar figure increases, depicted by the upward trend of the dashed lines on Figure 1, should not be interpreted as sources of comfort. The Department of Defense study states that the total estimated dollar increases between FY 1973 and FY 1980 will be consumed by anticipated inflation. In other words, the $112 billion budget in 1980 will be identical in purchasing power to the FY 1973 budget of $83 billion. Very little, if any, growth in purchasing power is expected in this decade. It is more likely that actual expenditures will be less than predicted, if peace prevails.

PURPOSE OF THE STUDY

The purpose of this study is to identify and document means to reduce Air Force aeronautical weapon systems costs to affordable levels. If this is not accomplished, national security will suffer.

Recent Air Force attempts to modify the systems acquisition process to reduce costs have met with only moderate success. However, by building on these initial attempts, it is hypothesized that an organizational plan and method of operation for conceptual Air Force aeronautical systems design can be developed which contributes to systems cost reduction. In addition, some aspects of cost reduction beyond the conceptual phase are treated. These may not necessarily fall within the purview of the developed organization, but are considered in an attempt to consolidate as much of the current knowledge as possible on cost reduction possibilities into one document.

AIR FORCE SYSTEMS ACQUISITION

Within the Air Force, the systems acquisition process as it is now structured, is inefficient. Functions are scattered, ineffectual, and mired in the bureaucracy. As a result, system acquisition is time consuming and costly. However, three recent attempts to restructure the process for efficiency have met with some success, but more importantly, have indicated the type of organization and method of operation that could reduce the costs of systems acquisition substantially. A planning organization, with conceptual design capability and having decentralized decision authority with direct access to Air Force Headquarters and the Department of Defense, would reduce the time and cost required in the systems acquisition process considerably.[19] Additionally, all of the conventional functions of conceptual design need to be reevaluated with the supposition of reducing cost.

Precedents within and without the conceptual phase of systems acquisition have been increasing the cost of weapon system acquisition. Specifications are overly constraining and need to be improved. Non-standardization contributes substantially to logistics costs. Consideration must be given to the cost of operations and maintenance, that is, life cycle costs. Contracting methods used are not as effective as some recently tried, such as warranty contracting. Testing is excessive, and too little use is made of simulators for pilot training.

This multi-faceted problem, however, it not insurmountable. Only recently has any real emphasis been placed on holding cost down during the conceptual design phase. In the past, all design work was accomplished prior to considering cost. Recent cost reduction efforts, such as the design techniques used in Fairchild's Republic Company A-10 close support aircraft, the prototyping concept, competitive fly-offs, and innovative contracting methods, have given cause for hope.

In speaking about the A-10 close support aircraft program, Edward G. Uhl, President of Fairchild Industries, Inc., says:

> Over the past few years the defense procurement system has been under fire from all sides. As a result, we have had a complete "soul searching," both in industry and in the Department of Defense, and made considerable improvements. . . . We have a more orderly process incorporating the building of prototypes, having a fly-off between aircraft, and contracts that call for "design to cost" and containing built-in milestones that must be demonstrated before the program can proceed.[20]

Mr. Uhl feels that the defense/industry team has, in the case of the A-10, developed a logical procurement and contracting system that will preclude many of the mistakes that have been made in the past.

In relation to efficiency of operation, there continues to be discussions of the question of whether the government should produce what it needs. The economist's answer is generally that it doesn't matter who produces what the government uses; it only matters that the government pays the bill through taxation. The author does not suggest that the Department of Defense or the Air Force begin building aircraft, but it has been the author's experience that an in-house organization capable of conceptual weapon systems design and describing in detail to a contractor what it is the Air Force needs, results in considerable savings of money and time, thus increasing efficiency.

RESEARCH STRATEGY

This research is generally descriptive in nature, and relies heavily on published works and interviews in the area of aeronautical systems cost control. Recent attempts at cost control, however, through organizational concepts and methods of operation, standardization, and new contracting methods, form somewhat of an empirical base to build upon.

Within the Air Force, three approaches to the conceptual phase of systems acquisition have been used over the past ten years. These are objectively compared against each other, and their advantages and disadvantages assessed. A new organization is developed; and based on the findings, the advantageous aspects of these past approaches are incorporated. Presented is an attempt to show savings based on an in-house design capability. The developed organization is detailed including structure, position within the hierarchy, functional aspects, and size. In addition, innovative management approaches, proven effective and documented in the literature, are incorporated.

Applicable concepts, theories, and principles relating to systems cost reduction, both in the conceptual phase of the acquisition process and beyond, are treated. Centralized and decentralized decision authority are compared based on past Air Force practice. The impact of specifications on cost are reviewed and improvements suggested. The benefits of standardization are assessed. The need for life cycle costing is determined. Various contracting methods are compared, advantages and disadvantages delineated, and improvements suggested. Testing practices, and the use of simulators as these relate to possible system cost reduction are discussed.

RESEARCH TECHNIQUES

The method of operation of the developed organization is based on comparison and evaluation of three distinctly different approaches which have been used in the past. Assessment of these is through use of published data, interviews, and experience of the researcher. Organization efficiency is compared by utilization of proxies such as time spent to bring selected systems from idea to contract for production. In-house conceptual design and planning capability of past organizations is determined studying the ease with which the transition is made between the in-house and contracted work. That is, the organization's ability to develop an acceptable Request for Proposal is determined by the number of questions contractors had upon receipt of the Request for Proposal, and the number of design iterations required to select a contractor for system production. For instance, a poor Request for Proposal results in unacceptable contractor designs which requires another Request for Proposal, and another set of contractor designs, all of which must be evaluated. This results in considerable unproductive effort, lost time, and schedule slippage. To be certain time and design iterations spent on different systems truly represent the capabilities of the organization being studied, and are valid and reliable comparison criteria, a check is made to determine any external influences such as priority considerations, unforeseen technological problems, political motivation, budget changes, and mission requirement revisions.

Data on centralized and decentralized decision authority is obtained through use of the interview method. Assessment of centralized and decentralized decision authority is made by comparison to each other. Compared is length of time to secure decisions, and adequacy of decisions. The literature and experience of the researcher are used to assess and suggest improvements in the current use of specifications. Contracting methods are compared against one another using data from documented analyses. Documentation and experience of the researcher (example cases) are used to assess savings possibilities relative to standardization, life cycle costing, testing practices, and the use of simulators.

With the exception of published data, structured interviews constitute the basic methodology used. Bias of the interviewees is minimized through use of carefully developed questions. Key people are interviewed who were employed in organizations utilized by the Air Force in the past. Interviews consist of questions relative to communications and in-house capability.

ASSUMPTIONS AND LIMITATIONS

The study assumes that aeronautical weapon systems will continue to be needed for national security, and the necessary resources will be available for production and operation. It assumes that the government and industry structures and relationships will remain essentially as they are now.

At this point, some limitations of the research and conclusions should be highlighted. The method of operation of the organization is developed based on analyses of the operational methods of three past Air Force organizations. It combines the best attributes of all the past approaches. In addition, the developed organization incorporates some recently documented, proven, innovative management concepts; but it may not be the best possible solution.

Complete analyses of specifications, standardization, life cycle costing, contracting methods, testing, and simulators are studies beyond the schedule and budget limitations of this work, but are given cursory treatment here to point out areas, other than organization and method of operation, that contribute to aeronautical systems cost reduction. To reduce systems cost significantly, all should be considered together. Finally, the magnitudes of possible resource savings are presented where obtainable, however the determination of a single cost reduction percentage, considering all facets of the systems acquisition process, is not possible within the scope of this effort.

FOOTNOTES

[1]These are the words of Leonard Sullivan, Jr., Director, Defense Program Analyses & Evaluation, as stated in "Comment," Defense Management Journal, Vol. IX, No. 3 (July, 1973), p. 1.

[2]Aeronautical systems are defined as those aircraft and missiles which operate in the atmosphere. Ballistic missiles and spacecraft are excluded, but general thoughts and conclusions may be applied to the acquisition of these. The systems acquisition process, as it is used in this paper, is defined as the general procedure followed to procure a weapon system. It includes definition of the concept, generation of the mission requirements, Air Force in-house preliminary design, requests for contractor proposals, evaluation of proposals, contractor selection, a buy of a limited number of pre-production articles, and testing. In addition, consideration of ownership costs (life cycle costs) during this preproduction phase are also included. That is, consideration is given to reliability of components, ease of maintenance, etc.

[3]John S. Foster, Jr., Defense Management Journal, Vol. IX, No. 3 (July, 1973), p. 4.

[4]Ibid., p. 5.

[5]John S. Foster, Jr. and Leonard Sullivan, Jr., "Impact of the Problem on the Military/Industry R & D Outlook." (An address before the Armed Forces Management Association/ National Security Industrial Association Symposium: Cost--A Principal System Design Parameter, Washington, D. C., August 16-17, 1972.)

[6]"Goldwater on Defense," Aviation Week and Space Technology, November 12, 1973, editorial page.

[7]Ibid.

[8]John S. Foster, Jr. and Leonard Sullivan, Jr., op. cit.

[9]Ibid.

[10]Taken from an address by The Honorable Kenneth Rush, Deputy Secretary of Defense, "The Problem." (An address before the Armed Forces Management Association/National Security Industrial Association Symposium: Cost--A Principal System Design Parameter, at Washington, D. C., August 16-17, 1972.)

[11]The conceptual phase, as used here, is defined as all the steps of the systems acquisition process (outlined in Footnote 2) up to and including contractor selection.

[12]Robert N. Ginsburg, Air Force Policy Letter For Commanders, AFRP 190-1, Washington, D. C., September 15, 1973.

[13]Jacques S. Gansler, "Acquisition Objective Changes from One of Sophistication to Reliability at Lower Cost," Defense Management Journal, Vol. IX, No. 3 (July, 1973), p. 3.

[14]Ibid.

[15]I. C. Kidd, Jr., "Happiness Is Quality and Cost Effectiveness," Defense Management Journal, Vol. IX, No. 3 (July, 1973), p. 33.

[16]Congress and the Federal Budget, Government Finance Brief No. 23, New York: Tax Foundation, Inc., September, 1973, pp. 3-4.

[17]Robert N. Ginsburgh, Air Force Policy Letter For Commanders, AFRP 190-1, Washington, D. C., October 1, 1973.

[18]John S. Foster, Jr. and Leonard Sullivan, Jr., op. cit.

[19]Decentralized decision authority, as used here, means decentralized in the conceptual design organization, and not in Air Force Headquarters or the Department of Defense.

[20]Craig Powell, "A-10," Government Executive, Vol. 5, No. 11 (November, 1973), p. 15.

CHAPTER II

THE NEED FOR WEAPON SYSTEMS

IS THERE A NEED

The question, why build weapons at all, is justified, but not easily answered. From the beginning man has sought peace, but war has been his legacy. This should not be construed to mean that peace should not be sought, but history indicates it is indeed difficult, and it is getting increasingly so. War has greatly increased in frequency and intensity in this century. "Since World War II there have been 12 limited wars in the world, 39 political assassinations, 48 personal revolts, 74 rebellions for independence, 162 social revolutions, either political, economic, racial or religious."[1]

PUBLIC VIEW

It is fashionable today to criticize science. It is distressing, however, that the present climate of anti-science is not producing genuine criticism, which is greatly needed, but only critical gestures which are vague like back-to-nature modes of dress and life styles. None of this has any effect on what is actually happening. Scott Edwards, Associate Professor of Political Science at California State University, states:

> A mere posture of opposition runs into a perfect triangle of contradictions. This was evident from the first in the youth movement. Electronics was bad when applied to weaponry or suburban gadgetry, but good when applied to the amplification of rock music.[2]

Contradictions like these between what people say and the real tendency of their actions are common enough, especially among the young. They would hardly be worth mentioning, except they point out a very real and growing problem which is very well stated by Lt. Gen. Edmund F. O'Connor:

> Since WW II, a whole generation of Americans has grown up experiencing no real threat to our homeland. Although large numbers of men fought in Korea and Vietnam, those wars posed no physical threat to the fabric of American life at home. This security derived from the nuclear umbrella which we fashioned and bought with billions of defense dollars. The deterrent has worked as it was designed to do and has brought safety to the United States. Many people are now beginning to take this security for granted without realizing the resources required to sustain it. We cannot continue to provide this protection unless there is a willingness, and a will, to maintain it.[3]

This problem has also been stated by Senator Barry Goldwater in relation to the nation's airpower:

> . . . airpower has been the principal deterrent to worldwide nuclear war. But the unfortunate paradox of that magnificent achievement is that airpower's success has been so effective that many people have gradually lost their appreciation of the urgency and need for continuing effective defense.[4]

We must not take defense for granted. We must not become anesthetized to the true dangers of the situation.

Concern about the so-called "arms race" by the public presents an additional problem for the military.

However, it has been the Soviets, and not the United States, that created this problem. With reference to the development of the B-1 bomber, John G. Hubbell says:

> . . . honest debate won't find the United States accused of launching a new round in the arms race. The undeniable fact is that, during the past decade, it was the U.S.S.R. -- alone -- that kept the arms race alive by proceeding with history's mightiest arms build up. Now, having assured themselves of superiority over us in numbers of ICBMs, ballistic missile submarines, and deliverable nuclear megatonnage, the Soviets insist that they will improve the quality.[5]

The possibility of returning to a simpler life as suggested by the young, in which science plays a much reduced role, does not exist. We continue to rely on science and technology every moment of our lives. We in America are continually being challenged by foreign powers, and must remain strong to maintain a base from which to bargain. We must be ready, but we must also be constantly aware of the awesome power of weapons; and they must be employed wisely.

