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BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

Effectiveness Of U.S. Forces Can Be Increased Through Improved Weapon System Design

Many of today's military systems cannot be adequately operated, maintained, or supported because the Department of Defense does not pay enough attention to logistic support, human factors, and quality assurance during the design phase of the acquisition process. These problems deter the systems' effectiveness to defend our country in case of war.

GAO therefore makes recommendations to improve the management and planning of ownership considerations that have an impact on the effectiveness of a weapon system.

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COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-201505

To the President of the Senate and the
Speaker of the House of Representatives

This report discusses weaknesses in the Department of Defense's major system acquisition process which are contributing to the operation, maintenance, and support problems of many deployed weapon systems. We consider the message of this report to be particularly important considering the problems our Armed Forces are having with weapon systems.

This review was undertaken in an effort to identify changes which are needed in the acquisition process to minimize problems with future weapon systems.

Copies of this report are being sent to the Director, Office of Management and Budget, and to the Secretaries of Defense, Army, Navy, and Air Force.

Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

EFFECTIVENESS OF U.S. FORCES CAN BE INCREASED THROUGH IMPROVED WEAPON SYSTEM DESIGN

D I G E S T

The United States' ability to fight a war may be severely hampered because many of the aircraft, ships, tanks, ordnance, and other systems the Armed Forces must use are suffering from numerous problems. While these systems may have the capability to perform their missions, it is often of little value because not all the systems can be adequately operated, maintained, or supported.

GAO has reported on these problems in the past and believes that many of them can be traced to the Department of Defense's (DOD's) system acquisition process, particularly the early phases before system design is set. The pressures to attain specific performance goals, such as speed, range, and firepower, within tight time and cost constraints have often led management to trade-off or otherwise not give adequate attention to long term "ownership considerations."

GAO examined three ownership considerations which appear to be among the most prominent detractors from the effectiveness of deployed systems--logistic support, human factors, and quality assurance. DOD has made changes to direct more attention to these three factors, but GAO believes that several additional actions need to be taken if these considerations are to receive adequate emphasis in the design of military systems and equipment. These actions will have to include greater support by the Congress and DOD for activities, such as logistics and human factors research, testing, and analysis.

LOGISTIC SUPPORT

Logistic support requirements, such as replacement parts, tools, test equipment, technical manuals and facilities, and the time and cost of providing these, are not being adequately addressed when designing systems and equipment. This contributes to low system readiness rates when deployed because the military supply and maintenance systems cannot meet the demands placed on them.

DOD is now placing greater emphasis on logistic support requirements during the acquisition process, including adopting a policy that supportability is as important as cost, schedule, and performance. The positive impact these changes need to have may never fully materialize because:

--The process for interfacing logistic considerations with other design considerations--logistic support analysis--is very difficult to do. Much of the data needed for design decisions is difficult to obtain; there is a shortage of trained people to do the analysis; and the analysis can be costly, especially if duplicative analyses are not eliminated. (See pp. 22 and 23.)

--The quantitative analysis needed to assess logistic plans, resources, and support-related parameters for meeting system readiness goals may be very difficult to perform because the analytical models for making such assessments may not be adequate. (See p. 23.)

--There is very little guidance to ensure that critical program documents contain the language needed to get systems designed that are supportable. (See p. 24.)

--Testing a system's supportability before it is deployed is difficult to do, requires dedicated test time and articles, and is expensive. (See pp. 24 and 25.)

--There is little incentive for management to either invest development funds or to trade-off technical performance to improve the supportability of a system because it is very difficult to quantify the benefits of such investments and trade-offs. (See p. 25.)

HUMAN FACTORS

Limitations such as skill levels, proficiency, availability, environmental stress, and fatigue of the personnel who operate and maintain military systems contribute to human-induced system failures. Indications are that these types of failures are quite high. New policy emphasis on human limitations in the design of systems may have a very limited impact because:

--Human factor specifications, standards, and handbooks used in designing and developing systems and equipment do not adequately address human limitations. (See p. 31.)

--There are no common methodologies and data sources for use by system designers in forecasting skill levels of future military personnel. (See pp. 31 and 32.)

--DOD testing policies and procedures do not tend to identify and resolve potential human-induced failures during the developmental stages of the acquisition process. (See pp. 32 and 33.)

QUALITY ASSURANCE

Systems being deployed are not as reliable as they are intended to be. Part of the problem is that the reliability inherent in system designs is being lost in the transition from design to production and deployment.

The extent of the problem is very difficult to quantify, but its existence points up the need for designing systems which can be manufactured to the tolerances called for in the specifications and then tested to confirm compliance. DOD recognizes the problem, but attempts to place greater emphasis on designing these types of features into systems are hampered because:

--There is a lack of guidance to project managers on how to evaluate designs for quality assurance. Part of the problem may be that there is only one person in the Office of the Secretary of Defense assigned to the policy aspects of quality assurance. (See p. 38.)

--Files on contractor quality histories have not been fully established and the cross-service product quality deficiency reporting requirement has not been fully implemented. (See p. 38.)

--Government engineers with adequate training in quality assurance are in short supply. (See p. 39.)

RECOMMENDATION TO THE CONGRESS

GAO recommends that the Congress direct more attention during its deliberations on DOD's budget to such matters as logistic support, human factors, and quality assurance considerations in the design and development of weapon systems.

RECOMMENDATIONS TO THE SECRETARY OF DEFENSE

Logistic support

GAO recommends that the Secretary of Defense

--develop new or modify current data reporting procedures to provide the information needed for performing logistic support analyses,

--establish logistic support research and study programs to develop improved quantitative assessment methods (see p. 26),

--provide detailed guidance to ensure that critical program documents contain the language needed to obtain systems which are supportable, and

--provide for improved testing and evaluation of the supportability of systems before they are deployed.

Human factors

GAO recommends that the Secretary of Defense

--modify human factor specifications, standards, and handbooks used in system design so that they adequately address all human limitations which can result in human-induced system failures,

--develop common methodologies and data sources for use by system designers in forecasting skill levels of military personnel 5 to 10 years in the future, and

--ensure that all major systems are subjected to adequate testing and examination from a human factors standpoint throughout the acquisition process, particularly in the developmental stages.

