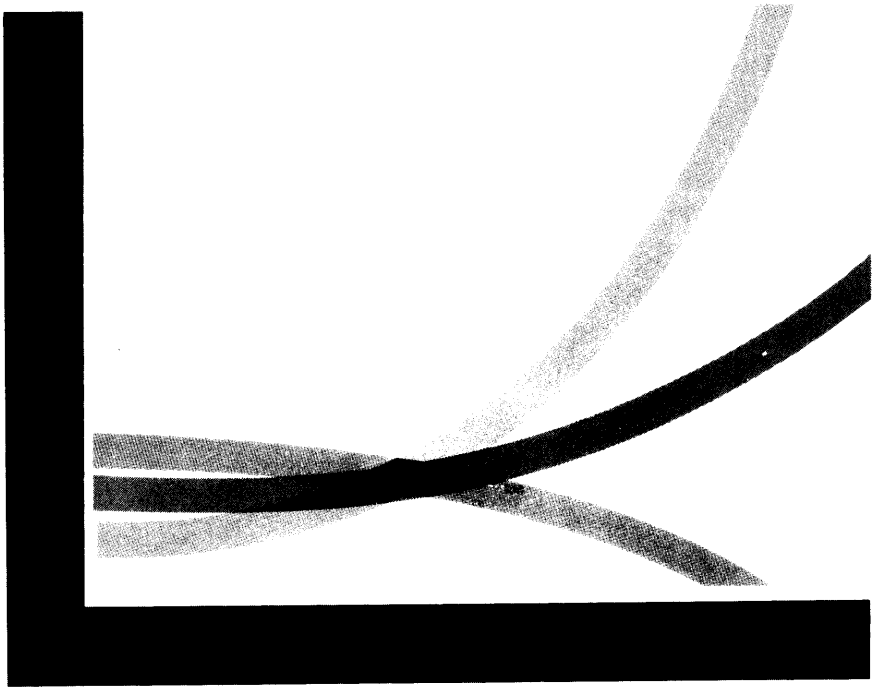
DEFENSE SCIENCE BOARD

REPORT OF THE TASK FORCE ON ELECTRONICS MANAGEMENT

30 April 1974



Office of the Director of Defense Research and Engineering · Washington, D.C.

THE DEPUTY SECRETARY OF DEFENSE
WASHINGTON, D C 20301

AUG 8 1974

MEMORANDUM FOR THE CHAIRMAN, DEFENSE SCIENCE BOARD

THROUGH: DIRECTOR, DEFENSE RESEARCH AND ENGINEERING

SUBJECT: Report of the Defense Science Board Task Force on Electronics Management

I have reviewed this effort and find it of particular interest at a time when we are searching for ways to improve our management methods and reduce costs. I recognize the significance of the Task Force recommendations, and after your verbal report last summer, we started the actions necessary to put some of them into practice. For instance, a special group is now working to find a way to make support costs more visible; an Electronics Panel to the Defense Materiel Specifications and Standards Board has been formed to promote selective electronics standardization; the Defense Advanced Research Projects Agency initiated a study to examine ways to improve maintenance and training aids; and a special group is working on ways to increase the use of warranties on programs. These are just some of the actions already underway, and we are preparing to initiate more, consistent with your recommendations.

The importance of this report is very apparent, and it will receive widespread distribution throughout the Department of Defense. I am personally interested in the progress in implementing the recommendations for improving the management of such a large portion of our Defense budget.

Finally, I would like you to express my appreciation to the Chairman and all the members of the Task Force for their participation in the study. I know these men contributed a great deal of their time and talent, and their recommendations on improving electronics management, when fully implemented, will greatly strengthen our national defense.

W. P. Clements, Jr.

OFFICE OF THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
WASHINGTON, D. C. 20301

24 June 1974

TO: THE SECRETARY OF DEFENSE

THROUGH: THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING

The attached report of the Defense Science Board Task Force on Electronics Management was prepared at the request of the Director of Defense Research and Engineering. The Task Force, under the Chairmanship of Dr. Richard D. DeLauer, consisted of members with a wide range of experience in industry and Government.

As Dr. DeLauer emphasizes in the Introduction, the Task Force identified high and rising unit cost as well as inadequate field reliability as the main problems facing electronics management. It is on these that the Task Force concentrated. Still, its several recommendations also address more general issues of optimum distribution of resources among initial cost, performance and support. As you know, many of the Task Force's recommendations are already being acted upon by your staff.

The report has been approved by the Defense Science Board and I recommend it to you for your consideration.

Solomon J. Buchsbaum
Chairman
Defense Science Board

OFFICE OF THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
WASHINGTON, D. C. 20301

22 April 1974

MEMORANDUM FOR THE CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Final Report of Task Force on Electronics Management

I am pleased to submit to you the final report of the Electronics Management Task Force. This report summarizes the findings, conclusions, and recommendations of the Task Force during its deliberations in the 1973 Defense Science Board Summer Study at Woods Hole, Massachusetts. It also reflects comments and suggestions provided by Task Force members subsequent to the Summer Study and from others within the Department of Defense and in industry who had an opportunity to review the report during its preparation.

Although our report places a good deal of emphasis on the matter of cost reduction, the Task Force clearly recognizes that there are many other aspects of the military electronics management challenge to be considered in addition to reducing costs. The procurement and ownership of electronics must be managed by the Department of Defense in such a way as to achieve a more equitable distribution among acquisition cost, performance, mission availability, and support costs. The recommendations presented are directed toward this end, and are intended to further the objective of acquiring military electronics systems with optimum operational readiness and adequate performance at minimum cost.

I would like to express my gratitude for the excellent cooperation which the Task Force has received from all quarters during the period of its investigations, and also to recognize the many outstanding contributions which were made to this study by all of the members of the Task Force and its Senior Review Group.

Richard D. DeLauer
Chairman, Electronics
Management Task Force

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INTRODUCTION

The Electronics Management Task Force was convened by the Defense Science Board at the request of the Director of Defense Research and Engineering. Among the objectives established for this Task Force were an evaluation, by an independent select group, of the alternative courses of action being recommended by the "Electronics-X" study effort being performed by the Institute for Defense Analyses for DDR&E and ASD/I&L, and the review of the results of related studies and experiments in the area of military electronics cost reduction. The Task Force was requested to develop and recommend a preferred series of specific implementing actions which could have a major impact on development, acquisition, and operating methodology for cost reduction and reliability improvement of electronic subsystems.

The Electronics Management Task Force carried out this assignment as a part of the annual Defense Science Board Summer Study conducted at Woods Hole, Massachusetts from August 6-17, 1973. During this Summer Study period, the Task Force received a number of in-process briefings on the findings and preliminary conclusions of the Electronics-X study, as well as detailed briefings on a number of electronics cost reduction activities currently being carried out under the auspices of the Army, Navy, and Air Force.

For a portion of the study period, the Task Force subdivided itself into six subgroups to hear detailed briefings on specific topical areas, and to hold discussions and to develop specific recommendations in these areas. The subgroup sessions were organized and scheduled in such a manner that each member of the Task Force was able to participate in the deliberations of two different subgroups. These subgroups were:

- *Requirements*
- *Design to a Cost*
- *Standardization*
- *Incentives and Contracting*
- *Field Reliability*
- *Maintenance and Support*

Following the subgroup sessions, the Task Force again convened as a committee of the whole for the purpose of developing the findings, conclusions, and recommendations presented in this report. These findings, conclusions, and recommendations were also presented in preliminary form in a final briefing presented by the Task Force Chairman as a summary report to the Woods Hole Summer Study Group on August 16, 1973.

To prepare for this final briefing, a review session was held on August 15, 1973 at which time the reactions and advice of a Senior Review Group were solicited prior to finalization of the summary briefing. This Senior Review Group consisted of senior commanders from the Army, Navy, and Air Force, representatives of the Assistant Secretaries for R&D of the Army, Navy, and Air Force, and senior representatives from DDR&E, ASD/I&L, and ARPA.

The Electronics Management Task Force is the latest in a series of Defense Science Board Task Forces which have examined various aspects of the problems relating to the cost of acquiring defense systems. Previous studies which have developed a foundation for the present investigation include:

- *Task Force on Research and Development Management (1969)*
- *Summer Study Panel on Weapons System Simplification (1970)*
- *Task Force on Avionics (1971-72)*
- *Task Force on Reducing Costs of Defense Systems Acquisition (1973)*

Each of these studies was concerned with a particular aspect of the problem of defense systems acquisition, and, although each has been able to benefit to some extent from the results of the others, they are intended to be independent and self-contained studies, rather than duplications of previous efforts.