PEACE THROUGH DETERRENCE

The fact that the United States has maintained a strong military force in the past is a key reason why peace has prevailed on American soil. This fact can be no more clearly emphasized than it was during the Cuban Missile crisis. For thirty days and nights, the Strategic Air Command kept a substantial percentage of its nuclear weapon equipped B-52 bombers on airborne alert within view of the U.S.S.R.'s air-defense radars, until Soviet nuclear missiles were removed from Cuba. If superior strength and a willingness to fight had not been clearly evident to the Soviet Union, nuclear missiles with targets in the United States, would have been emplanted within ninety miles of our shores. Secretary of Defense, James R. Schlesinger emphasizes:

> A position of strength is essential whenever one bargains with others whose interests and objectives are different from or opposed to our own. Collective action is indispensable--as well as access to the resources necessary for bargaining purposes.[6]

The strength of the United States has prevented nuclear war for twenty-eight years, and it can continue to do so--it must do so. If the United States loses this deterrent, it will be at the mercy of those who do not share our view of life, liberty and freedom for all. The Honorable Kenneth Rush, Deputy Secretary of Defense, aptly sums up the need for deterrence saying:

> We live in a world where times are changing and the hopes for a decade of peace after the President's successful visits to Peking and Moscow seem more attainable. I share these hopes as I know all of you do. Furthermore, I believe that these agreements were possible because the United States is strong. If we cannot stay strong, further agreements may not come to pass. I am concerned that the hopeful atmosphere generated by these talks and the Strategic Arms Limitation Treaty and Agreement does not result in a decreased willingness to support an adequate level of defense expenditures, as weakness will only undo past progress.[7]

THE TRIAD: MIXED FORCE DETERRENT

The Triad consists of manned aircraft, missile launching submarines, and intercontinental ballistic missiles. A mix of mutually supporting strategic forces is essential to provide: (1) assurance that a technological breakthrough against any one element will not negate the effectiveness of the entire force; (2) a hedge against widespread failures on any element due to unanticipated nuclear weapons effects; and (3) a compounding of the enemies problems in attempting to defeat or defend against U. S. forces. Robert C. Seamans, Jr., a past Secretary of the Air Force, says of the Triad:

> To anyone contemplating an attack on the United States, a deterrent that includes bombers as well as land-and sea-based missiles poses problems not easily solved. He can't time a surprise attack to hit all these forces simultaneously, and an attack on any of them would warn us to launch the others.[8]

The manned aircraft provides the most flexibility of the three elements making up the Triad. Unlike ballistic missiles, they can be launched and then recalled. Submarines are slow and must depend on being stationed at the trouble spot at the outbreak of hostilities. Aeronautical weapons play a very vital role in the Triad.

THE MISSION

America's commitment to the security of allies is worldwide. This extends, through formal agreement, to more than forty nations. The role of the Air Force in this environment is to develop, provide, and employ the aerospace power the United States needs to insure its defense at home and meet its security commitments abroad. Wherever and whenever conflict might occur, the Air Force must be qualitatively second to none. The Air Force must be prepared to act in concert with allied air, army, and naval forces. General Brown, the Air Force Chief of Staff has said, ". . . freedom, the security and welfare of America and other free nations around the world depend on the Air Force to a greater extent than is generally realized."[9] General Brown continued to say:

> In assessing our current posture, it is important to avoid an impression of a static air force. We are constantly evolving. In fact, the dynamic quality of the Air Force accounts for many of our past achievements and is the basis for my confidence in the future. The size of the Air Force has changed with world events. We are now adjusting the force to a revised international situation. . . .[10]

The United States and the Air Force must continue to be dynamic. A country which keeps its technological momentum and discovers new ways to provide more security within its limited resources will have an edge.

POTENTIAL ADVERSARIES

For the past three decades, the maintenance of a strong deterrent force in the United States has prevented nuclear conflict. A conflict, as Dwight Waldo describes it, "of a type which would annihilate a sizable part of humanity immediately and much (some say all) of humanity ultimately, certainly destroying 'civilization as we know it'."[11] We can not afford to allow this deterrent force to deteriorate. Senator Barry Goldwater explains, "strategic nuclear war has not occurred, but that threat has not diminished. Just because our deterrent forces have been successful doesn't mean they can be reduced. . . ."[12] In fact, the need for national security forces--forces for deterrence, and forces for battle, if necessary--is growing with the growing size and sophistication of the arms of potential adversaries.

Other than the United States, the great powers in the world are the Soviet Union, Red China, Western Europe, and Japan. Depending on future circumstances, there is the possibility that any of these could engage in conflict. The need for land, the desire to control the dwindling earth's resources, or merely an aggressive charismatic leader could plunge the world into a violent encounter. At this very moment, states the retired U. S. Army General Maxwell D. Taylor, "There is an expansion of the Soviet fleet in the Mediterranean and Southeast Asia with the desire to control the oil producing countries."[13] Further discussion of potential adversaries here will be limited to the Soviet Union and Red China.

THE SOVIET UNION

The Soviet Union has been continuously engaged in an aggressive build-up of their armed forces. Senator Barry Goldwater has said, ". . . while we have been relying on airplanes designed well over a decade ago, the Soviet Union has been passing us in aircraft design, development, and production and performance."[14] They have continuously encouraged students to enter the field of aeronautics, and increased production facility floor space. This trend is expected to continue. The Chairman of the Joint Chiefs of Staff, Admiral

Thomas H. Moorer, said to the House Foreign Affairs Committee recently:

> The capability of Soviet/Warsaw Pact forces as they exist today is significant. For the future, this capability will improve as a result of vigorous efforts to develop new weapon systems. The Soviet Army has great mobility and firepower now. New equipment and ammunition coming off production lines will make it even more powerful. The air threat will increase due to the introduction of new aircraft and weapon systems. New fighter aircraft are expected to enter the force, which will enhance their ground support capability.
>
> Ongoing Soviet naval construction and modernization programs evidence qualitative improvements to platforms, weapon systems and sensors, with emphasis on ASW (antisubmarine warfare) multipurpose combatants. Consistent with these trends, the Soviet Union recently launched its first aircraft carrier, which will probably be V/STOL (vertical and/or short take-off and landing) -- equipped.
>
> The Warsaw Pact military capabilities are indeed formidable. . . .[15]

In addition, "The Soviet Union is believed to be five years ahead of the U. S. in deployment of ocean surveillance satellites and is routinely using such photo-reconnaissance spacecraft to monitor the location of the U. S. fleet as well as to photograph shore facilities."[16]

All the furor over cost growth has obscured the very real threat of the Soviet military strength. It is an enormous military establishment with an Air Force larger than that of the United States. The Soviet Union has more missiles, as the Strategic Arms Limitation Agreement permits them, and their warheads are far more powerful than those of U. S. missiles. The Soviets are working toward a vastly superior strategic missile force. They have reached qualitative parity with U. S. military forces in general, and lead in some areas.

The question arises, Why are the Soviets engaged in this incessant arms build-up? What are their motives and goals? Senator Barry Goldwater expressed these concerns when he said, "This enormous momentum of the Soviets is what bothers me most. Why are they moving ahead so strongly?"[17] The answer to these questions is not immediately available, however their implications cannot be ignored. In a speech at the Bolshevik Party Anniversary meeting in Moscow on July 13, 1973, CPSU Central Committee Polítiburo member and Central Committee Secretary Mikhail Suslov said:

> Comrades, noting the positive changes in the international situation, our party naturally does not forget that these changes have been achieved as a result of the sharp struggle with the forces of imperialism. At the present time, the resistance to the easing of international tension still has not been completely overcome.
>
> The idealogical struggle, in which there is no peaceful coexistence between socialism and capitalism and cannot be, is particularly acute.
>
> Under the great banner of Leninism, under the leadership of the party of Lenin, the Soviet people are marching forward toward new victories of communism.[18]

The Soviet Union has not altered its goal of total world conquest for Communism. This is an integral part of the Communist doctrine.

RED CHINA

In the years since the fall of China to the Communists, there has been a steady relentless preparation for all-out war with the free world. Though the living conditions of the 800 million or more people of Red China are still basically like the nineteenth century, they have made remarkable progress in the production of weapons for war. Concerning Red China's potential and purpose, Victor Petrov said in 1967,

> China does possess all the prerequisites for being or becoming a world power. Communist China's economic growth is evident and has been on the rise. With or without Soviet help, she will be progressing toward her avowed goal of reaching the industrial level of the other major powers of the world . . . a giant, for decades half-asleep, sheepishly watching the rest of the world go by on the path of technological progress. This giant has apparently been awakened.[19]

Red China is definitely on its way to becoming a world power, but the design for the use of this stature is not peace. Within one year after the take-over of China, Communist leaders started the war in Korea. They have since supported the war in Vietnam and have traveled to several countries in Africa and the Middle East seeking to aggravate internal subversion and "wars of liberation." The Chinese insist that the world can be captured only by force of arms and violence. That force of arms is available now that China has developed, and successfully exploded, a nuclear weapon.

Dr. David Inglis wrote in the February, 1965, Bulletin of the Atomic Scientists regarding this threat:

> Our concern should anticipate at least two decades ahead. In such a time the large human and material potential of an upsurging China constitutes a nuclear threat so vast that no effort should be spared to anticipate this threat.[20]

COMMUNIST DOCTRINE

The split between Soviet and Chinese Communists is over an interpretation of Communist doctrine. The Chinese insist that the world can only be captured by force of arms and violence. The Soviets prefer to believe that the free world can be captured by the relatively limited violence of internal subversion. The Soviets, however, are not opposed to the use of violence to accomplish their goals of total world conquest.

Total world conquest is an integral part of the Communist doctrine. Without the total destruction of the capitalist system the basic goal of Communism could not be attained, that is, the changing of man's nature by the complete change of his environment. According to Communist doctrine, as long as capitalism exists in the world, it continues to infect man's environment and prevents him from being a creature that loves to work and shares his wealth equally with his fellow man.

BRIDGING THE MILITARY/PUBLIC GAP

Secretary of Defense Schlesinger has established a policy to keep the American people fully informed about matters of national defense. With reference to this policy, Secretary of the Air Force, John L. McLucas says:

> The public has to have a balanced perspective about where defense fits into today's world, about where we're going, about the problems we face, and what we're going to do about them.[21]

With regard to the improvement of military/industry credibility before the public and Congress, Admiral I. C. Kidd, Jr., suggests:

> Credibility can be achieved principally through the exercise of collective conservatism--conservatism in our estimates, conservatism in our agreements with each other, conservatism in resisting "gold-plating," and conservatism in promises of performance, price and delivery schedules. If we can progress to the point of fulfilling these conditions, we shall establish credibility not only with the public and Congress but also, incidentally, with each other. As a consequence of an aura of conservatism and thus credibility, we will find a greater willingness within the Congress to provide the necessary dollars to buy what we need to do our job for the taxpayers.[22]

In the interest of national security, the military and the public must not underestimate the strength of the competition. Changes are needed, but must be accomplished with complete knowledge of the situation.

FOOTNOTES

[1]"Is Insurrection Brewing in U. S.?", U. S. News and World Report, Vol. LXIII, No. 26 (December 25, 1967), pp. 33-35.

[2]Scott Edwards, "ANTISCIENCE: The Legacy of the Counterculture," The Humanist, Vol. XXXIII, No. 4 (July/August 1973), p. 10.

[3]Lt. Gen. Edmund F. O'Connor is Vice Commander of the Air Force Logistics Command. His words were taken from his article, "Preserving the Peace," Astronautics & Aeronautics, Vol. XI, No. 11 (November 1973), p. 67.

[4]"Goldwater on Defense," Aviation Week and Space Technology, November 12, 1973, editorial page.

[5]John G. Hubbell, "Shall We Build This Superbomber?", Reader's Digest, December 1972.

[6]Stated at a meeting of the AFL/CIO Constitutional Convention in Bal Harbour, Florida, on October 18, 1973, as reprinted in Robert N. Ginsburgh, Air Force Policy Letter for Commanders, AFRP 190-1, Washington, D. C., November 1, 1973.

[7]Taken from an address by the Honorable Kenneth Rush, Deputy Secretary of Defense, "The Problem." (An address before the Armed Forces Management Association/National Security Industrial Association Symposium: Cost--A Principal System Design Parameter, at Washington, D. C., August 16-17, 1972.)

[8]John G. Hubbell, op. cit.

[9]Robert N. Ginsburgh, Air Force Policy Letter for Commanders, AFRP 190-1, Washington, D. C., October 15, 1973.

[10] Ibid.

[11] Dwight Waldo, "Reflections on Public Science Policy and Administration in a Troubled Milieu," Public Science Policy and Administration, edited by Albert H. Rosenthal (Albuquerque: University of New Mexico Press 1973), p. 256.

[12] "Goldwater on Defense," op. cit.

[13] General Taylor made the comment at the twenty-fifth anniversary banquet of the Albuquerque Committee on Foreign Relations held at the Kirtland AFB, New Mexico, Officer's Club-West. Quoted in the Albuquerque Journal, Wednesday, December 5, 1973.

[14] "Goldwater on Defense," op. cit.

[15] Quoted in Robert N. Ginsburgh, Air Force Policy Letter for Commanders, AFRP 190-1, Washington, D. C., August 15, 1973.

[16] Philip J. Klass, "Soviets Push Ocean Surveillance," Aviation Week and Space Technology, September 10, 1973 pp. 12-13.

[17] Taken from extracts of a talk made by Senator Barry Goldwater at a recent meeting of the Wings Club of New York as printed in "Goldwater Stresses Defense Technology," Aviation Week and Space Technology, November 19, 1973, p. 63.

[18] Robert N. Ginsburgh, Air Force Policy Letter for Commanders, AFRP 190-1, Washington, D. C., September 1, 1973.

[19] Victor Petrov, China: Emerging World Power (D. Van Nostrand Co., Inc.: Princeton, N. J., 1967).

[20] David R. Inglis, "The Chinese Bombshell," Bulletin of the Atomic Scientists, February 1965.

[21] Robert N. Ginsburgh, Air Force Policy Letter for Commanders, AFRP 190-1, Washington, D. C., November 1, 1973.

[22] I. C. Kidd, Jr., "Happiness Is Quality and Cost Effectiveness," Defense Management Journal, Vol. IX, No. 3 (July 1973), p. 31.