Quality assurance

GAO recommends that the Secretary of Defense

--produce comprehensive guidance for program managers as to how a design should be evaluated for quality assurance,

--ensure that the quality history files on contractors are fully established and that the cross-service quality deficiency reporting requirement is fully implemented, and

--strengthen the quality assurance work force so as to permit their active involvement in the design phase of the acquisition process.

AGENCY COMMENTS

DOD agreed with GAO's findings, conclusions, and recommendations. (See app. III.) Changes were made to the report, where appropriate, to reflect specific comments.

Contents

ABBREVIATIONS

DOD	Department of Defense
DSARC	Defense Systems Acquisition Review Council
GAO	General Accounting Office
ILS	integrated logistic support

ABBREVIATIONS

IOC	initial operational capability
LSA	logistic support analysis
MENS	Mission Element Need Statement
MK	Mark
OSD	Office of the Secretary of Defense
TOW	Tube-launched, Optically-Tracked, Wire Command Link

CHAPTER 1

INTRODUCTION

Each year the Department of Defense (DOD) spends billions of dollars to research, design, develop, produce, and support major weapon systems. The process for acquiring these systems is extremely complicated and influenced by a host of factors (in addition to technical performance and acquisition cost and schedule) that affect the effectiveness of a weapon system. These include:

Survivability	Supportability
Vulnerability	Compatibility
Operational suitability	Reliability
Transportability	Maintainability
Availability	Durability
Interoperability	Quality

These factors called "ownership considerations" must be balanced during the acquisition process by the program manager in an endless juggling act to acquire a system which meets mission requirements within program acquisition cost and schedule constraints.

Many of the problems being experienced with the operation, maintenance, and support of weapon systems can be related back to the extent to which ownership considerations were a factor in the early acquisition process. This report focuses on the things that must be done to give some of these considerations more weight in the acquisition process balancing act.

Within the past few years DOD has revised policies, issued guidance, and made organizational changes designed to elevate ownership considerations to a higher level of attention throughout the acquisition process. Some of DOD's actions are very recent, and their impact remains to be seen.

OBJECTIVES, SCOPE, AND METHODOLOGY

Because of the concern expressed by many military and other observers over the combat readiness of U.S. Armed Forces, we initiated this review to (1) identify some of the more prominent causes of problems with acquiring and fielding major weapon systems and (2) recommend some meaningful actions to reduce problems with deployed systems in the future. We were specifically concerned with identifying weaknesses in the acquisition process which were contributing to the deployment of weapon systems which are difficult to operate, maintain, and support. The review was not intended to provide an indepth examination of the entire acquisition process, but rather to focus on those areas of the process which we believe offer significant opportunity for improvement.

This review included visits to many locations in the United States and Europe. (See app. I for the list of locations visited.)

We approached this job as follows:

--Through research and visits to users, weapon systems were selected for review which exhibited problems that we believed:

1. Were mission significant.

2. Might have been prevented or anticipated during the acquisition cycle.

3. Were being experienced by more than one piece of equipment of the same type.

4. Could be researched because information would probably still be available on acquisition process decisions.

--These problems were traced back into the acquisition cycle to determine root causes and the trade-off decision which led to these causes.

--We were able to determine most problem causes. All of the causes fell into several broad categories, and all seemed to involve inadequate attention to ownership consideration in weapon system design. Three major early design phase considerations were selected for further work.

--A detailed review into the areas of logistic support, human factors, and quality assurance was conducted with emphasis placed on how these ownership considerations are addressed in the early phases of the acquisition cycle (mainly between milestones 0 and I). Much of the information was obtained through discussions with DOD and industry representatives involved with the acquisition of weapon systems.

--Improvements to the acquisition cycle were postulated to hopefully alleviate similar problems in the future.

Our office has issued numerous reports that relate to readiness, logistic support, military personnel, the DOD acquisition process, and other matters discussed in this report. For a listing of some of the most relevant reports issued since January 1979, see appendix II. A February 1979 DOD study, "Defense Resource Management Study," also reported on some of the issues discussed in this report. The study report recommended increased emphasis on ownership considerations in the acquisition process and identification and application of innovative support concepts for new systems being developed.

COMMENTS OF OUR PROCUREMENT ADVISORY PANEL

A draft of this report was submitted for review and comment to 18 members of our Procurement Advisory Panel. The Panel is comprised of top management officials from industry and the academic community. Changes were made to the report, where appropriate, to reflect their comments. They fully support the need for more emphasis on ownership considerations in the design of weapon systems but are concerned that the funds needed to bring about the desired improvements may not be provided, particularly considering the national problem of funding an adequate DOD program. A summary of other key comments made by Panel members is included in appendix IV.

CHAPTER 2

HIGHLY SOPHISTICATED WEAPON SYSTEMS MUST BE DESIGNED WITH USERS IN MIND

America's leadership in technology is decades old and this technology has provided truly advanced defense systems. Technology has also introduced new challenges to weapon system designers to assure that the readiness of our forces is maintained at high levels. All the design participants, however, have not kept pace. A tank hatch that a soldier, clothed for winter, cannot fit through; a major shipboard fire control system that cannot be adequately supported; aircraft test equipment that causes more problems than it solves; and a handheld missile that when fired startles the person that fires it, resulting in misses, are some examples of the problems with currently fielded weapon systems. However, it is difficult to pinpoint the degree to which system effectiveness has been impaired due to lack of attention to system designs and ownership considerations. What is needed is a more balanced approach in designing weapon systems which gives full and adequate attention to ownership considerations.

Although increased policy emphasis has recently been given to ownership considerations, the effect will be meaningless unless new policies are properly implemented. We believe there are three important ownership factors in the acquisition process which recent history suggests are among the most prominent detractors from the effectiveness of deployed systems--logistic support, human reliability, and quality assurance. Our selection of these ownership factors for analysis does not imply that others are unimportant. Rather, we suggest that there has been an imbalance of funding and attention given between the measurable characteristics of weapon system development (cost, schedule, and performance) and these other factors which significantly influence the eventual effectiveness of the system in the field.

COMPLEXITY/SOPHISTICATION

The terms complexity and sophistication in relationship to weapon systems are in themselves something of an enigma. We did not find any formal definition of these terms within DOD nor did we find a finite technique for quantifying system complexity or sophistication. What is complex/sophisticated to the operator or the maintenance crew of tanks may not be for the engineers who designed and fabricated the tank, or to the program manager who managed the development effort.