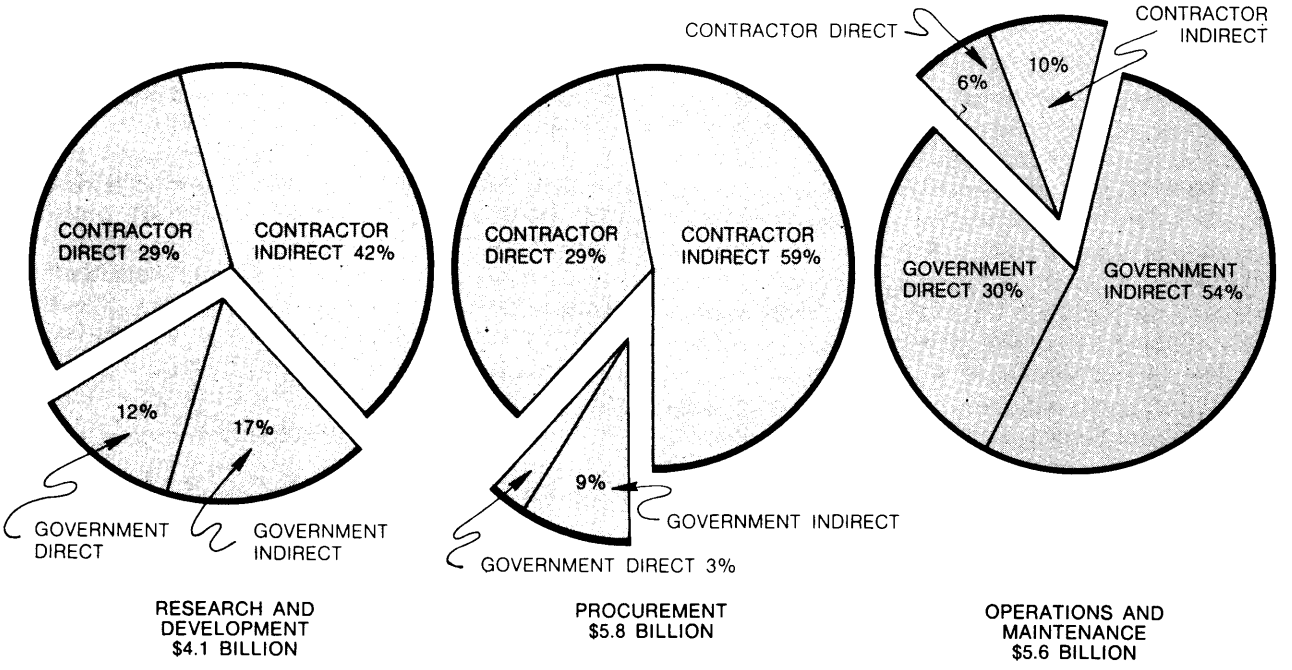
In approaching the question of Electronics Management, the Task Force concluded that the principal current DOD electronics problems are the following:

- *High, and rising, unit costs*
- *Inadequate field reliability*

As a consequence of these two problems, the quantities of electronic equipment available to meet the current military needs are going down.

The FY 1974 DOD budget included an estimated outlay of some $15.5 billion for electronics, in the

Figure 1–Electronics Budget Cost Distributions



SOURCE: ELECTRONICS-X STUDY

three budget categories of Research and Development, Procurement, and Operations and Maintenance, as depicted in Figure 1. This was approximately 33 percent of the total DOD FY 1974 budget in these categories. The distribution of the electronics cost allocation among the three budget categories indicates that about two-thirds — nearly 37 percent by industry and about 27 percent by government — of the total electronics budget is allocated for indirect cost.

This Final Report is organized into seven main chapters or sections, each dealing with a different aspect of the military electronics management situation examined by the Task Force. In each section, a specific Finding is presented, followed by a brief Discussion of the major aspects of the problem which were considered by the Task Force. At the end of each section is a Recommendation or series of related Recommendations which, if put into effect by DOD, are believed by the Task Force to have potential for exercising a real impact on the cost and reliability of the electronic systems and equipment which DOD now has in its present inventory and which it will acquire in the years to come. At the end of each section, the anticipated Impact of these recommendations is briefly summarized.

The findings, conclusions, and recommendations of the Task Force on Electronics Management are presented on the following pages of this report, arranged by the following topical areas:

I. **Full Cost Accounting and Allocation**
II. **Meeting the Military Needs**
III. **Uncertainties in Cost and Schedule**
IV. **Design to a Cost**
V. **Maintenance and Support**
VI. **Field Reliability**
VII. **Standardization**

SUMMARY OF RECOMMENDATIONS

The primary recommendations of the Electronics Management Task Force are summarized as follows:

1. DIRECT THAT PROPER STEPS BE TAKEN TO EXTEND THE DOD COST ACCOUNTING SYSTEM TO PROVIDE FOR PROPER ALLOCATION OF ALL DIRECT AND INDIRECT COSTS.
2. ESTABLISH PROCEDURES TO INSURE PROPER TOP LEVEL MANAGEMENT REVIEW OF ALL MAJOR ELECTRONIC SUBSYSTEM ACQUISITION PROGRAMS, BOTH THOSE SUBSUMED IN MAJOR WEAPON SYSTEMS AND THOSE INDEPENDENTLY DEVELOPED.
3. DIRECT THAT THE EXPLICIT OPTIONS FOR ALTERNATE WAYS OF MEETING A MILITARY REQUIREMENT BE IDENTIFIED EARLY IN THE CONCEPT FORMULATION PHASE.
4. ASSESS DOD'S IN-HOUSE CAPABILITY IN COST ESTIMATING AND ANALYSIS, THEN UPGRADE THE STATURE OF COSTING IN THE PROCUREMENT PROCESS.
5. TAKE STEPS TO INSURE THAT UNIT PRODUCTION COST IS EXPLICITLY RELATED TO FLEXIBILITY IN PERFORMANCE AND SCHEDULE IN DESIGN TO A COST CONTRACTS.
6. REDUCE THE LEVEL OF IN-HOUSE MAINTENANCE AND SUPPORT BY SOMETHING LIKE 5 PERCENT PER YEAR OR MORE, AND INITIATE ALTERNATE MEANS OF PROVIDING THE NECESSARY SUPPORT SERVICES.
7. ALLOCATE SUFFICIENT RDT&E FUNDS TO UPGRADE THE RELIABILITY OF ELECTRONIC EQUIPMENT IN THE PRESENT OPERATIONAL INVENTORY.
8. CONDUCT A COMPREHENSIVE STUDY OF ELECTRONICS STANDARDIZATION BEFORE ESTABLISHING DOD POLICIES OR FORMAL PROGRAMS FOR STANDARDIZATION.

It should be noted that the concepts discussed in the first section of the report, on Full Cost Accounting and Allocation, are considered by the Task Force to be integrally related to the effective accomplishment of any of the other six topical areas outlined in the subsequent sections. If the basic capabilities for the identification of true costs recommended in Section I are not provided, it will be difficult or impossible for DOD to be able to assess the effectiveness or true impact of any actions which may be implemented as a result of the recommendations in the succeeding sections. It is the consensus of the Task Force that this recommendation on the proper allocation of all direct and indirect costs should have the highest priority of all.

Even if none of the other recommendations herein are adopted by DOD, it is believed that the existing process for acquisition of military electronics would benefit greatly if the initial recommendation is implemented. However, by itself, it will not produce the improvements in the electronics acquisition process which are believed to be necessary and desirable. Without it, the impact of the other recommendations will be extremely difficult to perceive or evaluate, and therefore, funds to implement them will be more difficult to obtain. Thus, there is a strong need to develop accurate measures of the cost of equipment ownership for items in the inventory and to develop techniques for predicting the *total* costs of new systems.

The development of accurate electronics cost and schedule estimates has not been successful to date. While some of the difficulty is due to fundamental uncertainties in future prices and technologies as well as changes in military need, it should be possible to reduce both development and production cost uncertainties in the future. In addition, there is a pressing need to identify costs of ownership for both current and future systems.

In terms of relative priorities for immediate cost-saving impact and improvement in field reliability and mission availability, the Task Force believes that the most significant results can perhaps be realized if the recommendations relating to *Field Reliability* (7) and *Maintenance and Support* (6) are given the next highest priority for implementation after Recommendation (1). Of course, exact prioritization is a very subjective matter, but it appears that the greatest near-term potential lies in taking those actions which will result in improving the reliability and reducing the maintenance and support costs of military electronics presently in, or soon to enter the operational inventory.

Although these two areas possess the greatest potential for immediate payoff, the recommendations given in the other areas are also worthy of the most serious consideration by DOD, as they generally relate to actions which have potential for longer-range impact on the cost, reliability, and availability of military electronics. It should also be noted that, even though considerable emphasis is given to various approaches to achieving electronics cost reductions in the body of this report, the Task Force is firmly of the opinion that cost reduction is only one element of the total electronics management task. The procurement and ownership of military electronics should be managed in such a way as to achieve a more equitable distribution among cost, acquisition, performance, and support. Thus, any follow-on actions resulting from adoption of the recommendations presented in this report should be directed toward all aspects of the principle of providing military electronic systems with optimum operational readiness and adequate performance at minimum cost.