CHAPTER III

COST REDUCTION POSSIBILITIES

PAST ORGANIZATION AND PRACTICE

In the past decade, three significantly different attempts have been made to improve the Air Force's systems acquisition process. However, serious effort directed at holding costs down and treating cost as an important system design parameter, equal to performance considerations, is only a very recent innovation.

In the last decade, the Department of Defense and the Air Force instituted various concepts, theories, and principles in a concentrated effort to reduce the costs of aeronautical weapon systems. Not all possibilities have been tried, but degrees of success of those that were are pointing the way toward substantial cost reductions.

CONCEPTS, THEORIES, AND PRINCIPLES

In the early sixties, Robert S. McNamara, then Secretary of Defense, made "cost-effectiveness" a household word. The thought was good; but the procedural considerations, eventually outlined in Directive 5200.9, strangled it. Essentially this Directive stated that every component of a system had to be shown to be very low risk prior to any fabrication of hardware--including test hardware in many cases. This resulted in literally mountains of engineering design paperwork and very little testing and prototyping of components. Some claimed Directive 5200.9 assured weapon systems would be obsolete before they were built. Adding to the volume of the paperwork was the edict that no decisions were to be made anywhere but at the top of the Department of Defense hierarchy. This included decisions that should have properly been made in engineering, such as whether an aircraft to perform a given mission would use jet or propeller propulsion. The slow journey and distortion of data through the hierarchy of overhead organizations, which this edict made mandatory, further complicated the systems acquisition process.

Within the Air Force, through the Aeronautical Systems Division and the Air Force Systems Command, the Air Force's preliminary systems design organization, the Deputy for Development Planning, attempted to respond to Directive 5200.9.[1] Utilizing computer design techniques, this organization presented "decision makers" with literally thousands of system choices showing cost, performance, and effectiveness trade-offs. Problems arose as top management became inundated with data. This, together with the cumbersomeness with which the bureaucracy operated, made decision making almost impossible.

Secretary McNamara, a man pre-occupied with statistical data, and his staff somehow processed the data that reached them and made decisions to build. Decisions based largely on paper studies and very little testing. Decisions based on engineering data subject to distortion, while moving through the hierarchy. Lt. General Otto J. Glasser, Deputy Chief of Staff/Research & Development in Air Force Headquarters, recently said of this era in systems acquisition:

> In the 1960's, with the pressure on to compress development lead times and with the rapid increase in analytical capability available through computers, building prototypes of defense systems as we did in the 1950's gave way to studies--paper airplanes-- as the means of determining how to apply basic knowledge and technology to new defense systems. So much confidence was placed in these paper airplanes that we not only eliminated the prototypes, but went so far as to commit ourselves contractually to production even before detailed design and testing of the systems had been done.[2]

In 1971, over reaction to the problems created by Directive 5200.9 resulted in the genesis of the Advanced Prototype Program. While prototyping can be very beneficial, the Advanced Prototype Program in the minds of management meant a departure from engineering analyses and an almost total dependence on flight evaluation. Somehow, magically, aeronautical systems acceptable to the Air Force would be designed and built by defense contractors and the money spent on planning and analyses in the past would be saved. With the staffing of the Deputy for Prototypes, the Advanced Prototype Program was implemented and "planning" was eliminated. The theory behind the Program was, using a minimum number of people and very little paper, develop prototypes of future Air Force systems at vastly reduced costs. General Otto J. Glasser outlined the Advanced Prototype Program as follows:

> Among the key features of the Advanced Prototype Program are streamlined management, simplified procurement, minimal documentation and reporting, use of design goals rather than specifications and adaptive performance measurement.
>
> The management approach for this program is designed to help us gain the greatest possible technical knowledge with modest dollar expenditures. Two features are particularly noteworthy. First, emphasis has been placed on performing the programs with a minimum number of people--a small number of highly qualified and highly motivated people in the Government matched by small teams of experienced, inventive and innovative designers and craftsmen in industry. With these small teams, we seek more personal and less formal communication. . . .
>
> Second, we have acknowledged financially and contractually that there are risks to be taken in programs designed to apply and advance technology. Cost reimbursement contracts are being used--specially tailored "level of effort" contracts which recognize that the contractor may not succeed in achieving all of the design goals enunciated in the statement of work. His primary requirement is to deliver completed hardware representing his best efforts within the maximum dollar amount of the contract.[3]

The Deputy for Prototypes was formed in the Aeronautical Systems Division of the Air Force at Wright-Patterson Air Force Base in Ohio, and its mission was defined. It consisted of approximately twenty people. It was given the responsibility for development of the C-130 transport replacement, the Advanced Medium STOL Transport, and the Light Weight Fighter. In each case, two contractors would be chosen and utilized to build prototypes; and, the winning design would be selected as the result of a competitive fly-off.

Somewhat before the inception of the Advanced Prototype Program and the Deputy for Prototypes, a conventional preliminary design process had been started for the A-X close support aircraft by the Deputy for Development Planning.

After successfully describing an acceptable vehicle for Air Force needs and some decision-to-build difficulties, contracts were awarded for two prototypes. The competing contractors were Northrop Aviation and Fairchild's Republic Company. They would build aircraft designated A-9 and A-10, respectively. The winner was to be selected based on the results of competitive flight testing.

EMPIRICAL FINDINGS

Directive 5200.9 was almost totally unworkable because of procedural restrictions, the decision process used, and the volume of engineering paperwork required. It contributed to almost ten years of study of the B-1 bomber prior to a decision to build.

The mission of the Deputy for Prototypes was generally that a very few people would have total responsibility for the entire acquisition process. Given a concept and general guidelines, it would generate Requests for Proposals which would be limited to a maximum of twenty pages. Contractor system design responses would be evaluated; and two contractors would be selected to build competitive prototypes.

A major policy change benefiting expeditious systems development by the Deputy for Prototypes was decentralization of decision authority. The Aeronautical Systems Division Commander, under whom the Deputy for Prototypes was located, was given almost complete control of decision-making for engineering development. For consultation on critical decisions, he was free to communicate directly with the Secretary of the Air Force, thus by-passing much of the hierarchy.

Decentralized decision authority and access to the Secretary of the Air Force, however, was not enough to make the ill-conceived Advanced Prototype Program a success. Upon initiation of operations, the Deputy for Prototypes met with immediate problems. Twenty people, which could not be expected to be expert in every area of system design, could not adequately describe a system in a Request for Proposal limited to twenty pages. However, an attempt was made in the writing of the Request for Proposal for the Advanced Medium STOL Transport; and it was sent to interested contractors. These contractors, all of whom were competing for the two prototype contracts, immediately flooded the Deputy for Prototypes with over 3000 engineering questions. The office realized it could not answer these and requested the support of the Deputy for Development Planning. The questions were then answered, but only after a considerable amount of time was lost doing engineering analyses which should have been accomplished prior to the writing of the Request for Proposal. The pendulum had swung too far from paper studies to hardware. General Glasser voiced this fear too late in July, 1972:

> In converting to the old system (prototyping), however, we must remember that we had some troubles then, too. We must be cautious that we do not leap from our current problems back to a previous set. It is imperative that we adopt a systems development and acquisition process that uses the best of all the previous methods we have tried. In other words, we must achieve an effective balance between paper studies and hardware prototyping in determining

what defense systems we can and should develop to meet future needs.[4]

The process followed in the development of the A-X Close Support Aircraft came closer to an acceptable solution to the problem of systems acquisition. The Deputy for Development Planning, utilizing a matrix type organization, analyzed alternative designs in-house and described the most desirable aircraft design in detail prior to issuing a Request for Proposal. Having done the study, the Deputy for Development Planning was able to write an excellent, comprehensive Request for Proposal, and evaluate and select winning contractor designs quickly and knowledgeably. Also, as a result of the knowledge gained by accomplishing the in-house design study, the description of the desired aircraft in the Request for Proposal included many ideas which contributed to a very low cost design. A dual benefit was thus realized; a means to control cost escalation as the result of elimination of unneeded and unwanted sophistication, and an acceptable low cost aircraft for the Air Force. Both the A-9 and the A-10 prototypes which resulted were excellent designs and relatively inexpensive. A fly-off was held and the Republic Company A-10 was selected for possible production.

EVALUATION OF CURRENT KNOWLEDGE

The Advanced Prototype Program approach to the problem of reducing aeronautical systems costs, as envisaged by top management, contains several flaws. The Deputy for Prototypes is grossly undermanned; and, the necessary engineering skills are lacking. The idea of reducing personnel and paperwork required was used to extreme measures. Essentially, in-house planning was eliminated resulting in heavy dependence on contractors, which are not intimately familiar with the needs of the Air Force, to define desirable systems. In addition to being an unwise practice, this leads to many false starts as both parties learn and attempt to agree on a satisfactory solution. False starts result in a considerable amount of unproductive effort which waste time and monetary resources. In the final analysis, the in-house work must be done, and doing it in an orderly fashion prior to writing a Request for Proposal is most efficient. Advance planning is the key element in resource savings.

The acquisition process followed in the development of the A-10 Close Support Aircraft seems to be the most adequate used to date, but was largely accidental. It began as a conventional preliminary design following the process used in the sixties. At the time the design planning was complete, prototyping had become the favored method of operation. Thus the decision to proceed with the development of two competitive prototypes was made, and a balance between paper and hardware was achieved. A formal matrix type organization borrowing techniques used during the development of the A-10 seems to have the greatest chance for success in reducing systems costs.

THE REQUIREMENTS PROCESS

There are generally four problems in the definition of requirements which are normally resolved in the Air Force Systems Command, Air Force Headquarters, and the Department of Defense. The definition of requirements must consider: (1) operator needs; (2) resolution of conflicting requirements; (3) elimination of excessive requirements; and (4) avoidance of duplication.

In any system design, operator needs must be considered. However, operators such as the Strategic Air Command, the Tactical Air Command, and others are separate organizations from the developing command. Thus a means for interaction must be devised. General George S. Brown, Commander of the Air Force Systems Command in 1972, discussed the need for interaction:

> . . . We are conducting joint operational/technical reviews on our major acquisition programs. While we in AFSC (Air Force Systems Command) can best understand the practical problems involved in meeting system performance requirements, only the operating commands can describe the essentiality of those requirements to their operational plans. In these joint reviews, then, the operator and the developer jointly relate system design specifications of the RFP (Request for Proposal) to operational requirements. . . .[5]

Occasionally conflicting or incompatible requirements need to be resolved. This also requires interaction between the developer and the user. Also, excessive requirements must be identified and eliminated.

Finally, duplication of systems and subsystems among the Air Force, Army, and Navy must be avoided. This falls under the responsibility of the Department of Defense. The Honorable Kenneth Rush, Deputy Secretary of Defense in 1972, commented on this problem:

> . . . We are continuing to emphasize the development and use of the area coordinating paper. We use this paper to establish functional mission areas corresponding to military operations. Within this framework we attempt to identify mission deficiencies as well as requirement duplication between services. We are hopeful that this process will help control costs by reducing duplication before it starts and by emphasizing low cost alternatives.[6]

The developed organization must communicate with interested organizations; however, this thesis assumes these problems will be resolved for the most part at higher levels.

SOLUTIONS

There is a need for a good preliminary design capability within the Air Force for planning purposes. The solution suggested here incorporates the Deputy for Prototypes into the Deputy for Development Planning and designates the resulting organization the Air Force Deputy for Systems Planning and Development. The organization is adequately staffed in both numbers and skills of personnel, and incorporates many, recent, innovative organizational techniques and management concepts.

The Deputy for Systems Planning and Development concerns itself with every new Air Force Aeronautical system up to the time a decision is made to produce these. At this point in the systems acquisition process, the system is assigned to a separate System Project Office which monitors contractor efforts. This follows current Air Force practice. The concept of prototyping is a good one and is used by the Deputy for Systems Planning and Development. A past Secretary of Defense, David Packard has said:

> Prototypes--hardware models--and adequate testing before production can be a major step forward to correct some of the disastrous failings characteristic of the total defense system approach. . . .
> I hope this prototype approach will be considered as one big step toward a new way of life in this business--for a new way of life is what we need.[7]

General Glasser stressed the importance of prototyping saying, "Under . . . conditions of high technological risk, advanced development prototyping becomes immensely important."[8] The purpose of prototyping is, General Glasser continues,

> . . . to determine the benefits obtainable from existing technology and to advance it to where it clearly provides useful options for the development of future defense systems. The idea is to verify through actual use that this technology is applicable and adaptable to military hardware.[9]

Not all systems, however, are prototyped by two contractors and involved in competitive fly-offs. Large and expensive systems, such as the B-1 Bomber, cannot be prototyped by two contractors within budget constraints. Prototyping is followed in those less expensive systems such as small fighter, transport and utility aircraft; and only used, in those cases where the necessity of inclusion of new technology increases the risk involved in successful development within the allotted budget. Competitive prototyping and fly-offs are used when the possibility of multiple design solutions exist and budget constraints allow.

THE CONCEPTUAL PHASE

The Deputy for Systems Planning and Development is responsible for following all Air Force aeronautical systems through the systems acquisition process. One of the basic characteristics of the Deputy for Systems Planning and Development is Matrix organization--the overlay of project management across functional organization. For specific tasks, specialists are drawn from functional organizations and brought together as a team under the direction of a project manager. By doing this, a team spirit environment is generated increasing motivation, and control by a single project manager assures task accomplishment. A team, once organized, remains with a project until production is authorized or it is canceled.

The use of the concept of Matrix organization enhances communications. In classical, hierarchical organization, downward communication is severely restricted. Operatives are given the minimum information necessary to accomplish their assigned tasks. This results in reduced motivation. In the Deputy for Systems Planning and Development, operatives are given as much information as possible. This not only allows them to understand how their task fits into the overall effort, thus motivating them, but provides the means to constantly proceed toward the desired solution with a minimum of unproductive effort. Also, the operatives realize they are an important part of a larger effort, and this reduces their conflict between job and self-image.

Motivation of personnel is a primary function of managers in the Deputy for Systems Planning and Development. Goals are established and maintained. Participative management is practiced.