In our attempts to establish the relationship between the terms "complexity/sophistication" and the operational availability of military systems, we identified many types of military equipment which were reported to be undependable and/or difficult to support and operate. These vary from simple infantry entrenching tools (for example, shovels) which did not fit in their carrying pouches, through boilers which could not be properly maintained, to aircraft avionics that failed because of software program deficiencies. (For examples, see app. V.)

Some people measure complexity by the number of component parts while others allude to the relationship and interdependencies of various components and/or subsystems. Some understand sophistication to mean the state-of-the-art status of a component. Others use sophistication interchangeably with complexity.

We believe that in defining the terms complexity/sophistication in relation to weapon systems one must include such factors as logistical support, human factors, quality assurance, and even the conditions under which hardware must be employed (for example, day versus night time).

TECHNOLOGY IS A DRIVING FORCE

The demand for high performance has forced designers to incorporate new technology into systems often before its reliability has been fully assessed. On the design table reliability is sometimes compromised in favor of performance and cost. When this happens, the cost in field repairs and low system readiness rates can be high.

In the commercial sector, firms tend to rely on evolutionary product improvements. Quantum changes occur only when technology advances have been proven. Product improvements are generally made to correct specific problems in the design or manufacturing process, and the impact of these changes on reliability and quality are evaluated. They recognize that design is an iterative process and seldom, if ever, will they produce a perfect design the first time, even though they incorporate all currently known techniques.

In contrast, DOD tends to push state-of-the-art advances in many areas simultaneously. We can see examples of this in major subassemblies of systems, such as the automatic test equipment on the F-15; the Tube-launched, Optically-Tracked, Wire Command Link (TOW) Missile System on the COBRA helicopter; the Mark (MK)-86 Fire Control System on Navy ships; and the turret of the M60A2 tank. Specifically:

--The F-15 relies on intricate electronics to survive and effectively accomplish its mission. In our review we examined the automatic test equipment used to support the F-15, since this is known to affect the aircraft's poor readiness. The software used in three different levels of equipment was incompatible and the built-in test and avionics intermediate shop equipment was unreliable. Without modifications, it seems doubtful that the F-15 fleet readiness can appreciably improve. This is compounded by the well-publicized F-15 engine reliability and durability problems. (See our report, "Are Management Problems In the Acquisition of Aircraft Gas Turbine Engines Being Corrected?," PSAD-80-72, Sept. 30, 1980, which attributes the engine problems to inadequate definition of the engine's usage, emphasis on performance requirements, and inadequate flight testing.)

--The Army's only deployed attack helicopter, the AH-1 "COBRA," has a serious maintainability/reliability problem according to users in deployed Army units. One of the helicopter's primary missions is killing tanks using its TOW missile system. The subsystem used in launching and guiding the TOW missiles is experiencing only about 100 hours mean time between failure of critical mission-related components. The root cause of these failures is attributable to the poor reliability of various electronic modules and the system's built-in test equipment.

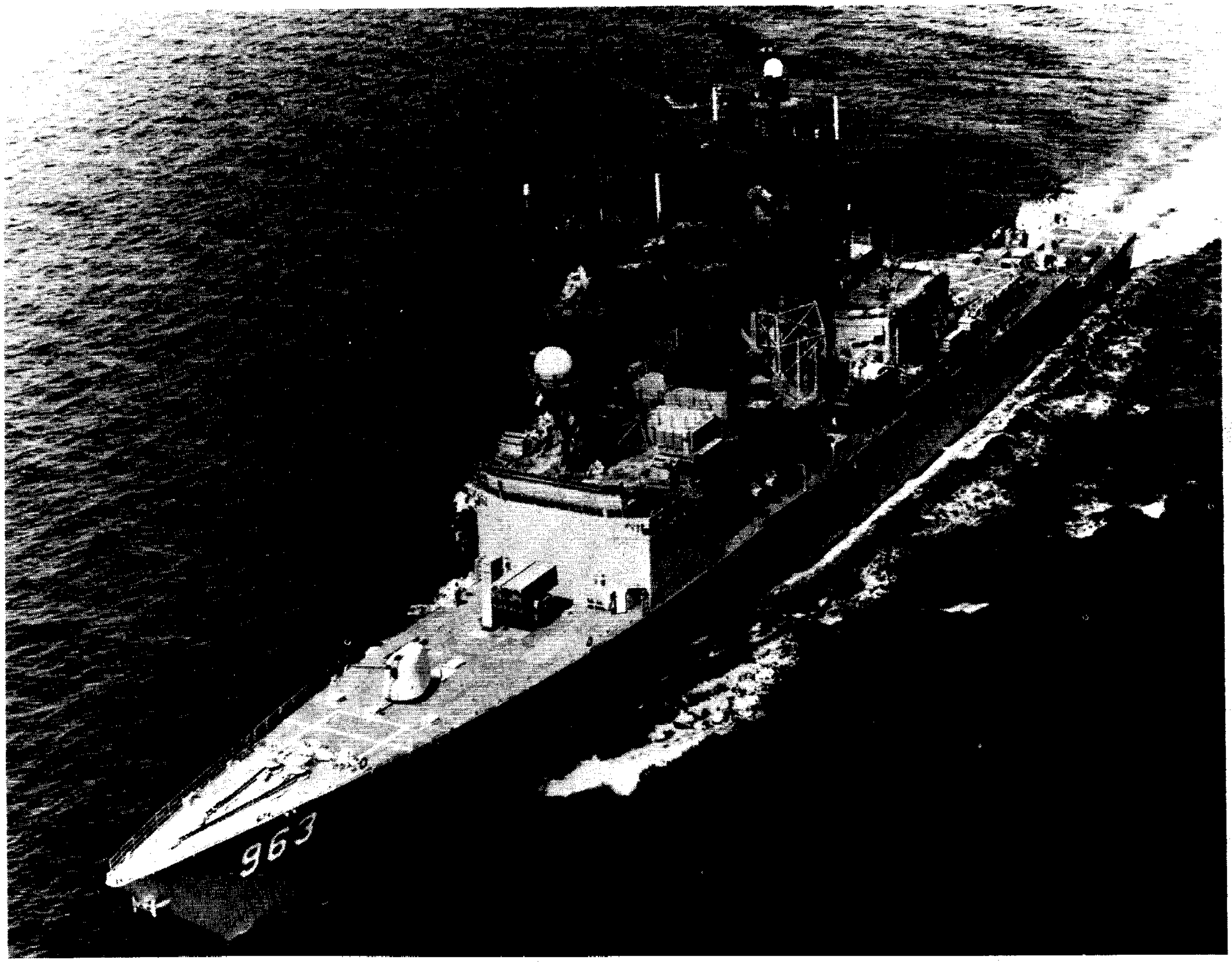
--The Navy's MK-86 fire control system is the primary weapon's control aboard the most advanced combat ships, providing multiple modes of operation and simultaneous tracking of more than one target. It is important to note that when the system is inoperable, the ship is virtually defenseless. In 1979 the system experienced an operational availability rate of only about 60 percent despite special supply support efforts. The primary reasons for this low availability was the large number of random failures among the 40,000 plus parts in the system and the extreme difficulties of the supply system to stock sufficient quantities of replacement components to meet the demands in a timely manner. Also, there is a long learning curve for repair technicians because of the system's complexity.