I. FULL COST ACCOUNTING AND ALLOCATION

FINDING: IT WILL BE IMPOSSIBLE FOR DOD TO DETERMINE THE TRUE IMPACT OF ELECTRONICS COST REDUCTION EFFORTS UNTIL BETTER COST ALLOCATION METHODS ARE DEVELOPED.

With respect to military electronics, government "indirect" costs are greater than direct costs (especially in the support phase), and the "indirect" costs are growing proportionately larger with fixed budgets, due both to rising manpower costs and increased equipment sophistication.

At the present time, it is difficult and in many cases not possible to obtain an accurate allocation of the "indirect" costs of electronic equipment owned and operated by the military Services. The government's ability to predict the indirect costs of electronic system ownership is significantly less developed than for the direct costs of ownership (and even these direct costs are frequently difficult to find on a subsystem basis).

Figure 1 indicated that the government indirect costs of electronics O&M in the FY 1974 budget were some 54 percent of the total electronics O&M budget of $5.6 billion, but this allocation, which was derived in the Electronics-X study, is admittedly based on source data of questionable validity. Accurate figures are presently impossible to obtain.

The present government accounting system and procedures used by the DOD do not permit the allocation of costs in such a way that the true impact of electronics acquisition cost reduction efforts, design to a cost contracting, in-house vs. contractor maintenance, contractor maintenance warranty agreements, field reliability improvement programs, and electronics standardization programs can be assessed with any degree of validity. Furthermore, adequate management "corrective actions" cannot be measured.

The DOD has correctly identified the need for determining the life cycle costs of major system acquisitions. While the problem of accurately estimating development and production costs has still not been adequately solved (as discussed further in Section III), it is appropriate to begin to emphasize cost of ownership. However, some words of caution are in order. First, the current deficiencies in cost accounting for O&M and overhead preclude the development of adequate ownership costs for equipment already in the inventory. Second, even when that problem is solved, considerable analytical effort will be necessary in order to use this information to validate and refine estimating techniques for the ownership costs of future equipment. Both steps are necessary; the efforts that are already underway in these areas should be expanded, both in setting up a data system and in gathering and using sample data. But premature contractual requirements for design to a "total" cost should be resisted until more is known.

RECOMMENDATIONS:

1. REVISE THE DOD ACCOUNTING SYSTEM TO BETTER IDENTIFY ALL ALLOCABLE DIRECT *AND* INDIRECT COSTS SO AS TO ESTABLISH TRUER COSTS OF ELECTRONICS.
2. IDENTIFY THOSE SUPPORT FUNCTIONS (INDIRECT COSTS) THAT ARE SUSCEPTIBLE TO REDUCTION IF POLICY ALTERNATIVES TO CURRENT SUPPORT PRACTICES ARE ADOPTED.

The following are the anticipated impacts of the above recommendations:

- *Better basis on which to conduct cost benefit analyses to support and measure more effective decision making.*
- *Identification of inadequacies in the ability to identify, compare, and evaluate the allocation of DOD vs. industry overhead support.*
- *Improved ability to assess the real effectiveness of design to a cost, in-house vs. contractor maintenance, warranty arrangements, field reliability improvement programs, and electronics standardization programs.*
- *Reduction of the level (and therefore costs) of "support" required for electronics equipment.*

II. MEETING THE MILITARY NEEDS

FINDING: ABERRATIONS IN THE PRESENT PROCESS OF MILITARY ELECTRONICS REQUIREMENTS DEFINITION AND ACQUISITION CAN AND DO DRIVE THE COSTS OF ACQUIRING SUCH EQUIPMENT. MANY SUCH ABERRATIONS RELATE TO COST-DRIVING ELEMENTS WHICH ARE NOT CONSISTENTLY SUBJECTED TO TOP-LEVEL AND DETAILED MANAGEMENT REVIEW.

Major electronic subsystems which are subsumed in major weapon systems (referred to herein as Class II electronics) and independently developed electronic subsystems intended for use in major weapon systems but not developed as a part of the major system program (referred to as Class III electronics) account for approximately ⅔ of the current DOD electronics acquisition budget (RDT&E plus procurement). The magnitude of each class of electronics in the FY 1974 acquisition budget is indicated in Figure 2. At the present time, Class II and III electronic subsystems are not subject to the Defense Systems Acquisition Review Council (DSARC) type of management review.

Typical aberrations of the requirements/acquisition process which have been found to be present with respect to these Class II and III electronic subsystems include the following:

- *Misunderstanding the Need*
- *Failure to Allow for Uncertainty in the Threat, and in Predicted Cost and Performance*
- *Adding Requirements "Down the Line"*
- *Poor User-Producer Interaction*
- *Insufficient User-Producer Iteration*
- *Pushing for Excessive Performance*
- *Unscheduled Addition of New Technology*
- *Poor Cost and Performance Data Base*
- *Inconsistent Commitment to Size of Buy*
- *"No Requirement"*
- *Contract Constraints and Excessive "ilities" Requirements*
- *Insufficient Comparison Between Product Improvement and New Generation Systems*
- *Insufficient "Reward" for Applying Standardization.*

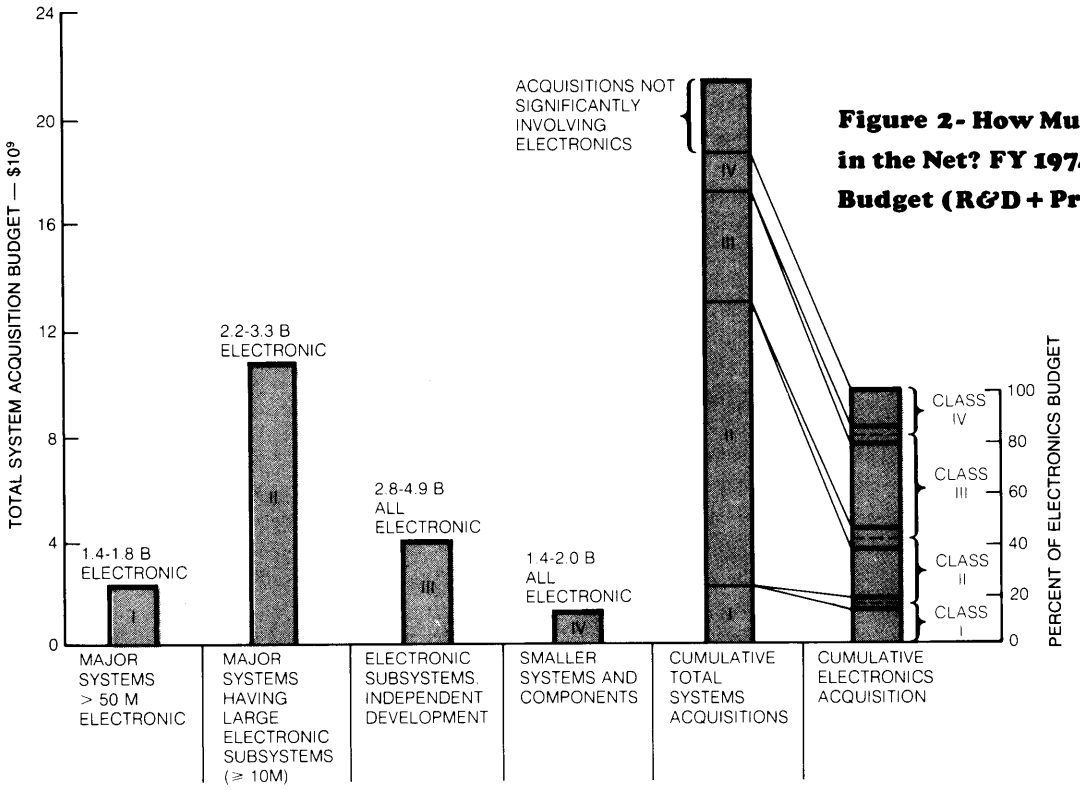


Figure 2- How Much Gets Caught in the Net? FY 1974 Acquisition Budget (R&D + Procurement)

The presence of aberrations such as these in a program obviously will tend to drive up the costs of acquisition, and the lack of a formal procedure for management review of the several billions of dollars worth of Class II and III programs, both as to their initiation and their progress, appears to be a significant factor in the growth in cost of their acquisition.

Since these Class II and III programs are not presently subject to formal management review in the same way that major weapon systems programs are, it is possible to expend large amounts of RDT&E money (and even, perhaps, production funds) without a detailed management evaluation having been made of the degree or extent to which such electronic subsystems satisfy or match a stated military threat or an approved military requirement.