Use is made of the federal promotion principle known as "impact of the man on his job." This is a deliberate channel set up, separate from the administrative channel, for advancement of exceptional scientists and engineers.

An innovative organizational concept alone, however, will not solve all the problems associated with the systems acquisition process. The decision process must be streamlined. The Deputy for Development Planning, which forms the basis of the Air Force Deputy for Systems Planning and Development, is located in the Aeronautical Systems Division. This means the current hierarchical decision line is through the Aeronautical Systems Division, the Air Force Systems Command, Air Force Headquarters, and finally, the Department of Defense. Over the years many groups have become unnecessarily involved in decisions. The journey of requirements or results through this hierarchy of overhead organizations can take many months and become distorted. The concern for centralization and control of the McNamara era has resulted in inordinate amounts of time and energy being spent in overhead organizations and is a major problem in government today. Decision and management authority is decentralized in the Deputy for Systems Planning and Development with direct access to the Secretary of the Air Force. A degree of centralization is required to accomplish the Department of Defense and Air Force missions. This will be accomplished through regular meetings of the concerned parties.

BEYOND THE CONCEPTUAL PHASE

Development specifications are major contributors to high systems costs. While some controls are needed, the standard Air Force Specifications have been modified over the years incorporating general design rules, many of which are unnecessary constraints on specific purpose systems. Consequently, systems have unnecessary complexity built into them, increasing cost drastically. Specifications should be considered as guidance only, and each new system design should be studied independently in relation to the specifications.

Contracting methods should be improved. For instance, subsystems warranty contracting, where the contractor is responsible for maintenance, results in much improved products and provides the Air Force a means of holding the contractor to design performance. The contractor, through his maintenance task, will discover the cause of problems and improve his product. Thus, both parties benefit.

One must not fall into the trap of considering only initial unit cost. The cost of operations and maintenance over the life of a system is far greater than the initial unit cost. Life cycle cost must be considered in the conceptual and development phase of systems acquisition. Such things as reliability, maintenance ease, and standardization of parts among different types of aircraft must be given careful and deliberate consideration. Non-standardization has made the logistician's job a very costly nightmare. It is also a cause for errors by maintenance, support, and operational crews.

The area of production aircraft testing presents an ideal opportunity for cost reduction. For instance, certifying aircraft to carry weapons through use of scale model testing in a wind tunnel and/or mathematical simulation models, rather than testing in actual flight, results in considerable savings.

Another means of reducing costly flying time is the use of simulators for pilot training.

IMPLEMENTING COST AS AN EQUAL DESIGN PARAMETER

The Honorable Kenneth Rush has said in behalf of the Defense Department, ". . . We intend to make cost a full partner of performance and schedule."[10] While some attempts to design to cost have been initiated in such system designs as the Air Force's A-10 close support aircraft, the Navy's patrol frigate, and the Army's advanced armed helicopter, it may not be easily implemented. The engineering community must be induced to change its thinking from that of maximum performance to performance within a cost. The Army's Major General Frank A. Hinrichs, Commanding General of the U. S. Army Aviation Systems Command, summarizes the problem saying:

> Although a number of factors influence cost of weapon systems, the "nothing but the best" syndrome in the military and in defense industry is a significant contributor to the problem.

> Military users have insisted on systems that have pushed the technological state of the art. Industry designers and engineers have been eager to satisfy DOD requirements with systems concepts that maximized performance. In other words, we have been totally committed to "designing to performance" with production cost given little consideration. If the trend toward higher cost of systems is to be stopped, a change from this traditional approach is needed.[11]

PSYCHOLOGICAL IMPLICATIONS

The "mind set" of the engineering community, committed over the years to strive for maximum attainable performance, must now be changed to achieving the best performance within pre-determined cost ceilings. Jacques S. Gansler explains:

> We must change our way of thinking and create new incentives. . . . We must change our procedures and, if necessary, modify our institutional structures.
>
> To institute these changes will require convincing people that we have a problem and motivating them to solve it. Cost consciousness must become a way of life. . . .[12]

Changing the engineering community's "frame of reference" will take considerable effort and time, however, it can and must be done. Dr. John S. Foster offers a hopeful note:

> The design-to-a-price practice is spreading and it's working. One of the most exciting aspects of this concept is that the industry engineers are truly stimulated by the added challenge. The design-to-a-price incentive drives them. They don't stop when they have satisfied the performance requirements, instead they go on to invent elegantly simple, low cost and highly reliable new ways to do the job.[13]

Reducing costs partly depends on engineering innovation as indicated by Dr. Foster. Engineers by nature, however, are innovative and should be up to the challenge. Engineers of the Deputy for Systems Planning and Development are offered the challenge to reduce costs. This is one of the goals of the organization. To facilitate the change in engineering thinking, lecturers are utilized periodically to disseminate ideas for reducing costs.

DEALING WITH INDUSTRY

It is extremely difficult for government to be sure it gets a fair return on its dollar when contracting with industry. Generally, government must convince industry of the need to reduce costs, and trust industry to do so. Lt. General Edmund F. O'Connor, Vice Commander of the Air Force Logistics Command, explains:

> Industry should deliberately design for lower costs. Keep designs simple, avoid sophistication, do not reinvent things which do exist and adapt them to the job at hand.
>
> We both must look for ways to design for the lowest life cycle costs. The total cost of ownership assumes more and more importance. Operation, maintenance, modification, supply, and training typically cost 10 to 20 times acquisition. A system expensive to maintain and operate imposes an unacceptable mortgage on the future.
>
> We both must find ways to reduce overhead. Industry should have a real incentive do to so because lower indirect costs can give a company a big competitive edge.[14]

The best means to assure the government is receiving an adequate return on its dollar is to maintain a good in-house capability. An in-house preliminary design team can monitor contractor work knowledgeably and assure simplicity of design, contractor honesty, and reasonable costs. Lt. General

O'Connor agrees the government must be capable of doing this. ". . . often industry urges us to buy the latest thing. We must challenge these requirements whenever we think they are goldplated."[15] In addition, warranty contracting will help to alleviate some cost problems.

FOOTNOTES

[1]The Deputy for Development Planning consisted of approximately 300 highly skilled aircraft engineering design and administrative personnel. The organization, still in existence, is similar to an industry preliminary systems design team such as might be found in the Boeing Company or North American Rockwell.

[2]Otto J. Glasser, "Air Force Looks Forward to Return to Prototyping," Defense Management Journal, Vol. VIII, No. 2 (July, 1972), p. 14.

[3]Ibid., p. 17.

[4]Ibid., p. 15.

[5]Extracted from an address by General George S. Brown, "Air Force Initiatives in Controlling System Cost." (An address before the Armed Forces Management Association/National Security Industrial Association Symposium: Cost--A Principal System Design Parameter, at Washington, D. C., August 16-17, 1972) as reprinted in "Holding the Cost Line," Aviation Week and Space Technology, September 18, 1972, editorial page.

[6]The Honorable Kenneth Rush, "The Problem." (An address before the Armed Forces Management Association/National Security Industrial Association Symposium: Cost--A Principal System Design Parameter, at Washington, D. C., August 16-17, 1972.)

[7]David Packard, "Improving R & D Management Through Prototyping," Defense Management Journal, Vol. VIII, No. 2 (July, 1972), pp. 3-6.

[8]Otto J. Glasser, op. cit., p. 17.

[9]Ibid.

[10]Kenneth Rush, op. cit.

[11]Frank A. Hinrichs, "Army Views Challenge of Design to Cost," Defense Management Journal, Vol. IX, No. 3 (July, 1973), p. 11.

[12]Jacques S. Gansler, "Acquisition Objective Changes from One of Sophistication to Reliability at Lower Cost," Defense Management Journal, Vol. IX, No. 3 (July, 1973), p. 6.

[13]Taken from an address by John S. Foster, Jr. and Leonard Sullivan, Jr., "Impact of the Problem on the Military/Industry R & D Outlook." (An address before the Armed Forces Management Association/National Security Industrial Association Symposium: Cost--A Principal System Design Parameter, at Washington, D. C., August 16-17, 1972).

[14]Taken from Lt. General Edmund F. O'Connor, "Preserving the Peace," Astronautics & Aeronautics, Vol. XI, No. 11 (November, 1973), p.68.

[15]Ibid.

CHAPTER IV

ORGANIZING FOR EFFICIENCY

PLANNING

Essential to organization planning are three key requirements:

1. Clear-cut requirements must be established to provide the framework of the objective.
2. The *modus operandi* should be established.
3. The human and nonhuman resources should be aligned to aid the overall operation.[1]

These are dealt with systematically in this chapter with the exception of nonhuman resources. Although mandatory for operation of the developed organization, they are not considered as essential to this study.

REQUIREMENTS

The objective of the Deputy for Systems Planning and Development is to efficiently manage all Air Force systems from idea to release to a System Project Office for production monitoring. This requires the capability to formulate requirements in a concerted effort with higher headquarters, understand and design system concepts, knowledgeably contract for industry designs, and select a winning contractor.

Essentially this means Air Force maintenance of a competent conceptual systems design group with direct access to higher authority.

RESULTS OF INTERVIEWS

Telephone interviews were conducted and consisted of questions relative to communications (decentralized decision authority) and the benefits of maintaining an Air Force in-house conceptual systems design capability. Both supervisory and non-supervisory personnel were interviewed in the Deputy for Prototypes and the Deputy for Development Planning in the Air Force's Aeronautical Systems Division at Wright-Patterson Air Force Base, Ohio. In the Deputy for Prototypes, interviews were held with a high level supervisor, a systems project manager, an engineer, and a contracting specialist. In the Deputy for Development Planning, a supervisor, a design integration specialist, and three engineers were interviewed. In an effort to induce truthful answers, all subjects were told their names would not be disclosed. With two exceptions, the consensus of opinions were that access to higher authority greatly facilitates the making of decisions. It was unanimously agreed that it is essential that the Air Force maintain a competent in-house conceptual systems design organization.

Direct access to higher authority combined with decentralized decision authority, as recently utilized by the Deputy for Prototypes, has resulted in much saved time and more informed decisions. Data, not having to traverse the obstacle course more commonly known as overhead organizations, is not subjected to unintentional distortion. Decision time in the Deputy for Prototypes now averages two weeks as opposed to as much as six months when the normal chain-of-command is used. In addition, most decisions which are not of critical importance to the program under consideration are made on the spot without the necessity of headquarters approval. As an example, the Deputy for Prototypes was able to accomplish the contractor evaluations of the Advanced Medium STOL Transport, select two competitive contractors, and make the decision to build in approximately ninety days using a direct access line to the Secretary of the Air Force. This is opposed to six months for a similar task for the C-5 transport using the conventional chain-of-command. Both tasks had the benefit of in-house systems design capability provided by the Deputy for Development Planning. In an extreme case, using the conventional chain-of-command, six months elapsed from the time the Secretary of Defense decided to go ahead with the development of the Subsonic Cruise Armed Decoy (SCAD) to the time Air Force Engineers in the Deputy for Development Planning received formal notice to initiate design work. This resulted from the myriad of overhead offices which the directive had to hurdle along the way. To complicate matters further, the directive, containing the mission requirements for the SCAD, became distorted beyond recognition during its six months journey. Personnel of each overhead organization receiving the directive, feeling compelled to be useful, made changes which emphasized their specific area of interest. The requirements contained in the version of the directive received by the Deputy for Development Planning in no way stated what the Secretary of Defense had agreed to six months earlier. Before work could commence, a lengthy clarification process had to be performed.

Some would maintain that decentralization of decision authority in a large complex organization such as the Air Force is unreasonable. In this case however, it is not only reasonable; it is the single most important contributor to efficiency. The developed organization is the only design group of its kind in the Air Force. Therefore, restricting communications does not foster unnecessary duplication. The direct access line to the Secretary of the Air Force (or his staff) merely eliminates overhead organizations. Some of the organizations do perform a service and the conventional chain-of-command is maintained, but is not used for critical decisions requiring immediate attention. Necessary contacts are maintained with the using commands such as the Strategic Air Command (SAC), the Tactical Air Command (TAC), and the Material Air Command (MAC). Contacts are also maintained with subsystem advanced development groups so that the specialists in the Deputy for Systems Planning and Development are able to stay abreast of the state-of-the-art.

A competent in-house design capability is mandatory for efficient systems development. Without it a considerable amount of unproductive time is spent. The interviewees in both the Deputy for Prototypes and the Deputy for Development Planning unanimously agreed that a decision would not have been possible concerning the Advanced Medium STOL Transport in ninety days were it not for the design verification provided.