THE AIR FORCE'S F–15 AIRCRAFT HAS EXPERIENCED EXTENSIVE PROBLEMS WITH BOTH ITS AUTOMATIC TEST EQUIPMENT AND ITS ENGINES

SOURCE: DEPARTMENT OF THE AIR FORCE

THE ARMY'S AH–1 HELICOPTER HAS EQUIPMENT RELIABILITY PROBLEMS WHICH IMPACT ITS ABILITY TO FIRE ITS MISSILES

SOURCE: U.S. DEPARTMENT OF THE ARMY



OVER 40 U.S. NAVY WARSHIPS LIKE THE U.S.S. SPRUANCE (DD–963) ARE EQUIPPED WITH THE MK–86 WEAPONS CONTROL SYSTEM, WHICH IS OFTEN NOT OPERATIONAL

SOURCE: DEPARTMENT OF THE NAVY

--The Army's M60A2 tank can fire either a 152-mm. projectile or a missile through the same tube. The turret on this tank has been described by one M60A2 unit commander as "fantastically complex." The tank has a long history of unreliability. Operation of the tank is so difficult that one organization in Europe has printed a detailed checklist of sequential actions to be accomplished by the crew before driving and firing the weapon. We examined one subsystem of the turret, specifically the laser rangefinder, and found electronic reliability problems.

A comment by General Bernard W. Rogers, former Chief of Staff, U.S. Army, before the Senate Armed Services Committee in the fiscal year 1980 hearings succinctly describes the situation we see.

> "Constant striving to achieve technological excellence is causing undue technical complexity, leading to high cost and long gestation. Worse, we have come to assume in this country that increases in military performance come only from technology and that the purpose of technology is to improve upon the various physical characteristics of familiar weapon systems. The result is a failure to anticipate shifts in military requirements, aggravated by long gestation periods in weapons development."

Dr. William J. Perry, Under Secretary of Defense for Research and Engineering, also recognizes an overreliance on technology. In his statement before the Senate Armed Services Committee on March 14, 1979, he stated that a dangerous communications gap has developed between the developer of systems and the user. This gap has led to systems that are largely technology driven and are poorly united to the operational need because the user did not know how to state his need in terms of the available technology. He also stated that DOD research and development programs have applied technology to enhance performance without adequate considerations of its impact on the user in terms of support costs and the number of skill levels of U.S. military personnel. The results, according to Dr. Perry, have been visible in a number of operating systems with low readiness and the need for expensive retrofits and modifications.

Private industry perceives problems with DOD's approach

General Rogers and Dr. Perry's concern about DOD's over-reliance on technology is not without foundation. In our discussions with representatives of major defense contractors, we surfaced several professional opinions that reflect upon the life-cycle reliability of military systems. These opinions indicate that DOD does practice the philosophy expressed by General Rogers. Two of the major points raised by industry follow.

--DOD tries to incorporate too many "unproven" technical approaches in new systems. We were told that a single state-of-the-art component or subassembly in a new system might be feasible in that it could be watched and helped to mature. However, multiple state-of-the-art innovations are not practical because they cannot be adequately monitored and fixed and normally tend to produce an unreliable system.

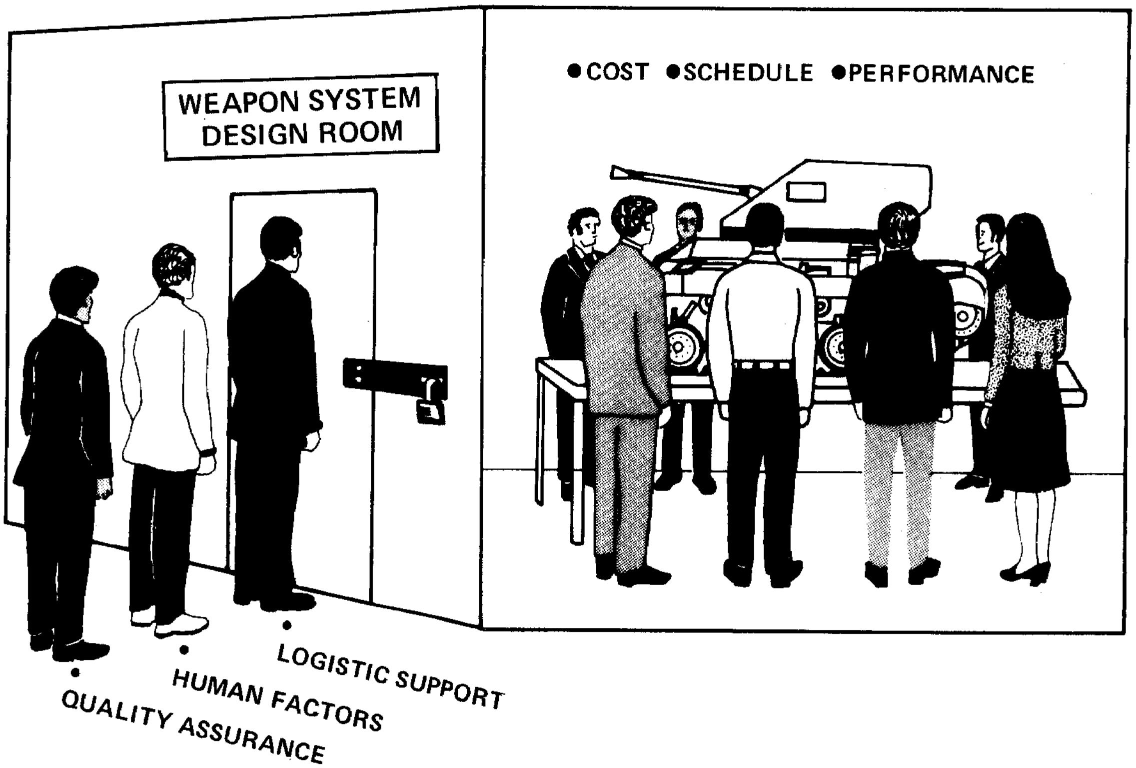
--The common approach used by DOD and the defense industry to compensate for poor human aptitudes, inadequate training, and reduced numbers of personnel is to incorporate more automation. In effect, the reliance upon man is being phased out of a system by using built-in test equipment; removable/replaceable modules; and more reliance on returning modules for factory, depot/general, support-type repair (as opposed to diagnosis and repair at military units). This approach leads to rather complex electronic components and can increase the number of "black boxes" needed in the supply system to keep a system operational.