The Task Force determined that, in establishing specific electronic system or subsystem requirements, there is a distinct tendency to emphasize the physical characteristics and functional performance required of the equipment, often at the expense of a clear examination and delineation of other critical requirements parameters such as acquisition and life cycle costs, development and production schedules, related process specifications, and quantities required to satisfy operational force needs. This emphasis on performance and configuration can have obviously adverse effects on the cost, schedule, and quantities procurable of the subsystem, and can potentially affect the degree to which the subsystem, even though successfully developed, can be effective in satisfying the stated military need (e.g., too expensive to buy in the required quantities, too late in availability, or very sophisticated and therefore difficult to operate and maintain). Also, a very large penalty must often be paid in terms of total acquisition and/or ownership costs for attempting to obtain electronic equipment which possesses reduced size or weight, or is developed on an overly ambitious schedule, for instance. The penalty associated with attempting to go beyond what is generally accepted as being "reasonable" is typically quite severe. Trying to push the state of the art in one area usually tends to increase the cost and delay the schedule of the entire project, even though the bulk of the effort may be "state of the art."

It was also observed that there is frequently a considerable degree of uncertainty during the acquisition decision-making process as to whether a stated military need could — or should — be best satisfied by developing a new electronic subsystem in sufficient numbers to counter the threat, or by investing in product improvements R&D, then modifying existing weapon systems so as to incorporate the results of the product improvement program.

Data were also examined by the Task Force (generated as a part of the Electronics-X study by the Institute for Defense Analyses and reviewed in preliminary format) which indicated that the average cost growth of a new generation weapon system as compared with the initial system intended to satisfy the military need (in terms of constant dollars) is 4 or 5 times per decade, compared with an average cost growth of about 2 times per decade for product improvement in an existing weapon system. These approximate cost growth relationships are depicted in graphical form in Figure 3, where the general slopes of the curves approximate the cost-ratio of the new and modified systems to the initial system.

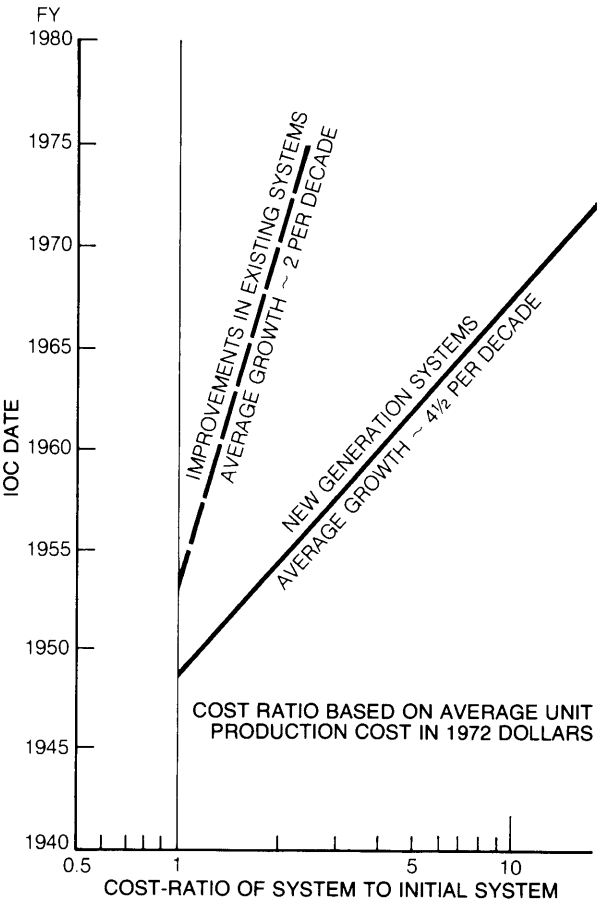


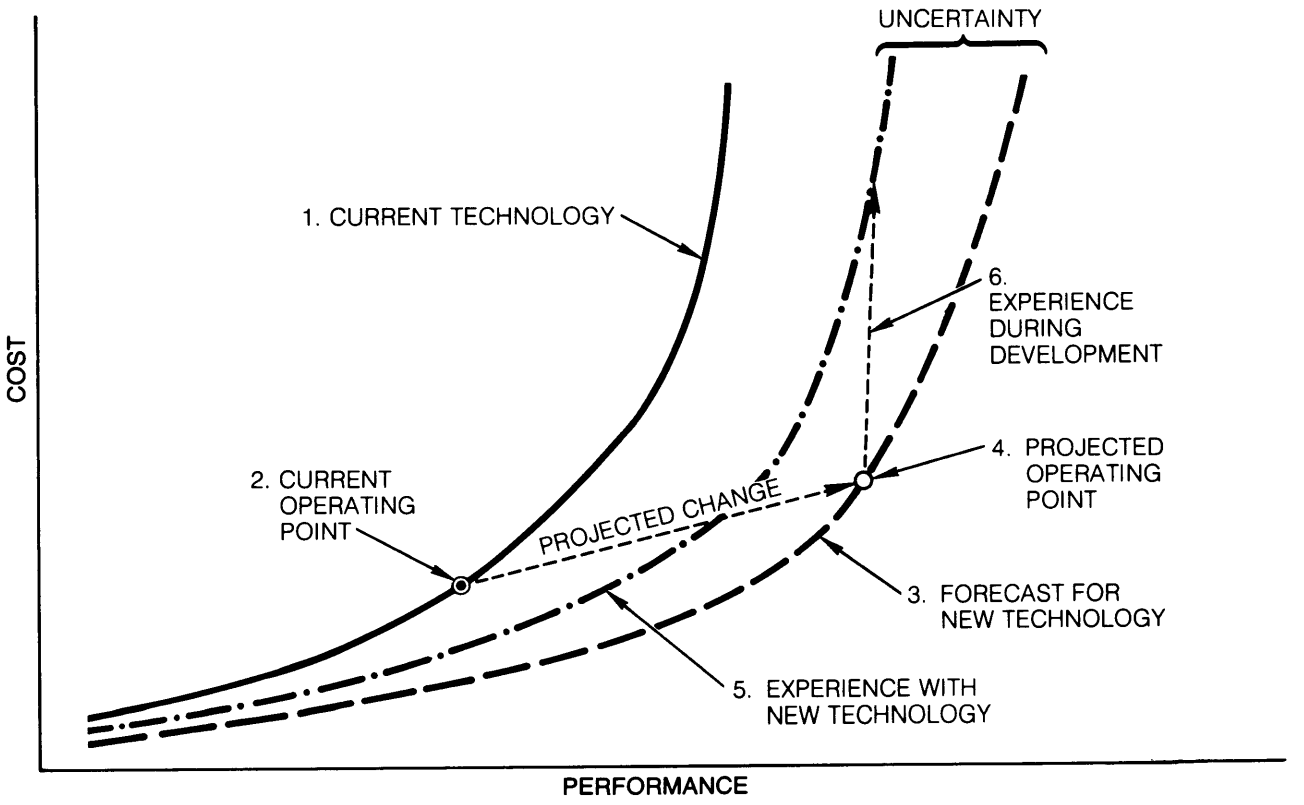
Figure 3—Progression of Costs

The lack of clear distinction between new generation and product improvement alternatives can often lead to a mis-timing of new generation acquisition decisions, or to failure to allow for technical and schedule uncertainties which may result from pressing the state of the art too hard, or frequently to cost growth through the proliferation of cost-driving "added requirements" during the design and development phase of the new generation acquisition.

Another factor that is frequently overlooked in making the acquisition decision to meet a stated military need is the impact of technological uncertainty on the acquisition cost and system performance of electronic systems alternatives. As depicted in Figure 4, there is a diverging band of uncertainty associated with a change from current technology to new technology in order to achieve performance improvement. The greater the desired performance increment, the more rapidly the costs tend to increase if the new technology fails to meet its forecast.

As indicated in Figure 4, the cost growth involved in achieving a desired increment of performance improvement can be substantial when the experience with new technology during development is considered. In military electronics practice, it seems to be generally true that advances in new technology are exploited to obtain increased performance rather than to utilize new technology to realize equivalent performance at lower cost and higher reliability. Large jumps in technology are nearly always found to be very costly, and are very seldom undertaken in commercial practice, which prefers to use small advances in technology to achieve improved performance at lower cost (i.e., from the "current operating point" in Figure 4, move down and to the right, rather than up and to the right to the "projected operating point" as shown). Due to the uncertainties in the use of new technology, particularly in the case of complex electronics, the strategy depicted in Figure 4 will nearly always result in higher acquisition costs. This is especially true if performance objectives are held firm when the technology uncertainty is realized.

Figure 4–Impact of Uncertainty on Systems Acquisition Cost and Schedule



Most development contracts carry incentives on performance and cost which tend to motivate the contractor against expending additional engineering effort during development to reduce the unit production cost. This type of incentive contracting minimizes current program costs, but not total acquisition cost of electronic equipment.