THE DEPUTY FOR SYSTEMS PLANNING AND DEVELOPMENT

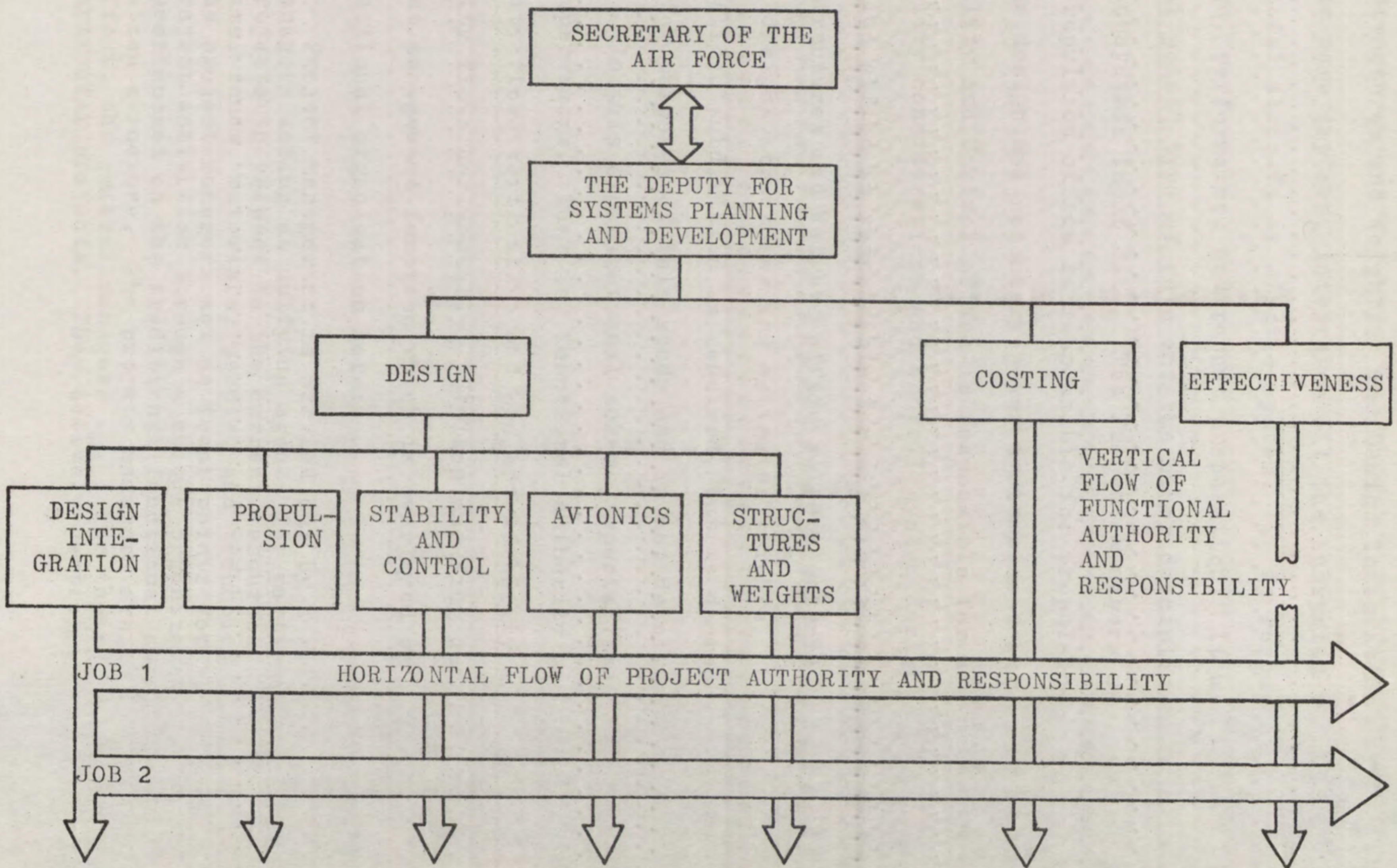
The developed organization is shown in Figure 2. It is designated as the Deputy for Systems Planning and Development and is provided with decentralized decision authority and a direct access line to the office of the Secretary of the Air Force. The organization consolidates the functions of the Deputy for Prototypes and the Deputy for Development Planning. It is a mixed or matrix organization consisting of project management overlayed on functional organization.

For scoping purposes of this thesis only the basic design organization is shown. Although required, the functions of graphics, personnel, contracting, reproduction, etc., are not considered pertinent to the problem being researched.

ORGANIZATIONAL STRUCTURE

The core of the Deputy for Systems Planning and Development consists of three major office subdivisions; Design, Costing, and Effectiveness. These are on equal status in the hierarchy; and thus these diciplines are treated equally during design formulation. The Design office is subdivided into Design Integration, Propulsion, Stability and Control, Avionics,

FIG. 2 THE DEPUTY FOR SYSTEMS PLANNING AND DEVELOPMENT



and Structures and Weights. The Design Integration office, as its name implies, integrates all the subsystem pieces into the total aircraft or missile system. It is responsible for design, performance, and report preparation. It assumes a "focal point" type of role and the other disciplines supply the subsystems input data. The Project Managers reside here. The Propulsion office is responsible for propulsion aspects of the design and secondary power systems as required. The Stability and Control office is responsible for aircraft stability considerations, and control system design. The Avionics office is responsible for all electrical design work. The Structures and Weights office selects materials to be used, designs structures and estimates weights. Greater specialized subdivision is required, but is deemed not necessary for purposes of this study and is not detailed on figure 2.

In this organizational scheme, specialists respond to two supervisors. That is, functional authority and responsibility flows vertically; and project authority and responsibility flows horizontally. Cleland and King describe the project management function which is overlayed on a conventional functional organization here:

> Project management is carried out by a set of managers acting as unifying agents for particular projects in respect to the current resources of time, funds, materials, people, and technology. The project managers act as focal points for their project activities through a unique organization superimposed on the traditional functional organization structure. The project managers are, in effect, the general managers . . . for their particular projects. They actively participate

> in planning, organizing, and controlling those major organizational and extraorganizational activities involved.[2]

By organizing in this manner, a team spirit environment is created and control by a single project manager assures task accomplishment in an orderly and timely fashion. The use of a matrix organization also enhances internal communications; since both vertical and horizontal lines of communication are utilized.

A mixed project and functional structure, or matrix organization, are desirable for large complex tasks. It provides an ideal environment for producing large projects within desired cost, schedule, and performance standards. The mixed organization has these many advantages as listed by Cleland and King:

1. The project is emphasized by designating one individual as the focal point for all matters pertaining to it.
2. Utilization of manpower can be flexible because a resevoir of specialists is maintained in functional organizations.
3. Specialized knowledge is available to all programs on an equal basis; knowledge and experience can be transferred from one project to another.
4. Project people have a functional home when they are no longer needed on a given project.
5. Responsiveness to project needs and customer desires is generally faster because lines of communication are established and decision points are centralized.
6. Management consistency between projects can be maintained through the deliberate conflict operating in the project-functional environment.
7. A better balance between time, cost, and performance can be obtained through the built-in checks and balances (the deliberate conflict) and the continuous negotiations carried on between the project and the functional organizations.[3]

ORGANIZATIONAL MECHANICS

An organization is a unique living organism whose basic component is the individual. All organizational attemps must consider the interaction of people, motivation, and leadership. According to Hersey and Blanchard:

> Most managers, if asked what they would do if they suddenly lost half their plant, equipment, or capital resources, are quick to answer. Insurance or borrowing are often avenues open to refurbish plant, equipment, or capital. Yet when these same managers are asked what they would do if they suddenly lost half of their human resources--managers, supervisors, and hourly employees--they are at a loss for words. There is no insurance against outflows of human resources. Recruiting, training, and developing large numbers of new personnel into a working team takes years. In a competitive environment this is almost an impossible task. Organizations are only beginning to realize that their most important assets are human resources and that the managing of these resources is one of their most crucial tasks.[4]

There is a consensus in the behaviorally oriented management literature that a participative organizational environment is generally desired. With reference to leadership roles, Hampton, Summer, and Weber state; ". . . the more or less explicit rationale for participative leadership rests upon the idea that leaders can permit subordinates to satisfy their higher level needs through the job." Further, ". . . general supervision and employee-centered supervision more often accompanied better group performance."[5] Douglas McGregor advocates participative leadership in his Theory Y and Likert advocates it in his System 4. The Deputy for Systems Planning and Development is patterned after Likert's System 4.

Likert in his studies found that prevailing management styles of organization can be depicted on a continuum from System 1 through System 4. These systems as described by Hersey and Blanchard are:

> System 1 - Management is seen as having no confidence or trust in subordinates, since they are seldom involved in any aspect of the decision-making process. The bulk of the decisions and the goal setting of the organization are made at the top and issued down the chain of command. Subordinates are forced to work with fear, threats, punishment, and occasional rewards and need satisfaction at the physiological and safety levels. The little superior-subordinate interaction that does take place is usually with fear and mistrust. While the control process is highly concentrated in top management, an informal organization generally develops which opposes the goals of the formal organization.
>
> System 2 - Management is seen as having condescending confidence and trust in subordinates, such as master has toward servant. While the bulk of the decisions and goal setting of the organization are made at the top, many decisions are made within a prescribed framework at lower levels. Rewards and some actual or potential punishment are used to motivate workers. Any superior-subordinate interaction takes place with some condescension by superiors and fear and caution by subordinates. While the control process is still concentrated in top management, some is delegated to middle and lower levels. An informal organization usually develops, but it does not always resist formal organizational goals.
>
> System 3 - Management is seen as having substantial but not complete confidence and trust in subordinates. While broad policy and general decisions are kept at the top, subordinates are permitted to make more specific decisions at lower levels. Communication flows both up and down the hierarchy. Rewards, occasional punishment, and some involvement are used to motivate workers. There is a moderate amount of superior-subordinate interaction, often with a fair amount of confidence and trust. Significant aspects of the control process are delegated downward with a feeling of responsibility at both higher and lower levels. An informal organization may develop, but it may either support or partially resist goals of the organization.

> System 4 - Management is seen as having complete confidence and trust in subordinates. Decision making is widely dispersed throughout the organization, although well integrated. Communication flows not only up and down the hierarchy but among peers. Workers are not motivated by participation and involvement in developing economic rewards, setting goals, improving methods, and appraising progress toward goals. There is extensive, friendly superior-subordinate interaction with a high degree of confidence and trust. There is widespread responsibility for the control process, with the lower units fully involved. The informal and formal organizations are often one and the same. Thus, all social forces support efforts to achieve stated organizational goals.[6]

In summary, System 1 is a task-oriented, highly structured authoritarian management style, while System 4 is a relationships-oriented management style based on teamwork, mutual trust, and confidence. Systems 2 and 3 are intermediate stages between two extremes. The extremes closely approximate McGegor's Theory X and Theory Y assumptions.

To expedite the analysis of an organization's present behavior, Likert's group developed an instrument which enables members to rate their organization in terms of its management system. This instrument is designed to gather data about a number of operating characteristics including leadership, motivation, communication, decision making, interaction and influence, goal setting, and the control process. It is reprinted here as Table 1 to give further insight into the characteristics of the System 4 organization utilized in the Deputy for Systems Planning and Development.

TABLE 1 -- **Profile of Organizational Characteristics**

	System 1	System 2	System 3	System 4
Leadership				
1. How much confidence is shown in subordinates?	None	Condescending	Substantial	Complete
2. How free do they feel to talk to superior about job?	Not at all	Not very	Rather free	Fully free
3. Are subordinates' ideas sought and used, if worthy?	Seldom	Sometimes	Usually	Always
Motivation				
4. Is predominant use made of (1) fear, (2) threats, (3) punishment, (4) rewards, (5) involvement?	1, 2, 3, occasionally 4	4, some 3	4, some 3 and 5	5, 4, based on group set goals
5. Where is responsibility felt for achieving organizational goals?	Mostly at top	Top and middle	Fairly general	At all levels
Communication				
6. What is the direction of information flow?	Downward	Mostly downward	Down and up	Down, up, and sideways
7. How is downward communication accepted?	With suspicion	Possibly with suspicion	With caution	With open mind
8. How accurate is upward communication?	Often wrong	Censored for boss	Limited accuracy	Accurate
9. How well do superiors know problems faced by subordinates?	Know little	Some knowledge	Quite well	Very well

TABLE 1 (Continued)

Interaction				
10. What is character of interaction?	Little, always with fear and distrust	Little, usually with some condescension	Moderate, often fair amount of confidence and trust	Extensive, high degree of confidence and trust
11. How much cooperative teamwork is present?	None	Relatively little	Moderate amount	Very substantial amount throughout organization
Decisions				
12. At what level are decisions formally made?	Mostly at top	Policy at top, some delegation	Broad policy at top, more delegation	Throughout but well integrated
13. What is the origin of technical and professional knowledge used in decision making?	Top management	Upper and middle	To certain extent throughout	To a great extent throughout
14. Are subordinates involved in decisions related to their work?	Not at all	Occasionally consulted	Generally consulted	Fully involved
15. What does decision-making process contribute to motivation?	Nothing, often weakens it	Relatively little	Some contribution	Substantial
Goals				
16. How are organizational goals established?	Orders issued	Orders, some communication invited	After discussion, by orders	Group action (except in crisis)
17. How much covert resistance to goals is present?	Strong resistance	Moderate resistance	Some resistance at times	Little or none
Control				
18. How concentrated are review and control functions?	Highly at top	Relatively high at top	Moderate delegation to lower levels	Quite widely shared
19. Is there an informal organization resisting the formal one?	Yes	Usually	Sometimes	No—same goals as formal
20. What are cost, productivity, and other control data used for?	Policing, punishment	Reward and punishment	Reward, some self-guidance	Self-guidance, problem solving

Taken from <u>Public Science Policy and Administration</u> edited by Albert H. Rosenthal, pp. 152-153.

MANAGEMENT

The filling of management positions is one of the most poorly handled functions in government. Many times it is based on seniority with little regard for capability in either the specialty or management. Other times, a good specialist is promoted into a management position that his technical education hasn't equipped him to handle. Only very recently has any emphasis at all been placed on management degrees. Managers for the organization developed here are selected not only for their expertise in the functional discipline, but also for their management talents. Younger specialists, with a desire to enter into management, are given training opportunities to help them progress.

While the author believes that in supervisory positions administration is approximately sixty percent art and only forty percent specialty expertise--that forty percent specialty expertise is mandatory for effectiveness. Robert Golembiewski has written:

> As organizations grow ever more complex, the powerful demands of hierarchy and specialty are likely to become increasingly at odds. They already are significant sore spots. Indeed, if some observers are correct, we are even today far down the primrose path toward our own organizational disaster. "In short," goes one variation, "the most symptomatic characteristic of modern bureaucracy is the growing imbalance between ability and authority. . . ." Ability is what the specialists have, in this view. And hierarchical authorities toward the top of organizations begin to take forms suspiciously like that of a rattle-shaking high priest at the organizational equivalent of a fertility rite.[7]

In addition to having expertise in the specialty and being able to perform the formal aspects of management, managers must be very fluent in dealing with the human aspects of organization. They must be capable of dealing with their personnel and those of clientele groups.