MAINTAINING THE BALANCE

In the following chapters we will discuss some of the changes necessary in the early design phase of an acquisition (for example, logistics, human factors, and quality that must become critical design considerations). In the past this has not generally been the case. In fact, we were told that for years these considerations have been essentially "locked out" of the design process. (See p. 12.) The pressures to attain specific performance goals within tight time and development cost constraints have led management to trade-off or otherwise sacrifice the ownership considerations to meet short term budget and schedule pressures. This must change if we are to have more effective systems.

Of equal importance, however, is what happens throughout the entire acquisition process to the implementation of these considerations by management under the pressures of a rapidly changing weapon system program. The program manager is constantly being confronted by the need to make trade-off decisions that affect the high visibility aspects of a program. In this environment, ownership considerations can easily be traded-off for short term solutions which favor those high visibility aspects. No matter how well the ownership factors have been designed into a system, they will not be fully effective unless management is motivated to better ensure their consideration during the entire process.

FIGURE I



To help all levels of management give greater emphasis in their thinking toward the ownership considerations, it might be necessary to change the way in which the procurement community thinks about cost (research and development, procurement, and support), schedule (initial operational capability (IOC)), and performance (speed, weight, firepower, and so forth). For example, cost should be the life-cycle cost of an acquisition, schedule should be the time when a fully supportable system is fielded, and performance should be a measure of a system's readiness to do the job for which it was designed.

RECOMMENDATION TO THE CONGRESS

The Congress can significantly influence the direction DOD takes regarding developing weapon systems which are operable, maintainable, and supportable. In view of the problems being experienced with deployed weapon systems and questions concerning the readiness of our Armed Forces, it is particularly important that such emphasis be exerted now. Accordingly, we recommend that the Congress direct more attention during its deliberations on DOD's budget to such matters as logistic support, human factors, and quality assurance considerations in the design and development of weapon systems.

CHAPTER 3

LOGISTIC SUPPORT--A

VITAL DESIGN CONSIDERATION NOT ADEQUATELY ADDRESSED

> "* * * Past Defense Reports have emphasized unreliable and hard-to-support equipment designs as a major, and often the principal, contributor to less-than-desirable weapon system performance in the field."

These words from the Secretary of Defense's annual report for fiscal year 1980 highlight both the need for designing logistic support into military systems and the failure to satisfy that need. DOD has been trying to implement some changes in the acquisition process to address this situation and bring the process more into balance with its needs. There are, however, many problems to be overcome which could severely curtail the positive impact that these policy changes need to have. These problems include: (1) difficulties in doing logistic support analyses (LSA), (2) difficulties in doing quantitative analyses for projecting readiness rates of various system designs and for justifying system design investments and trade-offs to improve logistic supportability, (3) lack of guidance on addressing logistic support requirements in critical program documents, (4) insufficient evaluation and testing of the integrated logistic support (ILS) planning and logistic supportability of systems, and (5) a complacent attitude on the part of decisionmakers.

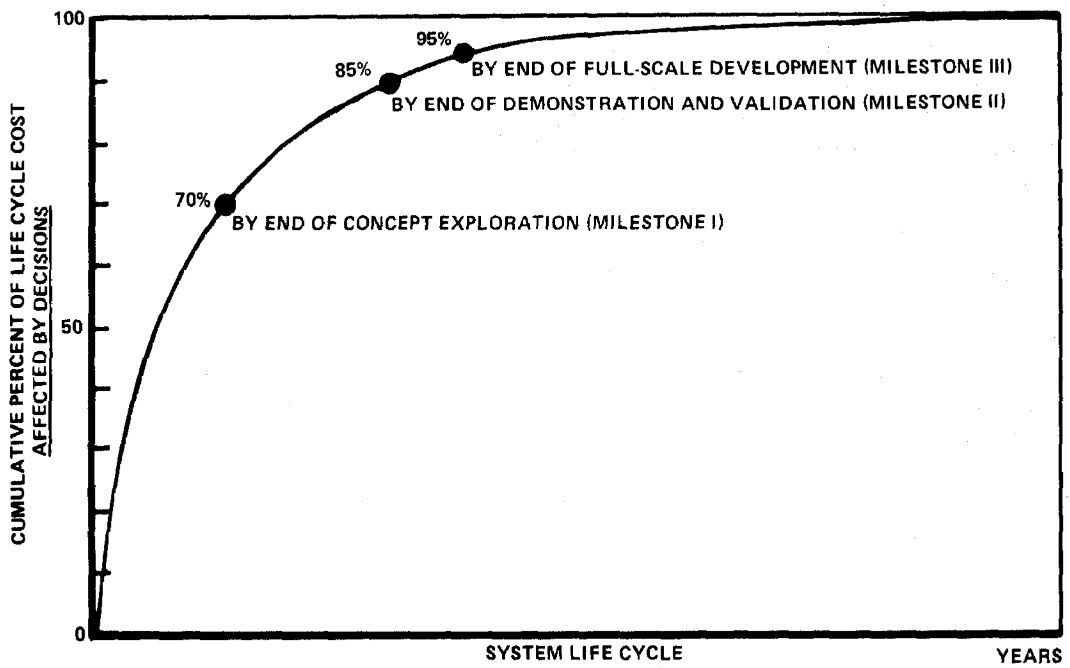
LOGISTIC SUPPORT CONSIDERATIONS MUST INFLUENCE DESIGN

Logistic support and the planning for it need to be serious considerations in the design, development, and production of defense systems. All systems depend upon logistic support to create and sustain their effectiveness. The design capability of a system can only be realized if the parts, tools, test equipment, personnel, facilities, fuel, and so forth (that is, logistic support) are available when needed. The cost of providing this support for a system often exceeds the development and procurement costs. The high cost of support can be seen in the fiscal year 1981 DOD budget requests with about $60 billion--37 percent of the total budget--programed for logistics.