RECOMMENDATIONS:

1. CHANGE THE NEED PHILOSOPHY FROM ONE THAT IS TECHNOLOGY-DRIVEN TO ONE THAT IS DRIVEN BY STATED MILITARY NEEDS: "BECAUSE WE *CAN*, WE *MUST*" IS A PHILOSOPHY WHICH CAN NO LONGER BE AFFORDED.
2. REALISTIC NEED DATES AND QUANTITIES SHOULD BE CONSISTENTLY STATED IN THE DEFINITION OF REQUIREMENTS.
3. MANAGEMENT OF ELECTRONICS PROGRAMS BY THE SERVICES, PARTICULARLY CLASS II AND III, SHOULD INSURE THAT INITIATION AND PROGRESS ARE COMPATIBLE WITH ESTABLISHED GOALS FOR NUMBERS, COST, RELIABILITY, STANDARDIZATION, AND SCHEDULES, EVEN IF PERFORMANCE MUST BE COMPROMISED.
4. ACQUISITION DECISIONS SHOULD CONSIDER NEW GENERATION VERSUS PRODUCT IMPROVEMENT CHOICES; COMPETITION SHOULD BE CONTINUED AS LONG AS FEASIBLE.
5. WHENEVER FEASIBLE, MULTI-CONTRACTOR DESIGN AND PRICE COMPETITIONS SHOULD BE CONTINUED THROUGH DEVELOPMENT AND INTO PRODUCTION.

The impact of the above recommendations should include lower acquisition costs to satisfy military electronics needs, elimination of unnecessary major electronics subsystem development activities, and reduction in the total costs of ownership of electronics subsystems and equipment. With respect to Recommendation No. 5 above, continuing competition for electronics equipment for aircraft and other complex installations may have greater impact if mandatory interface specifications are incorporated into the development specification, thus assuring the interchangeability of competitive equipment.

III. UNCERTAINTIES IN COST AND SCHEDULE

FINDING: **DEVELOPMENT OF ACCURATE ELECTRONICS COST AND SCHEDULE ESTIMATES HAS NOT BEEN SUCCESSFUL TO DATE.**

The accuracy of cost estimates generally varies in direct proportion to the degree of definition of the acquisition program and of the product or end item to be acquired. Unanticipated program and product changes are believed to account for nearly half of the "poor" estimates in weapon systems development and production programs, while the other causes are divided about equally between the effects of inflation and economic forecasting errors on the one hand, and incorrect estimating techniques and methods on the other.

The best cost and schedule estimates for electronics generally come from the lowest organizational element charged with responsibility for performing the effort being estimated. In contracted efforts, the best estimate is typically produced by the functional organizational elements using traditional engineering estimating techniques.

Most electronics cost estimates are made using an engineering pricing approach which requires a detailed preliminary design. This approach is inappropriate for government use in making independent cost estimates, as government agencies normally do not produce detailed preliminary designs, and also lack knowledge of, or access to, appropriate industrial cost factors to be applied to designs to find the estimated costs.[1]

Although there is a strong interrelationship between program costs and program schedules, cost growth can generally not be controlled effectively by means of schedule changes. Cost and schedule estimating efforts must be closely linked in order to emphasize their interrelationships and to provide an increased data base from past experience. Experience has shown that there is nearly always a cost penalty associated with the setting of an unrealistic program schedule. Even when the "realistic" amount of time has gone by, the program generally has cost more than it would have if it had been started originally on the more "realistic" schedule.

Studies of major weapon system development and production programs by the General Accounting Office led to the conclusion that the uncertainty of estimating the costs of the development and production phases during the development phase itself is, on a percentage basis, considerably greater than the estimating uncertainty during the production phase. Some data indicate that the uncertainty in development cost may be as much as 150 percent from DSARC I to DSARC III, while the average production cost growth during the production phase is only about 25 percent. No data were found to exist regarding the growth of the ultimate production unit price as predicted at DSARC I, II, III, and eventually achieved.

Although development cost growth during the development phase appears to be the more acute problem, on a percentage basis, than production cost growth during the production phase, this may not always be the case when absolute cost increments are considered. 150 percent cost growth at the front end of a program (i.e., during the development phase) may be considerably less in actual dollars than is 25 percent production cost growth during the production phase, particularly for programs with any production volume. The total cost of a program involving large production quantities is primarily in the production and support phases.

Therefore, the primary objective should be to manage the development phase to "design to a cost" for the production and support phases. Unfortunately, very little data exist in the DOD sphere to quantify the uncertainty in being able to achieve this objective. However, experience in the commercial electronics field — using both proven technology and advanced technology — suggests that it is indeed possible to achieve unit production cost targets which are quite close to those established by market research and preliminary design at the initiation of the development cycle.

The DOD should now begin to accumulate data on its design to a cost programs in order to quantify the cost uncertainties associated with attempting to predict the subsequent production and support costs of a product during its development phase.

It should also be recognized that uncertainties in estimating the costs of a program (nearly always with an optimistic bias) are in part the inherent result of a desire on the part of the government and the contractor to sell the program to higher management. Cultural pressures

[1] For a more detailed discussion of this point with respect to avionics, see D. J. Dreyfuss, *A Survey of Costing Methods in the Avionics Industry*, The Rand Corporation, WN-8235-ARPA, May 1973.

throughout the entire defense procurement community tend to make estimates progressively below realistically attainable levels. If the true costs of any given program were known at the outset, the program might well never be authorized in the first place. This, of course, would reduce the frequency with which cost growth occurs in defense procurement, but it might also deny the nation vitally needed new military electronics developments.

The parametric approach to cost estimating is generally found to be unsatisfactory in electronics procurement because individual firms are precluded from assembling cost data on design, development, and production experience which may be possessed by their competitors. Thus, each contractor is restricted to his own data and historical pricing experience, which permits only a small and statistically invalid costing data base. The government should sponsor studies of historical costing data on appropriate projects to enable it to fully understand the cost impact of the requirements which are placed on new acquisition programs. It may be possible to develop parametric cost models for electronic equipment types or classes which will permit far more accurate parametric estimating than has been possible up to now. If this is possible, it might eventually result in the ability of the DOD to include *lower cost* concepts instead of *higher performance* concepts, through improved ability to select the option that best meets the funding which is available.

It was also determined that the development of life cycle costs for electronics is at present a very imprecise process. The uncertainties in cost of ownership are very large even at the time of full scale production (DSARC III). This is perhaps due to inconsistency and lack of accuracy in definition of all the relevant ownership cost elements involved, and also due to the inability to quantify the government O&M costs with any degree of confidence, as discussed in Section I above.

RECOMMENDATIONS:

1. THE GOVERNMENT SHOULD EXTEND ITS CAPABILITY TO INDEPENDENTLY CONSTRUCT DETAILED COST AND SCHEDULE ESTIMATES FOR ELECTRONICS.
2. THE GOVERNMENT SHOULD DEVELOP ITS CAPABILITIES TO DO PARAMETRIC COST MODELING AND ESTIMATING.
3. THE INPUTS OF GOVERNMENT COST ESTIMATING SPECIALISTS AND PRICE ANALYSTS SHOULD BE CAREFULLY CONSIDERED IN THE DELIBERATIONS OF SOURCE SELECTION TEAMS.
4. THE ELECTRONICS PROCUREMENT CULTURE SHOULD BE CHANGED SO AS TO STRESS AND ENCOURAGE MORE REALISTIC COST AND SCHEDULE ESTIMATING PRACTICES BY BOTH CONTRACTORS AND PROCURING AGENCIES

The following are believed to be some of the more significant impacts which should result from adoption of the above recommendations:

- *More realistic and credible cost and schedule information on which to base budget requests and program management actions.*
- *Achievement of the objectives of electronics acquisition cost reduction, particularly in application of design to a cost concepts.*
- *Creation of an effective check against overoptimism in estimating program costs by the government program office and/or the contractor.*
- *Reduction in the absolute levels of unanticipated cost growth during the acquisition cycle.*
- *Ability to push for more realistic program schedules as a means of limiting or preventing unanticipated cost growth.*
- *Creation of a procurement environment in which reasonable contingency funding provisions (as discussed in Section IV) may be attainable.*
- *Some increase in the cost of government "overhead" functions to carry out the added management activities involved.*

IV. DESIGN TO A COST

FINDING: THE APPLICATION OF DESIGN TO A COST CONCEPTS TO MANY KINDS OF ELECTRONICS ACQUISITION PROGRAMS CAN BE VERY EFFECTIVE IN REDUCING COSTS, BUT IT SHOULD NOT BE CONSIDERED A PANACEA FOR ALL COST PROBLEMS.

In drawing up acquisition contracts to implement design to a cost principles, particular care should be given to the manner in which "what" is to be done, "when" it is to be accomplished, and at "what cost" are specified:

The "design-to" cost should normally be the unit production cost which the government, after detailed analyses by both industry and the DOD, is willing to pay for the desired military capability, and which is compatible with the likely quantities that will be procured, and with current — or otherwise specified — technology.