PERSONNEL MOTIVATION

Hersey and Blanchard frame the personnel problem:

> Today many employees enjoy a higher standard of living and tend to be better educated and more sophisticated than ever before. As a result, these workers have increased potential for self-direction and self-control. Consistent with these changes in maturity, a large majority of our population, in Maslow's terms, now have their basic physiological and safety-security needs fairly satisfied. Management can no longer depend on the satisfaction of these needs, through pay, incentive plans, hospitalization, and so forth, as primary motivating factors . . . In our society today, there is almost a built-in expectation in people that physiological and safety needs will be fulfilled. In fact, in our society people do not generally have to worry about where their next meal will come from or whether they will be protected from the elements or physical danger. They are now more susceptible to motivation from other needs: People want to belong, be recognized as "somebody," and have a chance to develop to their fullest potential.[8]

Behavior is basically goal-oriented. In other words, our behavior is generally motivated by a desire to attain some goal. Further, motivation is a direct result of employee satisfaction as defined by him. Therefore a successful manager must know his people. This is extremely difficult unless a manager can win the respect and trust of his subordinates.

One of the best traits a manager can possess is the ability to listen sympathetically. A manager can deduce many things about an employee by patiently listening to his problems. He can gain the employees respect by being sympathetic, understanding, and helpful. Management, after all, is a supportive role. Without operatives, there would be no need for managers. Hersey and Blanchard explain the problem:

> A manager has to know his people to understand what motivates them; he cannot just make assumptions. Even if a manager asked an employee how he felt about something, this does not necessarily result in relevant feedback. The quality of communications a manager receives from his employees is often based upon the rapport that has been established between his men and himself over a long period of time.[9]

In the Deputy for Systems Planning and Development every effort is made to determine employee personal goals. Management attends to these through time-off allowances for education providing it is relative to the specialty, facilitating the publishing of personal and organizational works, recognizing excellence, and other concessions as determined and feasible. To maintain proficiency on the job, thirty percent of the specialists' time is reserved for developing improved methods and keeping abreast of their discipline.

The setting of organizational goals is extremely important to efficient operation. According to Hersey and Blanchard: "Managers who are successful in motivating employees are often providing an environment in which appropriate goals (incentives) are available for need satisfaction."[10] In the Deputy for Systems Planning and Development every individual is encouraged to develop and maintain written goals. Every unit in the Deputy maintains written goals developed jointly by all involved. These are re-evaluated annually and progress checks are made quarterly.

Generous use is made of the federal promotion principle known as "impact of the man on his job." This is a deliberate "technical" channel set up for advancement of exceptional scientists and engineers. This type of advancement channel, separate from the administrative channel, is also known as the "dual ladder," "parallel ladder," "two-track," or "two-tier" system.

> Traditionally, in the old-style industrial or federal laboratory, advancement in grade and status came chiefly by promotion into supervisory and managerial posts. The poor changes (sic) of advancement as an individual worker created a strong incentive for the ambitious to compete for administrative assignments, even if they considered them distastful. In many cases this situation led excellent technical people to leave the field of their competence in order to flounder unhappily in their new management jobs.[11]

The "impact of the man on his job" principle allows exceptional scientists and engineers to be promoted to higher salaries without the necessity of assuming management duties, thus retaining these professionals in their most productive positions. "A study of a number of technically oriented companies indicated that most of the high-quality companies had established dual ladders, while the lower quality companies seldom had done so."[12]

FLESHING OUT THE ORGANIZATION

The Deputy for Systems Planning and Development is a result of consolidation of the Deputy for Development Planning and the Deputy for Prototypes. The Deputy for Development Planning assumes a leading role in the merger. The organization developed here borrows heavily from it.

THE MISSION

The specific mission of the Deputy for Systems Planning and Development is stated below. It is essentially that currently in use by the Deputy for Development Planning.

> Conducts in-house technical feasibility, parametric, and preliminary design studies, and engineering analyses and syntheses of potential weapon systems and subsystems to satisfy operational requirements and future mission forecasts, and provide the bases for determining costs, schedules, and effectiveness of these systems.
>
> Provides technical direction and evaluation of industry planning studies.
>
> Determines the prospective performance, and vulnerability of new or proposed weapon systems and major subsystems thereof under expected conditions of manufacture, handling, and operational usage.
>
> Conducts continuing trade-off studies of systems in conceptual development to provide bases for balancing performance and risk.
>
> Identifies critical technical problems and establishes quantitative goals through specific design analyses for guidance to the Air Force technology program.
>
> Conducts research to improve techniques and methods for systems and subsystems synthesis, analysis, and performance verification.
>
> Conducts an organized program of system development planning activities in specific advanced system areas.
>
> Manages assigned exploratory or advanced development programs for technology critical to the attainment of new system capabilities.[13]

ORGANIZATION SIZE

Based on the author's experience in the Deputy for Development Planning, approximately 100 projects are continuously performed concurrently. Some are minor, subsystem tasks requiring one to three specialists. Others are large, high-priority, total system design tasks utilizing as many as twenty specialists. However, an average personnel utilization factor is about five. Therefore, the Deputy for Systems Planning and Development will require approximately 500 specialists divided evenly among the three office subdivisions of Design, Costing, and Effectiveness. Span of control of functional managers is limited to about ten specialists. This is accomplished through greater specialty subdivision than detailed here. For instance, the Design Integration Office will be further subdivided into units such as Subsonic Aircraft Design, Supersonic Aircraft Design, Hypersonic Aircraft Design, and Missile Design.

FOOTNOTES

[1]David I. Cleland and William R. King, Systems Analysis and Project Management (New York: McGraw-Hill, Inc., 1968), p. 168.

[2]Ibid., p. 164.

[3]Ibid., p. 172.

[4]Paul Hersey and Kenneth H. Blanchard, Management of Organizational Behavior (2d ed.; Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1972), p. 60.

[5]David R. Hampton, Charles E. Summer, and Ross A. Webber, Organizational Behavior and the Practice of Management (Glenview, Ill.: Scott, Foresman and Company, 1973), pp. 602-603.

[6]Paul Hersey and Kenneth H. Blanchard, op. cit., pp. 61-62.

[7]Robert T. Golembiewski (Ed.), Perspectives on Public Management (Itasca, Ill.: F. G. Peacock Publishers, Inc., 1972), p. 107.

[8]Paul Hersey and Kenneth H. Blanchard, op. cit., p. 143.

[9]Ibid., p. 40.

[10]Ibid., p. 11.

[11]Nicholas J. Oganovic and Harold H. Leich, "Human Resources for Science Administration: Can Quality Be Enhanced," Public Science Policy and Administration, edited by Albert H. Rosenthal, Albuquerque: University of New Mexico Press, 1973, p. 78.

[12]Ibid., p. 79.

[13]Organization and Functions Chart Book, RCS: 1-SYS-03, Aeronautical Systems Division, WPAFB, AFSC, March 1, 1970, pp. 19-9 -- 19-11.

CHAPTER V

TOWARD SIGNIFICANT SAVINGS

CONSIDER ALL POSSIBILITIES

No single innovative cost savings idea will result in significant reductions in the cost of aeronautical systems. However, if a major effort is initiated to reduce costs, and every cost reduction possibility is implemented, the costs of aeronautical systems can be substantially reduced. The engineering community must be unrelenting in their quest for reduction in costs through innovation and simplicity without the loss of capability. Removing frills and non-essential performance alone can save an estimated thirty five percent.[1]

All organizational units, and individual specialists, in the Deputy for Systems Planning and Development continuously seek ways to reduce systems cost. Reductions are encouraged at the lowest level and to the penny. As an example: The Army transitioned from metal to plastic canteens; a cost savings of seventeen cents per canteen. The Army contracted to buy one million of the new canteens; a total savings of $170,000. In other words, it can be done. Costs can be reduced. The Soviets invariably do things much more simply than the U. S. government does with very little loss in capability. The simple metal "tractor" seat on their anti-aircraft guns doesn't result in any less accuracy than the U. S. anti-aircraft guns utilizing plush, padded, $300 seats. Finally, changes to designs based on the latest technology for technology's sake are avoided.

The remainder of this chapter is devoted to various cost reduction possibilities during systems acquisition and operation. Not all possibilities are treated; and a complete analysis of each area treated is beyond the scope of this effort. They are presented here in an attempt to consolidate as many ideas as possible into one document and to show the extent of cost reduction possibilities. It is hoped that this work will stimulate further detailed studies in these areas. To reduce aeronautical systems costs significantly, all must be considered together.

SIMPLIFICATION AND STANDARDIZATION

Simplification of designs and standardization of parts among aircraft types is a key means of reducing complexity and cost. Simplification and standardization not only reduce initial cost, but reduce the costs of logistics, training, operations, and maintenance. It also reduces the chances for errors by maintenance, support, and operational crews. Dr. Foster claims:

> Standardization will result in higher volume production, therefore lower cost and higher reliability; while at the same time greatly reducing the logistics and training costs. The savings could be substantial.[2]

The quest for the very best has led to the current problems of non-standardization and complexity. In the past, each new aircraft design was built independently of all others. Many contractors participate in systems building, and each has preferred methods of construction. Contractors in the past have developed special tools for maintenance because no existing tool would work. This creates training and maintenance problems. As an example, there are over 200 types of conventional weapons in the U. S. inventory. Each is different from all others. Only certain aircraft are certified to carry certain weapons. A load crew of four Airmen are trained as a team to load these weapons. They literally live, eat, and work together. Loading is currently such a complex task, each load crew is only trained to load four or five weapons on a very few aircraft types. Further, each Airman is trained in some specific aspect of the job. If an Airman leaves the team, the remaining three are recalled and retrained in a new unit of four. Their task requires familiarity with over 100 tools.

One can begin to realize the resources it takes to maintain a capability such as this. In addition, ample opportunities for error exist; and flexibility is reduced. It requires a half day to "turn around" an F-4 Phantom fighter/bomber. That is, if an F-4 goes on a raid in the morning and returns to base at noon, it will be six o'clock in the evening before that aircraft is fueled, loaded with weapons, and ready for take-off on another mission. This is very poor utilization. It could mean the difference between winning and losing a hard fought war. The logistics and communications accompanying this operation are horrendous. To be able to operate, someone must insure that the proper load crew, weapons, and aircraft arrive at the same operational base. A study done by the Air Force Systems Command in 1970, entitled The Tactical Aerial Weaponry Study, essentially determined that twenty carefully selected weapon types could replace the over 200 in the current inventory with minimal loss in capability.

Within the Department of Defense there exists very little in the way of standardization among the services. Dr. Foster uses tactical UHF radios as an example. He says:

> Let me indicate one example of our failure in an area that could benefit greatly from standardization--tactical UHF radios. These radios perform the same functions in four environments--shipboard, vehicular, ground, and aircraft. We have developed different equipment for each of these environments. What's worse, within each environment we have developed different types. Even within the same platform type we have different models of the same UHF radios. There are at least ten different airborne UHF transceivers of the same vintage employed in our forces today, all performing the same function.[3]

In this regard, the U. S. government could learn from the Soviet Union. They practice standardization extensively. As an example, the Soviets use the very same fuel pump on most of their fighter aircraft even though the aircraft are built by different companies.

In the past, there have been some attempts to standardize in the United States military. One of these is the Department of Defense Standardization Program. Although the program was established in 1952, emphasis was not placed on design standardization until 1965. Since that time, the three military services have established: The Parts Control Program (USAF), The Component Equipment List System (USN), and The Army Data Retrieval Engineering System.[4] Each program attempts to provide military design contractors with standard procedures. These programs have been working, but much still needs to be done. Also, consolidation of programs into one Department of Defense program would contribute to greater standardization.

Significant inroads into the problem of complexity and non-standardization can only be made if every design engineer is made aware of the problem and convinced to commit himself to its solution. In recent years some progress has been made. The Fairchild Republic Company's A-10 close support aircraft is an example of a successful attempt at developing a simple, low-cost aircraft. The number of parts is reduced drastically over comparable aircraft. Straight line elements in the fuselage produce a maximum amount of single curvature shapes. Constant cross section design in the wing and stabilizer creates a high degree of commonality of parts. The right and left landing gear are the same and interchangeable, reducing required spares and logistics. The right and left vertical tails are identical.

The current development of Boeing's Advanced Medium STOL Transport (AMST), designated the YC-14, stresses simplicity and low cost. Some parts of existing aircraft are being utilized.

> . . . economy features include the use of leading edge Krueger flaps that can be taken directly from the 747 transport production line, and some of the spoiler mechanisms can come from the 727 and 737 lines.
>
> In addition, the CF6-50D engines that were used in the 747 flight test program will be used in the YC-14.[5]

In summary, simplification of designs and standardization of parts among aircraft types not only reduce the initial cost of the aircraft, but reduces the cost of logistics, maintenance training, and operations. Additionally, flexibility is enhanced and the chance for errors diminished.

SPECIFICATIONS

The standard military specifications have been developed and modified over the years to incorporate all possible exigencies. Consequently, many design rules are made mandatory that are unnecessary. Also, many specifications are outdated. The last major revision of some of these occurred in 1952.

Although it would be a large, costly task, the specifications should be reviewed and revised in light of the current emphasis on reducing costs. They must be written to encourage standardization without unnecessary constraints. They should be "functional specifications" rather than detailed design specifications. Dr. Foster says:

> We are interested in the end product's field performance and interfaces, not in the details of the "insides." The designer must be allowed flexibility if both standardization and design-to-a-price are to work.[6]

An example of how constraining the specifications can be is the Army's attempt to purchase an inexpensive target for gunnery practice. A contractor developed a very unsophisticated, inexpensive missile target. The contractor utilized the cardboard centers that are used to roll carpet for handling as the fuselage, a simple "throw-away" motor, and minimal stabilizing equipment. The target was intended to be used only once as target practice. The "cardboard" missile met the Army's performance requirements, and the cost was a mere $300 each. The Army was not permitted to buy the target, however, because it did not meet the specifications. The specifications, written for conventional sophisticated missiles, called for a high degree of structural integrity. Specifications, therefore, should be used as guidance only, and "tailored" to special purpose systems.

LIFE CYCLE COSTING

In addition to initial cost, life cycle costs must be given careful consideration in the early phases of systems development. That is, operations and maintenance costs, over the life of the system, must be considered. These costs are usually far greater than the initial unit cost.