To acquire a weapon system which can be effectively and economically supported, there must be continuing interactions between the logistician and the design engineer throughout the acquisition process. This is particularly important during the early phases of design where the stage is set for the bulk of a system's life-cycle costs. Many studies of life-cycle and weapon system supportability show that most of a system's life-cycle costs are determined during formulation of concepts prior to milestone I of the weapon system acquisition process. (See fig. 2.)

FIGURE 2

SCHEDULE OF DECISIONS AFFECTING LIFE CYCLE COST

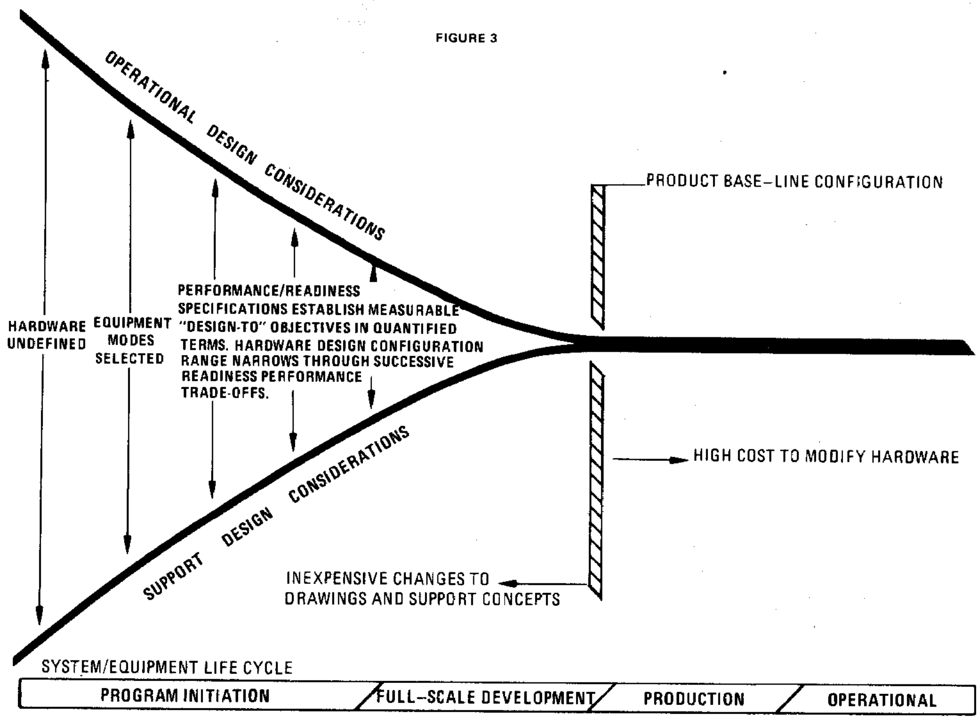


SOURCE: *Proceedings from National Security Industrial Association Symposium on Navy Systems Acquisition, October 27-28, 1977*

Impact of not considering logistic support in design

Some acquisition experts consider the above percentages to be quite high and possibly misleading. They point out that decisions made after milestone II are vitally important in determining the supportability of a system and should not be underestimated. Nevertheless, we found near universal agreement that the decisions made in the early stages of the acquisition process offer the greatest opportunity to influence a system's supportability. It is during this time that recognition of the consequences of the design on availability and supportability can lead to inexpensive changes to the design and improve eventual operational availability and supportability. As development proceeds and the design becomes more set, changes to improve supportability become more difficult and costly to make. Figure 3 from Military Standard 1388, "Logistic Support Analysis," illustrates our point.

FIGURE 3



Use of LSA in design

To promote early and continuing involvement between the design engineer and the logistician, a process known as LSA has been established. The purpose of the LSA process is to inject support criteria into weapon system designs and acquisitions and to define overall system support requirements. LSAs are to be done by the contractor and the effects of alternative designs are to be considered. Known scarcities, constraints, or logistics risks are to be identified and methods for overcoming or minimizing these problems developed. As the program progresses and designs become fixed, the LSA process concentrates on providing timely, valid data for all areas of logistic support (for example, maintenance, provisioning, personnel and training, and technical publications).

IN THE PAST--LOGISTIC SUPPORT SUFFERED FROM INATTENTION IN DESIGN

Since 1964 DOD policy directives have formally recognized the need to give attention to logistic support requirements throughout the acquisition process. In the intervening years, however, the approach to designing supportable systems has consisted principally of specific isolated efforts or analyses, not the systematic comprehensive approach of the LSA process. In fact, the LSA process has rarely been initiated in the design stages of system development as intended and, thus, has had little or no effect on system design.

When logistic support is not adequately addressed in the design process, the systems often suffer from low states of readiness when deployed because the military supply and maintenance systems cannot satisfactorily meet the weapon system's repair needs. We found numerous examples of this including the Army's Forward Area Alerting Radar System and the Navy's MK-86 Fire Control System. In each case, the logistic supportability of the design did not receive adequate review with the radar not being subjected to a logistic demonstration test and the fire control system not being subjected to a maintenance engineering analysis. These are critical steps in the acquisition process to ensure the logistic supportability of the design. Both systems have since encountered supportability problems that can be traced to the inadequate design evaluation.

Several interrelated factors have been cited as reasons for logistic support considerations having little impact on equipment design. Principally, as discussed in chapter 2, the problem has been that the acquisition process has focused on achieving technical performance parameters (speed, range, firepower, and so forth) within tight acquisition cost and schedule constraints with logistic supportability being a "consideration." Two important contributors to this situation have been the difficulties in doing LSAs in the design stage and difficulties in quantifying the benefits of logistic support design features.