As indicated in Figure 5, the "design-to" cost should be, ideally, a firm dollar value or point. Given the uncertainties in cost estimation discussed in the preceding section, and the importance of not unduly inhibiting the program manager's flexibility, it may be necessary to establish a narrow range (i.e., a moving "point") for the "design-to" cost, at least in the initial stages of development.

The "design-to" cost objective should normally be applied to the unit production cost, particularly in view of the fact that the deficiencies in the DOD cost accounting system examined in Section I above essentially preclude the life cycle cost target as an attainable option in design to a cost procurements at this time. However, it should be recognized that life cycle costs of electronic equipment are extremely important. If more effective techniques for estimating life cycle costs can be developed, it will be possible to invest in electronic hardware that may be higher in cost per unit, but much lower in cost over its total lifetime. Such tradeoffs of reliability and maintainability for unit production cost should be retained as objectives as the design to a cost concept evolves. Refined "design-to" costs during the development phase should take these factors into account.

- **TO DO "WHAT" AND "WHEN" AT "WHAT COST"?**

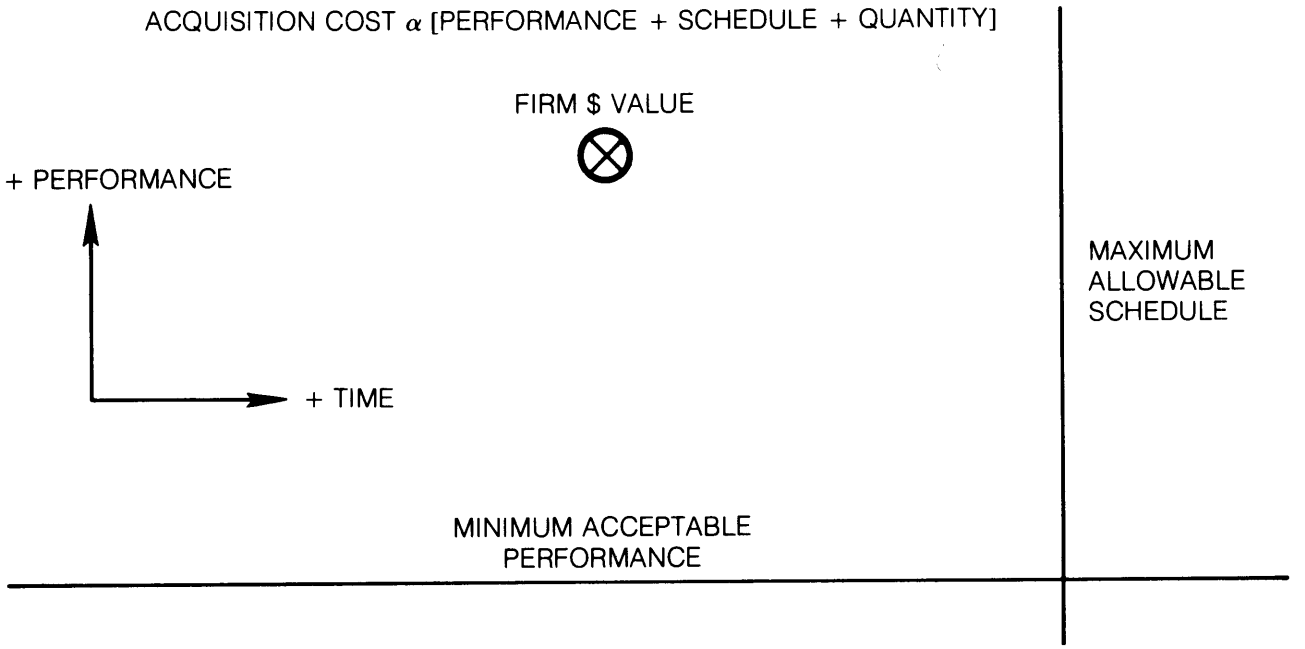


Figure 5—Design to a Cost

In order for the contractor to be able to achieve the specified "design-to" cost, the government program manager must have sufficient flexibility in his direction of the project to be able to authorize certain variations in the schedule on which the work will be performed (e.g., specific milestones during the acquisition cycle, or the IOC date for the end product). Such variations should naturally be within certain specified ranges, which may be established in advance by the procuring authority, or perhaps negotiated as the program proceeds. Similarly, the performance requirements for the equipment must be subject to negotiation within certain allowable limits in the same way as the schedule. The significant point to be recognized in design to a cost contracting is that the acquisition cost is in fact a dependent function of performance, schedule, and quantity. If it is desired to maintain an agreed-to "design-to" cost, and the quantity to be acquired is presumably a firm number, then it is clear that the only two parameters which can be varied are performance and schedule.

As depicted in Figure 5, it is necessary to establish the firm "design-to" cost at a point which will allow a certain amount of tradeoff between performance and schedule before either the minimum acceptable performance or the maximum allowable schedule is reached. If the firm dollar value objective is originally set at a point too near either the minimum acceptable performance or the maximum allowable schedule, the program manager will not have sufficient flexibility to trade off these two parameters in such a way as to meet the established "design-to" cost while still maintaining the desired quantity to be procured, the allowable schedule, and acceptable performance for the purpose intended.

Development schedules for electronics are often so short that there is barely sufficient time to select a design which will meet the performance requirement. Once this first-cut design is completed and a good product definition exists for a realistic production and maintenance cost estimate, the contractor can generally recognize opportunities for significant redesign for purposes of reduction of the cost of ownership. However, the schedule constraints of the program usually preclude this second design iteration, (nearly always done in commercial practice), with the result that too many (military) electronic systems go into the inventory with unnecessarily high costs of ownership.

In the evolution of commercial electronic products, it is general practice to first build a model which demonstrates the functioning of the device. The ensuing production design phase is intended primarily to reduce the cost of ownership of the product. This phase generally requires supplementing of the development team with personnel experienced in manufacturing methods, materials and processes, and specific experience in full maintenance. While it would be ideally desirable to include these production characteristics in the initially designed model, commercial experience has demonstrated that production-oriented specialists cannot couple effectively to a project until the basic functions have been defined and a functional working design exists. This is the reason for the two-iteration approach in commercial electronics development. It must be recognized that the second design iteration will increase the cost and duration of the RDT&E phase, but experience demonstrates that it also significantly reduces the unit production cost (or the cost of ownership) of the end product.

In the private sector, planned selling prices normally include substantial margins over manufacturing costs to allow for contingencies. In the DOD case, the budget review process ruthlessly excises contingencies, unless they are cleverly hidden. This is presumably consistent with our federal self-insurance doctrine, but in the real world of budget requests, authorizations, appropriations, and allocations as now practiced in the Congress, OMB, and DOD, it means inevitable and unpopular reprogrammings of dollars and/or quantities. The concept of allowing openly-identified contingency funds in budget submissions at levels as established by OSD guidelines would go a long way toward achieving program stability and avoiding the stigma of "cost growth." Precedent for such an approach exists in our military construction programs where the need for such reserves is much less acute.

In reviewing several of the first applications of the design to a cost concept to military electronics acquisitions (AN/APN 209 Altimeter, AN/ARN 114 Helicopter Loran, Low Cost EW Suite, AN/ARN XXX TACAN, AN/ARC XXX UHF Radio, and MICRON), the Task Force concluded that it will perhaps be several years before the results from these projects become available as guidance for further activity in this area. Since OSD has already directed that design to a cost goals be established for all major

DSARC programs.[1] and since the application of design to a cost contracting principles is rapidly being made to nearly all new military electronics procurements at this time, it seems clear that it will not be feasible to await the outcome of these initial applications before establishing further DOD ground rules and guidelines.

The Task Force observed, however, that it will obviously not be practicable to attempt to implement the design to a cost concept by merely adding a "design to a cost" clause at the end of the typical development contract which already contains contractual terms and conditions which are inconsistent and incompatible with the purpose and objectives of the design to a cost concept. The usual parade of MIL specs and standards, correction of deficiencies clauses, and the like is inconsistent with the management flexibility on which the success of design to a cost contracting depends. If design to a cost is implemented in an inflexible way, it will almost certainly be doomed to failure. Although design to a cost should not be looked upon as a panacea for all of DOD's acquisition problems in any event, it does appear to hold considerable promise for contributing to the solution of some of the problems now becoming very critical in this time of rising costs of acquisition and ownership of military electronics.