Reduction in operating costs can be effected through the use of standardized ground support equipment, the use of simulators to reduce actual flight time, and selection of "off-the-shelf" components such that spares might be available locally from commercial sources, thus allowing a smaller inventory to be maintained. Reduction of maintenance costs can range from simple solutions such as mounting components in easily accessible locations to more complex aspects such as improved component reliability. Maintenance by the builder should also be considered.

The vulnerability of a weapon system to attack can also impact total cost, since more vulnerable systems require more vehicles to complete a given task. Vulnerability is, among other things, a function of component location. In many cases the designer can improve a systems vulnerability at virtually no cost simply by locating critical components behind heavy structure.

There is also a need to develop good life cycle costing methods to facilitate prediction and design of the least expensive alternative. Early life cycle cost analysis work was aimed primarily at motivating contractors to reduce equipment support requirements. Now, however, life cycle costing is concerned with all aspects of acquisition. Almost everyone in the acquisition business today should consider life cycle costs in reaching decisions in their areas of responsibility. This can be accomplished only by significantly expanding the development and application of life cycle cost analysis procedures, and training many people to consider life cycle costs in making decisions in their area. Particular emphasis must be placed on expanding life cycle cost activities during system planning and design.

A considerable amount of quantitative analysis work will be required to provide the life cycle cost decision guidance needed. There is a wide range of equipment to be considered. Most have differing costs, uses, and support requirements. Likewise there is a broad range of decision issues including those related to research, requirements, design, procurements, support policies, etc. In addition, life cycle cost alternatives might relate to system or detail part design, system concept tradeoffs, performance requirements for any one of many performance parameters, the selection of a contract type or incentive terms, or any number of other issues. Developing computer aided models sensitive to all of these issues and alternatives will be a significant challenge, but would pay handsome dividends.

CONTRACTING METHODS

Many types of contracts are currently being used by the Air Force and government R & D agencies in general. Conventional contract types include Cost Reimbursement, Cost Plus Fixed Fee, Cost Plus Incentive Fee, Firm Fixed Price, and Fixed Price Incentive. Examples of unconventional contract types are Cost Sharing, Cost Reimbursement With Ceilings, Cost Plus Awards Fee, Retroactive Price Redetermination after Completion, and Firm Fixed Price Level of Effort.[7] Of these, Cost Plus Incentive Fee and Cost Plus Awards Fee seem to be the most adequate. With regard to contracting for greater systems reliability and minimized cost overruns, Dr. Foster states:

> . . . we must . . . establish and employ the necessary management incentives for industry. We will use more Cost Plus Award Fee contracts. We will reward contractors who give us quality,

on-time deliveries, and agreed-to costs, and penalize those who do not.[8]

Dr. Foster's notion is a valid one for total systems purchases, however it can only be considered as an interim solution. Actually, none of the contract types currently in use truly serves the needs of research organizations.[9] There is a critical need to refine these existing contractural techniques and develop new types. It may also be beneficial to standardize contracting methods among government agencies.

For aircraft and missile components, subsystems warranty contracting, where the contractor is responsible for maintenance, results in much improved products. It also provides the agency a means of holding the contractor to design performance. The contractor, through his maintenance task, will discover the cause of persistent problems and improve his product. Thus, both parties benefit, since the contractor's maintenance funds can be turned into profit. In this regard, Jacques S. Gansler says:

> . . . some type of warranty is the best approach to obtain field reliability of equipment, particularly in the subsystems area. It might be in the form of a supplier's repair warranty, as in commercial avionics, or it might be in the form of a field reliability warranty which, if not achieved, would require the supplier to redesign and retrofit.[10]

Dr. Foster agrees with this philosophy saying:

> We are taking action to ensure that the supplier gets far greater feedback of his equipment's field experience. That will help, but we must offer more incentives to improve field reliability. We talk about, and we are concerned about, life cycle costs, but we usually select suppliers on the basis of development or initial acquisition costs. One

> answer to the life cycle cost question is that we may find it advantageous more frequently to pay industry for a warranty of the equipment in the field--at least, in the early years of a system's deployment. The developer has designed his equipment for a certain field reliability, if he becomes the producer, he should stand behind it. The warranty would be similar to that given by suppliers of commercial avionics equipment. One from of this could be a maintenance contract under which equipment is kept working and available for an annual fee. Perhaps a field reliability warranty would provide the necessary incentive to industry to reduce the causes of field failures--and to do it during the design phase, rather than later.[11]

In summary, Cost Plus Incentive Fee and Cost Plus Awards Fee type contracts seem to be currently the most adequate, but need to be refined. For subsystems procurement, warranty contracting offers the chance to increase reliability, thus reducing life cycle costs.

TESTING

Testing of flight systems is a potential area of cost reductions, especially in the area of certifying aircraft to carry weapons. Greater use should be made of scale model testing in wind tunnels, and/or mathematical simulation models, as opposed to testing in actual flight. Aircraft hourly operating costs for fuel, maintenance, and spare parts range from about $50 an hour for light trainers to more than $1500 an hour for operational combat aircraft.[12]

One can quickly visualize the magnitude of potential savings when the vast number of possible weapon load configurations requiring certification are considered. As an example, consider certification of a hypothetical fighter/bomber aircraft. Assume the aircraft has five "hard points" where weapons can be loaded. Assume further that each hard point is capable of carrying three weapons. Finally, assume the aircraft is to be certified to carry ten different types of weapons in both pure and mixed loads. Each of these ten types of weapons, and mixes of weapons, must be tested on the aircraft in varying loads from one to fifteen weapons in all possible flight conditions. It is easy to see that thousands of flights will be required for certification purposes. In this computer era, wind tunnel and mathematical simulation model testing promises significant savings.

SIMULATORS

While there is no substitute for learning while in actual flight, the use of simulators for some aspects of pilot training can result in considerable savings. A substantial investment is required, but the potential savings warrant it.

Advancements in technology are continually improving flight simulators' ability to duplicate the operating characteristics of flying and flight environment. Without the cost and risk of actual flight, pilots can "fly" takeoffs and landings, hear engine noise, and feel the pull of gravity from sharp turns and other maneuvers. Similarly, without leaving the ground, military pilots can practice radar-controlled bombing and missile firing.

Commercial airlines have taken advantage of breakthroughs in simulator technology since the mid-1960s.

Beginning in 1967, the Federal Aviation Administration allowed commercial airlines to replace various phases of flight training with training in improved simulators.[13] Much of the military's flying time is for training, especially in combat aircraft, such as fighter and attack aircraft, patrol aircraft, and bombers. Except for actual combat missions, virtually all flying in these aircraft is for training.

Navy and Air Force studies completed in 1972 predicted that, with better simulators and improved training techniques, flight time at basic pilot training schools could be reduced in the mid-1980s by about 46 to 49%, depending on the type of aircraft involved.[14] The potential net savings available through the use of simulators depends on the exact amount of actual flight time that simulator training can replace. The General Accounting Office estimates that if 25% of the flight training done by the Navy and Air Force could be replaced by the use of simulators, an annual savings of about $455 million would result; a 50% replacement would save about $900 million annually.[15] In addition, greater use of simulators could help to ease the current fuel shortage.

Using simulators for pilot training offers the additional advantages of smaller inventory and reduced attrition. The possibility of an accident always exists during a flight, but accidents obviously cannot occur while using a simulator. Pilots can train as much as needed to cope with emergency situations, such as engine failures, without risking lives or aircraft. Also, about one of every four aircraft purchased is needed for support, that is, used for pilot training or to replace aircraft undergoing maintenance. The use of simulators may release some support aircraft for operational assignments or reduce the inventory required.

FUTURE STUDIES

The author does not pretend to believe that the foregoing list of areas and cost reduction ideas is all inclusive. Many other areas could be studied, and many other cost saving ideas developed and implemented. It is hoped that this treatment will stimulate the thoughts of development engineers to strive for adequate capability at minimum cost in all areas of aeronautical systems development, acquisition, and operation.

FOOTNOTES

[1]John S. Foster, Jr. and Leonard Sullivan, Jr., "Impact of the Problem on the Military/Industry R & D Outlook." (An address before the Armed Forces Management Association/National Security Industrial Association Symposium: Cost--A Principal System Design Parameter, Washington, D. C., August 16-17, 1972.)

[2]Ibid.

[3]Ibid.

[4]Robert F. Lehr, Jr., "The Defense Standardization Program," Master's Thesis, The University of New Mexico, 1972.

[5]Richard G. O'Lone, "Boeing Freezes AMST Prototype Design," Aviation Week and Space Technology, Vol. 100, No. 11 (March 18, 1974).

[6]John S. Foster, Jr. and Leonard Sullivan, Jr., op. cit.

[7]For a detailed discussion of contract types currently in use see Thomas E. Bahan, "The Research and Development Contract Issues and New Approaches," Master's Thesis, The University of New Mexico, 1972.

[8]John S. Foster, Jr. and Leonard Sullivan, Jr., op. cit.

[9]Thomas E. Bahan, op. cit., p. 72.

[10]Jacques S. Gansler, "Acquisition Objective Changes from One of Sophistication to Reliability at Lower Cost," Defense Management Journal, Vol. IX, No. 3 (July, 1973), p. 4.

[11]John S. Foster, Jr. and Leonard Sullivan, Jr., *op. cit*.

[12]U. S. Comptroller General, *Report to the Congress, Greater Use of Flight Simulators in Military Pilot Training Can Lower Costs and Increase Pilot Proficiency*, Report No. B-157905, August 8, 1973, p. 1.

[13]*Ibid*., p. 1.

[14]*Ibid*., p. 2.

[15]*Ibid*., p. 2.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

There is a body of knowledge, assembled in this work, that has not been fully exploited and utilized--which has been only recently given consideration--that can be applied to the aeronautical systems' acquisition process, and operational procedures-- which results in the most capable weapons at the least possible cost.

THE PROBLEM

Aeronautical systems costs have risen to extreme proportions. Defense budgets of the future will not allow purchases of sufficient numbers of adequately capable weapon systems if the trend of rising costs is allowed to continue. To maintain national security, cost reduction techniques must be implemented.

Improvements in the systems acquisition process of the Air Force are required. A planning organization capable of conceptual systems design with decentralized decision authority is needed. Also needed are improved specifications and contracting methods, more simplification and standardization of components among different types of aircraft, less expensive testing methods, and greater uses of simulators to replace flight time for pilot training. In addition, operations and maintenance costs--life cycle costs--must be considered in the design phase.

THE NEED

Recently, it has been fashionable to criticize science and technology. While constructive criticism is needed and welcomed, the vague critical gestures of the young are only destructive. The fact is, we continue to rely on science and technology in our daily lives, and should work together in the quest for acceptable solutions to any science and technology related problems.

The need for defensive measures in the United States is real. Potential adversaries, such as the Soviet Union and Red China, are accelerating the production of weapons, and are committed to the Communist doctrine of world conquest.

Defense must not be taken for granted. The maintenance of a strong United States military force in the past is a key reason why peace has prevailed on American soil. A position of strength is essential whenever one negotiates. Nuclear war has been averted for twenty-eight years through the use of the policy of deterrence and the Triad. In an address to the Rotary Club of Chicago on October 16, 1973, Air Force Chief of Staff, General George S. Brown, said, "If this Triad is adequately maintained and modernized, I see little likelihood that our ability and success in deterring nuclear war will change appreciably.[1]

Senator Barry Goldwater sums up the need for weapon systems very succinctly:

> We must continue to seek means of achieving and maintaining peace, but as we do we must recognize that the world is still not a very safe or peaceful place and we must remember that remaining strong enough to win a war is still the best way to avoid war. The full flush of detente, of interim arms limitation agreements, mutual and balanced force reductions and all the other attempts to preclude war, do not mean that we can unilaterally disarm.
> . . . we had better remember that maintaining our freedom is still number one--and that the other priorities disappear with the cannon smoke if our liberty is lost.
>
> Our foreign policy is based on partnership and negotiation through strength--and the strength of the United States is its industry and technology. Our allies depend upon our traditional characteristic, technological prowess. That is our contribution to the partnership. And it's the strength that makes negotiation possible.
>
> Furthermore, the cutting edge, the essence, the vanguard of that strength is the airpower we can bring to bear anywhere on the globe. Airpower is the vital ingredient to U. S. and world security. The nation without an air arm capable of defeating any challenger is defenseless.
>
> For a decade, U. S. aircraft were the indispensable elements that prevented a North Vietnamese takeover, even though severe restrictions were placed on air power applications by civilians who weren't sure which part of the airplane went down the runway first.[2]

In the words of Dwight Waldo, "What is now needed is nothing less than knowledge of how to survive and be creative, wise, and effective. . . ."[3]

RECOMMENDATIONS

Implementing "design-to-a-cost" may be a problem, since engineers have in the past generally been concerned with maximizing performance. However, some recent implementation attempts seem to indicate that engineers, necessarily inventive and innovative, may be able to readily adapt to the new frame of reference. That is, change their mind set from maximizing performance independent of cost to designing the best performance into systems within predetermined cost constraints. This kind of challenge seems to drive engineers to exceptional accomplishments.

Leonard Sullivan, Jr., sums up the need for innovative measures within the Department of Defense very succinctly:

> We can no longer afford to develop every individual system for maximum performance; rather, we must balance performance, numbers and cost to achieve the greatest total military capability from our available resources. We must learn to consider total force effectiveness rather than each individual weapon's cost effectiveness. . . . performance needs could be met within the cost if careful design and good management were applied.[4]

The Department of Defense and the Air Force must establish, and engage in, an exhaustive program aimed at making the cost problem and possible solutions known. Development engineers everywhere must be convinced to strive for adequate performance at minimum cost when designing aeronautical systems. Cost must be elevated to an equal system design parameter with performance and schedule.

THE DEPUTY FOR SYSTEMS PLANNING AND DEVELOPMENT

A good preliminary aeronautical systems design capability is needed within the Air Force to assure the military procures adequate weapons at reasonable costs. Recent attempts to implement organizational concepts, theories, and principles in an effort to reduce systems costs have met with some limited success. More importantly, however, they are pointing the way to satisfactory solutions.