<u>Difficulties getting data needed to conduct LSAs</u>

The design stage of the acquisition cycle is characterized by change upon change as the engineers attempt to produce designs which meet many requirements. Because of this dynamic state, the LSA process is often difficult to initiate in the very early stages of design. Also, one of the most important LSA tasks in these early stages is to review historical data to relate past experiences to the design requirements of new acquisitions. Information such as failure rates, major support cost drivers, and repair time on like or similar items is to be used to provide a basis for establishing qualitative and quantitative requirements on new equipment. We found that information of this nature has been very difficult to obtain. Existing DOD maintenance data reporting systems do not contain the information needed and, thus, special efforts must be initiated to get it.

Difficulties quantifying benefits

It is very difficult to quantify the benefits of design features which improve the logistic supportability of a system. Without such quantification, there is little motivation for the program manager and contractor to raise development/production costs by a "known" amount to save an "unknown" amount of money in future support costs.

THE PRESENT--DOD IS ATTEMPTING TO EMPHASIZE LOGISTIC SUPPORT

DOD has responded to this need by more clearly defining and emphasizing the role of logistic support in acquiring defense systems. Current initiatives include

- --revising DOD acquisition policies,
- --giving more visibility to logistics matters during Defense Systems Acquisition Review Council (DSARC) 1/ meetings,
- --improving the supportability of systems through early test and evaluation, and
- --giving additional attention to logistic matters by the services.

Considering past problems associated with obtaining the necessary visibility for logistics support considerations, these current initiatives represent a major step forward.

1/DSARC serves as an advisory body to the Secretary of Defense on the acquisition of major defense system programs and related policies and provides him with supporting information and recommendations when decisions are necessary.

Office of the Secretary of Defense policy efforts to improve logistic planning

The DOD Directive 5000.1, "Major System Acquisitions," and DOD Instruction 5000.2, "Major System Acquisition Procedures," were revised in March 1980. The DOD Directive 4100.35 concerning development of integrated logistics support programs was also revised and reissued in January 1980 as DOD Directive 5000.39, "Acquisition and Management of Integrated Logistic Support for Systems and Equipment." The revised policies stress the importance of logistic support in designing new systems and the need for logistic support planning very early in the acquisition process.

From a design standpoint, the DOD Directive 5000.1 emphasizes that logistic supportability is to be a design requirement as important as cost, schedule, and performance. Continuous interface between the program office and the manpower and logistics communities is to be maintained throughout the acquisition cycle. This is a major change from past policy, which usually subjugated logistic support to performance, schedule, and cost.

Whereas DOD Directive 5000.1 places increased importance on logistic support in the acquisition process, DOD Instruction 5000.2 generally establishes how this is to be accomplished. Early attention to logistic support begins at milestone 0 with the establishment of logistic constraints in the Mission Element Need Statement (MENS). The intent of the MENS process is to identify needs and then explore possible alternative solutions. The important consideration from the support viewpoint is that MENS presents an opportunity to influence the alternative selected from the very beginning.

In addition to including logistics constraints in MENS, DOD Instruction 5000.2 addresses other key actions designed to further emphasize supportability and influence system design. Beginning early in the system development process, both DOD and industry should consider innovative manpower and support concepts. When competitively obtaining alternative concept solutions to mission needs, the widest possible range of acquisition and support alternatives to satisfy the mission need is to be considered. Furthermore, readiness problems and support cost drivers of current systems are to be analyzed to identify potential areas of improvement to be addressed during concept formulation.

Directive 5000.39 reemphasizes the need for an ILS program that begins at milestone 0. To do this, the directive requires that program budgets include adequate funding for ILS planning, analysis, and cost reduction efforts. The ILS planning must be based on the constraints identified at milestone 0, the deployment concept, system readiness objectives, realistic maintenance, related reliability and maintainability estimates, and the documented LSA. Of particular note here is the importance given to LSA in ILS planning. For the first time, LSA is a requirement and is to begin at milestone 0.

Other major points in DOD 5000.39 include the use of ILS goals and objectives in acquisition strategic planning and contract incentives; the establishment of additional ILS research and study programs; and a clear "audit trail" of changes in support budgets, support related goals, and thresholds including changes in definition. Also, industry innovation in support alternatives is encouraged.

Attention to logistics matters by DSARC

The revised policies require the preparation of more detailed logistic support information for DSARC reviews and describe the logistic support activities which should be accomplished before each major milestone decision.

The composition of DSARC also provides some assurance that logistics factors will be addressed. The Assistant Secretary of Defense (Manpower, Reserve Affairs, and Logistics) is a permanent member of DSARC and is responsible for ensuring that logistic planning is consistent with system hardware parameters, logistic policies, and readiness objectives. Assisting in this effort is the ILS Analysis Division which reviews major acquisition programs from a logistic management standpoint as they become available for DSARC review. One of the primary assessments made is a quantitative analysis to project system readiness levels.

Testing for logistic support

In March 1979 DOD initiated a two-phased study of the weapon system test and evaluation process related to operational suitability, including logistic supportability.

The first phase of the study effort found that the requirement to evaluate operational suitability is well established in top level policy directives. However, guidelines for implementation do not exist in any consolidated form, nor does existing DOD documentation clearly state to what extent operational suitability will be addressed at each phase of the program.

The study further observed that the assessment of system operational suitability, under any conditions, is a complex undertaking. A number of factors and conditions were also identified which make the process more difficult and demanding. Some of the problems center around test hardware immaturity, lack of representative support and test equipment, nonrepresentative training, artificial test environments, and the complex nature of weapon systems and their supporting logistics systems.

In addition to these inherent technical problems, many development programs have been compressed to meet tight and concurrent schedule objectives. As a result, the time allotted for testing to evaluate the supportability characteristics of systems in development is often inadequate. The second phase of the study is addressing the need for revisions to current testing policies and procedures.

Attention to logistics matters by the services

The services have undertaken several initiatives to ensure the consideration of logistic support factors in the acquisition cycle. Two of these initiatives are (1) establishment of groups to review the status of logistic support planning for ongoing programs and (2) emphasis on implementing LSAs.

Logistic review groups

Each service has an extensive system acquisition review process. This process extends from the project office level up to and including the office of individual service secretaries. Although logistic support planning is addressed during these various levels of review, the services recently established individual logistic review groups in an attempt to give some additional attention to logistics considerations during the acquisition process. The ability of these groups to affect an individual program's logistics effort varies from service to service.

Additional attention being given to LSA

Groups specializing in applying LSA have been established in each of the services. These groups are available to assist project offices, upon request, with developing and implementing the LSA process in their respective programs.