RECOMMENDATIONS:

1. DON'T ATTEMPT TO INSTITUTIONALIZE THE CONCEPT. USE GUIDELINES RATHER THAN ASPR OR FORMAL DODD. MODIFY ASPR TO ENCOURAGE *FLEXIBILITY* WHERE INDICATED.
2. GIVE PROGRAM MANAGER SUFFICIENT AUTHORITY TO TRADE OFF SCHEDULE AND PERFORMANCE — WITHIN ESTABLISHED LIMITS — AS NECESSARY TO MEET THE "DESIGN-TO" COST.
3. ESTABLISH THE UNIT PRODUCTION COST EARLY IN CONCEPT DEVELOPMENT.
4. DON'T INCORPORATE TERMS AND CONDITIONS IN DESIGN TO A COST CONTRACTS WHICH CONFLICT WITH, OR INHIBIT, THE FLEXIBILITY THE CONCEPT REQUIRES.
5. INCLUDE TIME AND FUNDING FOR A PRODUCTION DESIGN PHASE SO THE "DESIGN-TO" COST GOAL CAN BE ASSURED AFTER BASIC PERFORMANCE IS DEMONSTRATED.
6. DURING SOURCE SELECTION AND PRODUCT DEVELOPMENT, STRESS LIFE CYCLE COSTS (ESPECIALLY RELIABILITY AND MAINTAINABILITY) AS WELL AS UNIT PRODUCTION COST.

Adoption of the above recommendations is believed to provide the DOD with a means of implementing design to a cost which will allow the acquisition of military electronics with significant savings in unit production costs or life cycle costs, or both, without adversely affecting field reliability, mission availability, or quantities necessary to satisfy force requirements. If administered with the proper degree of flexibility, design to a cost can be a very effective tool for controlling the cost growth of military electronics acquisitions in three significant areas:

- *Heightened cost consciousness*
- *Increased cost avoidance*
- *Greater cost reductions.*

[1]W. P. Clements Memorandum "Design to a Cost Objectives on DSARC Programs" June 18, 1973.

V. MAINTENANCE AND SUPPORT

FINDING: SUBSTANTIAL SAVINGS IN THE ANNUAL COST OF MILITARY SUPPORT OF ELECTRONIC EQUIPMENT CAN BE REALIZED IF SIGNIFICANT CHANGES ARE MADE IN THE PRESENT LOGISTIC AND SUPPORT CULTURE.

Of the total FY 1974 Operations and Maintenance budget, the electronics O&M portion is estimated to be more than one-quarter of the total, or greater than $5.6 billion. As discussed in Section I, the actual level is unknown due to limitations in the cost allocation system. The O&M area represents a very promising field for the realization of substantial cost savings, due not only to the absolute magnitude of the annual expenditure, but also because of the particular nature of the activities involved. Many of the procedures and techniques involved in the maintenance and support of electronics are non-military peculiar; that is, they involve activities which are commonly performed in industry, and which can be accomplished under competitive maintenance service contracts with industry insofar as the actual work to be done is concerned.

At the present time, the costs for manpower are estimated to account for perhaps as much as 75 percent of the military electronics maintenance costs. As the transition to an all-volunteer force continues, it can be expected that the costs for manpower — particularly skilled classifications as are needed to perform many electronic maintenance functions — will continue to rise at a very rapid rate. This will further compound the present problems of providing organic maintenance and support for military electronics which have arisen due to limitations of skilled and qualified personnel and rising costs in an environment of heavy pressures on the DOD budget.

There has been traditionally a policy in the government for the use of the private sector for such goods and services as can readily be supplied from that quarter. OMB Circular A-76 has delineated this as federal policy for many years, directing government agencies to obtain goods and services from the private sector except where such procurement would not be in the best interests of the government. In this regard, the Task Force recognizes and supports the need for the military Services to maintain significant capabilities to support much of their equipment, particularly in such circumstances as shipboard service, forward area or hazardous duty locations, non-routine and non-scheduled maintenance of mission-critical equipment, and equipment vital to the maintenance of combat readiness, for example.

But in addition to this type of maintenance and support, there is a large amount of routine depot-level maintenance and support work which could be accomplished as well (or better), and in many cases at lower cost, if assigned to qualified industrial contractors. True comparisons are difficult if not impossible to make under present procedures. Government costing for maintenance and support is done incrementally. Industry is required to consider the total costs associated with the effort, including depreciation, and also must consider return on investment.

In any event, there does appear to be some degree of merit in considering the possibilities of placing more electronics maintenance and support work with industrial contractors on a carefully selective basis — provided that the existing government maintenance and support complex is reduced to a corresponding degree. The Services obviously need to retain an in-house capability to accomplish certain types of maintenance and support, but it is believed that there is considerable room for reduction in the overall level of in-house maintenance and support of electronics without adverse impact on the total military capability.

The Task Force also gave serious consideration to the questions of the applicability and use of various kinds of contractor warranty arrangements for obtaining electronic equipment maintenance and repair for a certain initial period of time after equipment delivery. It appears that the selective use of warranties, particularly in the case of certain types of small, sealed, self-contained, and readily removable electronic units, may offer distinct advantages in contractor reliability design incentives, support cost savings, and increased reliability and availability of such equipment. Here, the practices being followed by the commercial airline industry, with technical support from ARINC, seem to be particularly applicable, or at least worthy of detailed examination by the Services. ARINC cost analyses were examined

which indicate that the use of failure-free warranties can be quite cost effective in certain instances, when applied to appropriate types of equipment and when used in selected environments. There are, of course, many unique requirements associated with military logistics which may preclude the use of contractor maintenance warranties in certain applications and with respect to particular types of electronics. But there are believed to be many potential applications (e.g., during the early phases of operational usage prior to design stabilization) where the employment of such warranties would be highly beneficial to the government.

In cases where the use of warranty agreements does appear to be appropriate, care would have to be taken to ensure that current DOD contract boilerplate covering such aspects as Correction of Deficiencies, Value Engineering, and Incentives is examined carefully and modified as necessary to make such terms and conditions consistent with the maintenance warranty features employed.

A reservation was expressed during the Task Force's consideration of warranties as to the value of attempting direct comparisons with such practice in the commercial electronics world, where "business relationships" and informal agreements facilitate warranty administration as opposed to the DOD procurement culture where user-producer relationships are kept at arm's length. Due to such differences, the DOD should be careful not to apply warranties indiscriminately as a solution to all maintenance and support problems. Warranties should be applied selectively and with deliberate speed, but they should not arbitrarily be applied across the board as another "ility" laid on top of other contractual clauses.

RECOMMENDATIONS:

1. DOD SHOULD ACCEPT THE CHALLENGE TO REALIZE MAJOR COST SAVINGS BY MAKING SIGNIFICANT CHANGES IN THE PRESENT ELECTRONICS LOGISTICS AND SUPPORT CULTURE: REDUCE THE LEVEL OF IN-HOUSE ELECTRONICS MAINTENANCE ACTIVITIES BY ESTABLISHING A PROGRAM WHICH HAS EXPLICIT GOALS SUCH AS 5 % REDUCTION PER YEAR OVER THE NEXT 10 YEARS.
2. ON A CAREFULLY SELECTIVE BASIS, INCREASE THE APPLICATION OF WARRANTY ARRANGEMENTS FOR APPROPRIATE TYPES OF ELECTRONIC EQUIPMENT. WHEN USED, MODIFY OR ELIMINATE INAPPROPRIATE CONTRACTUAL TERMS AND CONDITIONS.
3. IMPROVE THE "FEEDBACK" ON FIELD RELIABILITY AND AVAILABILITY TO ASSURE THAT AS THE ABOVE STEPS ARE TAKEN, THE MISSION AVAILABILITY OF MILITARY ELECTRONICS WILL ALSO IMPROVE.

Among the impacts which may be expected as a result of the above recommendations are reduced overall annual costs for military electronics maintenance and support, a gradual reduction in the total government investment in maintenance facilities, and decreased costs of ownership for individual items in the current military electronics inventory. The flexibility of the military support force should be considerably greater than at present, and the mission availability of military electronics should be at least as good as, if not better than, that presently attainable. It is believed that it should be possible to accomplish a gradual reduction in the level of in-house electronics maintenance without adversely impacting operational readiness if the above recommendations are properly and carefully administered.

VI. FIELD RELIABILITY

FINDING: THERE IS A POTENTIAL FOR SIGNIFICANT COST SAVINGS AND INCREASED MISSION AVAILABILITY IF RELIABILITY OF ELECTRONIC EQUIPMENT IN THE PRESENT INVENTORY CAN BE UPGRADED.

Military electronic equipment in the current inventory poses the following paradox: we have both extremely complex, highly reliable electronic systems in the military inventory, and we also have less complex, but very unreliable systems. Well-designed equipments can be as much as four times more reliable than the median, and poorly-designed equipments can be one-fourth as reliable. In general, the explanation appears to be that acceptable levels of field reliability *can* be achieved if the requisite investment in time and funds for appropriate development testing and production design specifications is made. Where a less comprehensive program is carried out, poor reliability is often the result. In short, we know *how* to achieve high reliability, and we *can* obtain it *if* we are willing to pay for it. Correspondingly, if the military can bring itself to specify electronic equipments that are half as complex, it could not only afford to buy twice as many, but each could operate reliably for up to twice as long.