The Deputy for Systems Planning and Development, developed in this thesis to respond to the need for an Air Force preliminary design organization to adequately monitor new systems in the conceptual phase of the systems acquisition process, borrows the best attributes of previous organizational attempts.

Specifically, the Deputy for Systems Planning and Development is to efficiently manage all Air Force systems from idea to release to a System Project Office for production monitoring. This requires the capability to formulate requirements in a concerted effort with higher headquarters, understand and design system concepts, knowledgeably contract for industry designs, and select a winning contractor. Essentially, this means Air Force maintenance of a competent conceptual systems design group which has direct access to the proper authorities.

The developed organization is of the matrix type. The Deputy for Systems Planning and Development consists of three major office subdivisions: Design, Costing, and Effectiveness. The Design office is further subdivided into Design Integration, Propulsion, Stability and Control, Avionics, and Structures and Weights. These offices are organized functionally in the traditional hierarchical manner, but project organization is used for all tasks. That is, authority and responsibility flow horizontally across the required functional units during conduct of the task. The Design Integration office functions as the focal point through use of a project manager.

The Deputy for Systems Planning and Development stresses participative management, and borrows heavily from Likert's System 4. This system is a relationships-oriented management style based on team work, mutual trust, and confidence. It closely approximates McGregor's Theory Y. In the organization, every effort is made to determine employee personal goals. Management attends to these through time-off allowances for education providing it is relative to the specialty of the employee, facilitating the publishing of employee personal and organizational works, recognizing and rewarding excellence, and other concessions as determined and feasible. To maintain proficiency, thirty percent of the specialists' time is reserved for developing and improving methods. Generous use is made of the federal promotion principle known as "impact of the man on his job." This is an advancement channel, separate from the administrative channel, specifically created for exceptional scientists and engineers.

Approximately 100 projects are performed concurrently by the organization. The Deputy consists of approximately 500 specialists in addition to the required administrative personnel. These are divided evenly among the three office subdivisions of Design, Costing and Effectiveness.

Implementation of a planning and development organization with the preceeding characteristics is recommended.

ADDITIONAL COST REDUCTION POSSIBILITIES

No single, innovative cost savings idea will result in significant reductions in the cost of developing, procuring and operating aeronautical systems. However, if a major effort is initiated to reduce cost, and every cost reduction possibility is implemented, the costs of systems can be significantly reduced.

Beyond the conceptual phase, costs can be reduced by using specifications as guides rather than the rule. Warranty contracting offers a means to control the performance of contractors. Considering life cycle costs and standardization in the design phase of aeronautical systems results in considerable savings in ownership costs. Reducing flight testing through use of mathematical simulations and/or scale model wind tunnel testing results in resource savings. Finally, greater use of simulators for pilot training to reduce actual flight hours results in considerable savings. To significantly reduce the costs of aeronautical systems, all of these areas must be considered together.

Development specifications are major contributors to high systems costs. While some controls are needed, the standard Air Force Specifications have been modified over the years incorporating general design rules in an attempt to address all possible system concepts. Consequently, unnecessary constraints are placed on special purpose systems which increases cost drastically. Specifications should be reviewed and revised and considered as guidance only, and each new system design should be studied independently in relation to the specifications.

Life cycle costs must be considered in the conceptual and development phase of system acquisition. The cost of operations and maintenance over the life of a system is far greater than the initial unit cost. Such things as simplicity, reliability, maintenance ease, and standardization of parts among different types of aircraft must be given careful and deliberate consideration.

Contracting methods should be improved. For instance, subsystems warranty contracting where the contractor is responsible for maintenance, results in much improved products and provides the Air Force a means of holding the contractor to design performance. The contractor, through his maintenance task, will discover the cause of problems and improve his product, thus both parties benefit.

The area of production aircraft testing presents an ideal opportunity for cost reduction. For example, certifying aircraft to carry weapons through use of scale model testing in a wind tunnel and/or mathematical simulation models, rather than testing in actual flight, results in considerable savings. Aircraft hourly operating costs for fuel, maintenance, and spare parts range from about $50 an hour for light trainers to more than $1500 an hour for combat aircraft.[5]

Another means of reducing costly flying time is the use of simulators for pilot training. The General Accounting Office estimates that if 25% of the flight training done by the Navy and Air Force could be replaced by the use of simulators, an annual savings of about $455 million would result; a 50% replacement would save about $900 million annually.[6]

GENERAL CONSIDERATIONS

In view of the current problems experienced in decision-making as a result of the myriad of overhead organizations, it is recommended that a select group of distinguished public administration and organizational theory personnel be established with the objective of improving efficiency in the Air Force and the Department of Defense. This group should operate within the framework of reducing the costs of aeronautical systems development, procurement, and operation through improved organization. It should consist of personnel from outside the Department of Defense, who are intimately familiar with the process of development, procurement, and operation of aeronautical systems. The group must be capable of reorganizing the current process while ignoring vested interests.

A related problem, hindering the making of adequate and timely decisions, is the growing imbalance between engineering and authority. The decision-maker and the development engineer must be made to understand each others' problems. It is recommended that a program be developed whereby selected development engineers are given the opportunity to spend 10 percent of their time participating in high level systems planning. Conversely, provisions should be made for the most senior decision-makers to spend approximately 5% of their time touring development facilities and being briefed on the problems of development and the latest technology.

FUTURE EFFORTS

The purpose of this study was to identify and document ways to reduce Air Force aeronautical weapon systems costs to affordable levels. It is believed that this research has achieved that objective by identifying problem areas and recommending practical solutions.

The author, however, does not pretend to believe that this study is all inclusive. It is hoped that it will stimulate the thoughts of development engineers everywhere to strive for adequate capability at minimum cost.

FOOTNOTES

[1]Robert N. Ginsburg, Air Force Policy Letter for Commanders, AFRP 190-1, Washington, D. C., November 1, 1973.

[2]"Goldwater Stresses Defense Technology," Aviation Week and Space Technology, November 19, 1973, p. 63.

[3]Dwight Waldo, "Reflections on Public Science Policy and Administration in a Troubled Milieu," Public Science Policy and Administration, edited by Albert H. Rosenthal (Albuquerque: University of New Mexico Press, 1973).

[4]Leonard Sullivan, Jr., "Comment," Defense Management Journal, Vol. IX, No. 3 (July, 1973), pp. 1-2.

[5]U. S. Comptroller General, Report to the Congress, Greater Use of Flight Simulators in Military Pilot Training Can Lower Costs and Increase Pilot Proficiency, Report No. B-157905, August 8, 1973, p. 1.

[6]Ibid., p. 2.

SELECTED BIBLIOGRAPHY

Argyris, Chris. Integrating the Individual and the Organization. New York: John Wiley & Sons, Inc., 1966.

Bahan, Thomas E. "The Research and Development Contract Issues and New Approaches," Master's Thesis, The University of New Mexico, 1972.

Cleland, David I. and King, William R. Management: A Systems Approach. New York: McGraw-Hill, Inc., 1970.

________. Systems Analysis and Project Management. New York: McGraw-Hill, Inc., 1968.

Congress and the Federal Budget, Government Brief No. 23, New York: Tax Foundation, Inc., September, 1973.

Edwards, Scott. "ANTISCIENCE: The Legacy of the Counterculture," The Humanist, Vol. XXXIII, No. 4 (July/August, 1973).

Foster, John S., Jr. Defense Management Journal, Vol. IX, No. 3 (July, 1973), pp. 4-5.

Foster, John S., Jr. and Sullivan, Leonard, Jr. "Impact of The Problem on the Military/Industry R & D Outlook." (An address before the Armed Forces Management Association/National Security Industrial Association Symposium: Cost--A Principal System Design Parameter, at Washington, D. C., August 16-17, 1972.)

Gansler, Jacques S. "Acquisition Objective Changes from One of Sophistication to Reliability at Lower Cost," Defense Management Journal, Vol. IX, No. 3 (July, 1973), pp. 3-6.

Ginsburgh, Robert N. Air Force Policy Letter for Commanders. AFRP 190-1, Washington, D. C., August 15, 1973.

________. Air Force Policy Letter for Commanders, AFRP 190-1, Washington, D. C., September 1, 1973.

________. Air Force Policy Letter for Commanders, AFRP 190-1, Washington, D. C., September 15, 1973.

________. Air Force Policy Letter for Commanders, AFRP 190-1, Washington, D. C. October 1, 1973.

________. Air Force Policy Letter for Commanders, AFRP 190-1, Washington, D. C., October 15, 1973.

________. Air Force Policy Letter for Commanders, AFRP 190-1, Washington, D. C., November 1, 1973.

Glasser, Otto J. "Air Force Looks Forward to Return to Prototyping," Defense Management Journal, Vol. VIII, No. 2 (July, 1972), pp. 14-18.

"Goldwater on Defense," Aviation Week and Space Technology, November 12, 1973, editorial page.

"Goldwater Stresses Defense Technology," Aviation Week and Space Technology, November 19, 1973, p. 63.

Golembiewski, Robert T. Perspectives on Public Management. Itasca, Ill.: F. E. Peacock Publishers, Inc., 1972.

Hampton, David R., Summer, Charles E., and Webber, Ross A. Organizational Behavior and the Practice of Management. Revised edition. Glenview, Ill.: Scott, Foresman and Company, 1973.

Hersey, Paul and Blanchard, Kenneth H. Management of Organizational Behavior. 2d ed. Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1972.

Hinrichs, Frank A. "Army Views Challenge of Design to Cost," Defense Management Journal, Vol. IX, No. 3 (July, 1973), pp. 11-16.

Hjornevik, Wesley L. "Guiding Work Relationships among Scientific, Engineering, and Administrative Professionals," Public Science Policy and Administration. ed. Albert H. Rosenthal. Albuquerque: University of New Mexico Press, 1973.

"Holding the Cost Line," Aviation Week and Space Technology, September 18, 1972, editorial page.

Hubbell, John G. "Shall We Build This Superbomber?", Reader's Digest, December, 1972.

Inglis, David R. "The Chinese Bombshell," Bulletin of the Atomic Scientists, February, 1965.

"Is Insurrection Brewing in U. S.?", U. S. News and World Report, Vol. LXIII, No. 26, Washington, D. C., December 25, 1967.

Kerlinger, Fred N. Foundations of Behavioral Research. New York: Holt, Rinehardt and Winston, Inc., 1966.

Kidd, I. C., Jr. "Happiness is Quality and Cost Effectiveness," Defense Management Journal, Vol. IX, No. 3 (July, 1973), pp. 31-34.

Klass, Philip J. "Soviets Push Ocean Surveillance," Aviation Week and Space Technology, Vol. XCIX, No. 11 (September 10, 1973), pp. 12-13.

Koontz, Harold and O'Donnell, Cyril. Management: A Book of Readings. 3d ed. New York: McGraw-Hill, Inc., 1972.

Kristol, Irving. "Decentralization for What?", in Robert T. Golembiewski, Frank Gibson, and Geoffrey Y. Cornog, Public Administration. 2d ed. Chicago: Rand McNally & Company, 1972.

Lehr, Robert F., Jr. "The Defense Standardization Program," Master's Thesis, The University of New Mexico, 1972.

Likert, Rensis. "Organizational Dynamics: Building Effective R & D Departments," Public Science Policy and Administration. ed. Albert H. Rosenthal. Albuquerque: University of New Mexico Press, 1973.

March, James G. and Simon, Herbert A. Organizations. New York: J. Wiley & Sons, Inc., 1967.

O'Connor, Edmund F. "Preserving the Peace," Astronautics & Aeronautics, Vol. XI, No. 11 (November, 1973), pp. 67-70.

Oganovic, Nicholas J. and Leich, Harold H. "Human Resources for Science Administration: Can Quality Be Enhanced," Public Science Policy and Administration. ed. Albert H. Rosenthal. Albuquerque: University of New Mexico Press, 1973.

O'Lone, Richard G. "Boeing Freezes AMST Prototype Design," Aviation Week and Space Technology, Vol. 100, No. 11 (March 18, 1974).

Organization and Functions Chart Book. RCS: 1-SYS-03, Aeronautical Systems Division, WPAFB, AFSC, March 1, 1970.

Packard, David. "Improving R & D Management Through Prototyping," Defense Management Journal, Vol. VIII, No. 2 (July, 1972), pp. 3-6.

Petrov, Victor. China: Emerging World Power. Princeton, N. J.: D. Van Nostrand Co., Inc., 1967.

Powell, Craig. "A-10," Government Executive, Vol. V, No. 11 (November, 1973), pp. 15-17.

Rush, Kenneth. "The Problem." (An address before the Armed Forces Management Association/National Security Industrial Association Symposium: Cost--A Principal System Design Parameter, at Washington, D. C., August 16-17, 1972.)

Simon, Herbert A., Smithburg, Donald W., and Thompson, Victor A. Public Administration. New York: Alfred A. Knopf, 1973.

Simon, Julian L. Basic Research Methods in Social Science. New York: Random House, 1969.

Stahl, O. Glenn. Public Personnel Administration. 6th ed. New York: Harper and Row, Inc., 1971.

Sullivan, Leonard, Jr. "Comment," Defense Management Journal, Vox. IX, No. 3 (July, 1973), pp. 1-2.

Taylor, Maxwell. Albuquerque Journal, December 5, 1973.

Terry, George R. Principles of Management. 5th ed. Homewood, Ill.: Richard D. Irwin, Inc., 1968.

Thompson, Victor A. Modern Organization. New York: Alfred A. Knopf, 1961.

U. S. Comptroller General, Report to the Congress, Greater Use of Flight Simulators in Military Pilot Training Can Lower Costs and Increase Pilot Proficiency. Report No. B-157905. August 8, 1973.

Waldo, Dwight. "Reflections on Public Science Policy and Administration in a Troubled Milieu," Public Science Policy and Administration. ed. Albert H. Rosenthal. Albuquerque: University of New Mexico Press, 1973.