The mean time between failures (MTBF) observed in operational electronic equipment is frequently far below the value called out in the development specification, and also often well below the value demonstrated during the course of development testing. There are indications that the MTBF called for in the procurement specification is frequently an unreasonably high figure (based on what is considered "desirable" as compared with what the state of the art indicates is a reasonable or achievable value). The specified MTBF frequently bears little or no relationship to what is required by the contemplated military use, also. Considerable design time and developmental test effort is expended in attempting to achieve these unreasonable specification values, most frequently without success. Such overspecification merely dissipates available resources without beneficial return.

MTBF's are frequently demonstrated during developmental testing which are higher than those experienced during field use. This is most often the result of unrealistic test environments which do not sufficiently reflect the operational-use environment or the true operating and maintenance conditions to which the equipment will later be subjected.

Experience has adequately demonstrated that reliability *can* be improved if careful design and testing are continued throughout the development program and *into* the initial production phase. Also, the performance of production testing in a realistic test environment which simulates operational-use conditions is known to enhance operational reliability. But test results can best enhance operational reliability if the *results* themselves become timely feedback to the contractor engaged in further development effort.

Field reliability can be increased if continuing product improvement activities are supported with adequate resources, and if the development contractor is provided with accurate field failure data upon which to base his product improvement efforts and testing.

The availability of proven and qualified electronic parts and components, together with the disciplined adherence to proven manufacturing processes and techniques will enhance the field reliability of military electronic equipment.

The carefully selective use of contractor maintenance warranties should result in improved reliability in certain types of electronic equipment, particularly where the warranty arrangement encourages the routine incorporation of product improvement modifications as a part of the maintenance and repair process.

Software related to electronics hardware also must be tested and evaluated thoroughly. For example, as computerized avionics systems become increasingly complex, software testing and evaluation becomes critical. This will require developers and users to invest time and money in systematic testing of software packages for such hardware as avionics, flight training simulators, and automatic test equipment. An example of the kind of problems that otherwise occur was revealed by a test program on the A-7 system. A major cause of seemingly low reliability of the bomb delivery system that had plagued the Air Force and the Navy for several years of operational use turned out to be software errors in the operational flight program that had not been isolated previously.

Finally, it was observed that the DOD maintenance culture tends to work against the best interests of operational equipment reliability at times due to the fact that maintenance funds must normally be used only to "fix" or "repair" faulty

equipment. Operational maintenance money is normally not allowed to be spent to "avoid repairing" equipment, even though this may be less expensive to the government in the long run.

RECOMMENDATIONS:

1. DOD SHOULD ALLOCATE SPECIFIC RESOURCES FOR ADDITIONAL RDT&E ON OPERATIONAL ELECTRONIC ITEMS TO IMPROVE RELIABILITY AND AVAILABILITY.
2. FEEDBACK OF FIELD FAILURE DATA TO THE DEVELOPMENT CONTRACTOR SHOULD BE STRENGTHENED, AND FUNDS PROVIDED FOR REDESIGN/RETROFIT WHERE OPERATIONAL PERFORMANCE OR RELIABILITY IS INADEQUATE.
3. TIME AND RESOURCES SHOULD BE MADE AVAILABLE FOR RIGOROUS DEVELOPMENT, SOME LIMITED PRODUCTION, AND OPERATIONAL TEST AND EVALUATION TO CORRECT DEFICIENCIES *BEFORE* EXTENSIVE FIELD DEPLOYMENT IS MADE.
4. DEVELOPMENT CONTRACTORS SHOULD BE ENCOURAGED TO SEEK THAT LEVEL OF LIFE CYCLE COST AT WHICH RELIABILITY AND COST ARE OPTIMIZED.
5. TO THE GREATEST PRACTICABLE EXTENT, DOD SHOULD PROVIDE FLEXIBILITY FOR INTERCHANGE OF DEVELOPMENT, PROCUREMENT, AND LOGISTICS FUNDING TO SUPPORT IMPROVEMENTS IN ELECTRONICS RELIABILITY AND AVAILABILITY.
6. WHEN MTBF OR FAILURE RATES ARE SPECIFIED, THEY SHOULD BE SET AT VALUES WHICH ARE REASONABLE, REALIZABLE, AND CONSISTENT WITH THE EXPECTED COMPLEXITY (OR UNIT PRODUCTION COST) AND THE TYPE OF ELECTRONICS REQUIRED.
7. DOD SHOULD CONDUCT A COMPREHENSIVE STUDY OF SOFTWARE DEVELOPMENT, TEST, AND EVALUATION PRACTICES AS A PRELUDE TO IDENTIFYING AND IMPLEMENTING SPECIFIC FORMAL PROGRAMS FOR ENHANCING SOFTWARE RELIABILITY.

Among the potential impacts of these recommendations for achieving greater field reliability in the operational electronics inventory are the following:

- *Improvement in the present levels of reliability and mission availability of military electronics in the current inventory, which is believed to possess a significant potential for near-term cost savings and increased operational effectiveness.*
- *Increasing the reliability of electronics in the current inventory attacks the cost problem on all three fronts: cost consciousness, cost avoidance, and cost reduction. It will also provide immediate improvement in operational readiness and mission performance capability.*
- *Achievement of the flexibility needed for the interchange of development, procurement, and logistics funding is recognized to be a very difficult task, which may be dependent on management and budget structure realignment.*

VII. STANDARDIZATION

FINDING: SIGNIFICANT COST SAVINGS AND RELIABILITY IMPROVEMENTS IN MILITARY ELECTRONICS SHOULD BE POSSIBLE THROUGH THE INSTITUTION OF PROPERLY DEFINED AND STRUCTURED PROGRAMS OF ELECTRONICS STANDARDIZATION.

Electronics standardization poses a dilemma for the Department of Defense: how to realize the advantages of volume buys, less development effort, proven equipment and parts, and reduced maintenance and support costs — while at the same time not raising costs, eliminating competition, stifling technological innovation and evolution, or conflicting with optimum systems engineering.

It must be recognized that there are major differences in the standardization approach which may be applicable to spacecraft electronics, missile electronics, avionics, shipboard and submarine electronics, Army field equipment, and air-conditioned rack electronics to name a few. Each type of electronics has its own particular design requirements and the type of standardization which may be suitable for one type may be wholly inappropriate for others.

Electronic standardization can be applied at any of a number of different levels: subsystems, equipments, modules, boards, parts, LSI standard cells, and semiconductor cells for example. An overall philosophy of electronics standardization does not currently exist within the DOD, but such a philosophy can and should be developed. The specific application of any type or level of standardization to military electronics, however, must always be carefully selected to fit the particular needs of the individual situation.

"Across the board" standardization of military electronics would be in conflict with the DOD philosophy of delegated program management within each of the service departments, and on any given program. The net effect of selective standardization, even if applied with the greatest of care, can be positive only if the overall situation is viewed as a management matrix in which such factors as military need, quantity, performance, reliability, cost, schedule, maintainability, mission availability, state of the art, producibility, and similar considerations are taken into account.

Standardization of electronic parts and components has been applied to military electronics with significant and measurable benefits for many years. With the rapid advent of new technology, standard parts will be at least partially supplanted by such new forms of electronic standardization as standard LSI cells and standard semiconductor processes. The influence of such technological advancements must be carefully considered in the establishment of DOD policy and guidelines for electronics standardization.

Increased emphasis appears to be desirable on tri-service standardization of subsystems and equipments such as aircraft radios, TACANS, and similar types of electronics commonly used by more than one service. This should include increased application of standardized interface / interconnection specifications with form-fit-function specifications (including computer language) of "black boxes" which can be interchangeably employed in various installations.

There are many activities relating to electronics standardization currently underway within various government organizations and agencies, such as the SAMSO and AEC programs for production of critical high-reliability parts and components on captive or controlled production lines in selected industrial contractors' plants, the Navy Standard Hardware Program, and the Defense Materiel Specifications and Standards Board, to name a few.

RECOMMENDATIONS:

1. DOD SHOULD CONDUCT A COMPREHENSIVE ELECTRONICS STANDARDIZATION STUDY — INCLUDING LEVELS, TYPES, TECHNOLOGIES, SPECS, AND IMPLEMENTING DOCUMENTATION — BEFORE ESTABLISHING POLICIES OR FORMAL PROGRAMS.
2. ELECTRONICS STANDARDIZATION SHOULD BE APPLIED ONLY ON A CAREFULLY SELECTIVE BASIS WITH DUE CONSIDERATION OF THE PARTICULAR CIRCUMSTANCES.
3. THE BEST AREA FOR INITIAL STANDARDIZATION EFFORTS MAY BE IN TRI-SERVICE APPLICATIONS OF STANDARD BLACK BOX INTERFACES.

If properly formulated and carefully applied, a well-conceived program of military electronics standardization can have a substantial positive impact on acquisition and life cycle costs as well as on the field reliability and mission availability of military electronic equipment and systems.