Another indication of the emphasis being placed on LSA is the establishment of an unofficial joint service LSA working group in late 1978. At this time the logistic establishments of all three services and the Marine Corps met to discuss the status of LSA implementation. It was decided a joint service effort would be initiated to develop a common basis for LSA implementation.

Since that time industry representatives have joined the group and a joint service memorandum of understanding has been signed. The memorandum of understanding defines how the services will work together to increase LSA's effectiveness. As a result, the Office of the Secretary of Defense (OSD) has recently agreed to formalize the working group and take the lead in directing its efforts. One of the first projects to be undertaken is the updating of Military Standard 1388. This is being done to (1) meet today's system engineering requirements, (2) more clearly explain the tailoring of the LSA process, and (3) assist in making LSA task statements more explicit.

THE FUTURE--WILL THE SYSTEMS DEPLOYED BE SUPPORTABLE?

While most everyone we interviewed was pleased with the new policies, many were also skeptical about whether the policies will be implemented. We share their concern. The problems which will make it difficult to satisfactorily implement the new policies include

--difficulties in doing LSAs,

--difficulties in projecting readiness rates,

--inadequate guidance, particularly on LSA,

--insufficient evaluation and testing, and

--potentially complacent attitudes on the part of decisionmakers.

Difficulties in doing LSAs

The three key difficulties to having an effective LSA program starting at milestone 0 are (1) getting the information needed to start analyses, (2) getting qualified people who can do LSA, and (3) getting the funds to pay for LSA. To have available the type of information and data needed on existing systems, equipment, and parts, the current defense data reporting procedures will have to be modified or new ones developed. (See pp. 17 and 18.) Until such changes are made, special data gathering efforts will have to be initiated on each new development program.

The shortage of qualified people to do LSA is also widely recognized within DOD and by contractors. DOD training programs have been expanded recently to try to cope with the problem, but it appears that the shortage will exist for many more years. Also, as noted earlier, the services have established offices to assist project offices and contractors with their LSA programs. These offices, however, said that they are in need of more trained staff members especially with the added emphasis now being placed on LSAs.

Because of the difficulty of getting data, the need for qualified people, and the complexity of an LSA program which can require elaborate computer software, LSA programs can be very expensive. Unless DOD is willing to invest more funds in the early research and development efforts of programs to pay for indepth LSAs, the comprehensive LSA efforts needed to effect design changes will not materialize. The amount of additional funds needed can be partially offset through tailoring LSA to the specific program needs and then purging separate analyses which provide only duplicative information to that obtained through LSA. We found this to be a very common problem. Also, LSAs can often be made simpler and less expensive by using relatively simple models complemented with a good knowledge of design alternatives.

Difficulties in projecting readiness rates

The quantitative analyses called for in Directive 5000.39 to assess the adequacy of logistic plans, resources, and support-related parameters to meet system goals will also be very difficult to perform. The major problems will be obtaining the necessary data inputs and developing valid models to use in projecting the probable system readiness rates. There are many models available, but their usefulness in making accurate readiness predictions is questionable.

Inadequate guidance

There has been and continues to be a shortage of guidance to ensure that critical initiating program documents--particularly MENS, requests for proposals, and contracts--contain the language needed to get logistic support designed into systems. The MENS statements are to contain logistics considerations, but only the Air Force has issued detailed guidance to assist those who prepare MENS to ensure that logistic considerations are effectively addressed. Guidance is also needed on how to incorporate qualitative and quantitative requirements in contracts which force designers to give attention to supportability.

Also, there is very little guidance provided by the services to project offices on how to implement LSA in contracts. Guidance is needed on how to prepare requests for proposals and contracts so that the contractor's LSA program will be tailored to the needs of the system to be acquired. Criteria is also needed for evaluating contractor's LSA program proposals for source selection purposes. A standard format is needed for contractors to use in preparing their LSA proposal to ensure that competing contractor's proposals can be compared and that each addresses all aspects of the proposed LSA effort. This guidance is important because, if a program is to have a comprehensive LSA, it must be written into the contract as it is the contractor who will do most of the LSA. While Directive 5000.39 contains implementing guidance, we believe that this needs to be supplemented with detailed guidance (possibly even model statements) to ensure that specific matters, such as those cited above, are adequately addressed.

Insufficient evaluation and testing

Adequate independent evaluation of a program's ILS planning, testing, and evaluation of a system's logistic supportability before a production decision are critical parts of the acquisition process. Currently, these tasks are not being adequately accomplished and improvements are needed.

We found that the logistic review groups in the Army, Navy, and Air Force (see p. 21) review primarily major programs and thus many less than major programs are not subjected to the type of independent review needed to ensure that logistic support is adequately planned. The Naval Material Command has instructed its three system commands (Air, Sea, and Electronics) to set up such reviews, but unless additional staff members are added, we believe it will be very difficult to get these reviews done.

The need for improved testing and evaluation of a system during development has been identified by OSD. (See pp. 20 and 21.) This will continue to be a serious problem until DOD takes steps to improve the quality of the testing program.

Complacent attitude of decisionmakers

The attitude toward logistic support which has fostered so many of the problems the Armed Forces have today may plague the implementation of the new policies. Decisionmakers throughout the acquisition process will have to be willing to invest the resources needed to implement the new policies.

Management will still be driven to meet cost, schedule, and technical performance parameters. Increased emphasis on initiating the LSA process at the start of the acquisition process will help, but LSAs do not make decisions. If management must sacrifice acquisition dollars or technical performance to improve supportability, there could be little impetus for them to do so, especially considering the extreme difficulties in quantifying the benefits of improved supportability. As a consequence, most design trade-offs may continue to favor cost, schedule, and technical performance.

CONCLUSIONS

In the past there has been insufficient attention given to logistic support planning during the acquisition cycle. We believe this has contributed to the poor operational availability/supportability of many deployed systems. These problems along with upward spiraling operational and support costs have led DOD to make long needed revisions to major acquisition policy, including making supportability as important an acquisition consideration as cost, schedule, and performance. Increased attention is now being directed to logistic factors at key acquisition decision points.

Although these initiatives represent a major step in the right direction, successful implementation will be difficult because of (1) the difficulties in doing LSAs, (2) the difficulties in doing quantitative analyses for projecting readiness rates of various system designs and for justifying system design investments and trade-offs to improve logistic supportability, (3) the lack of guidance on addressing logistic support requirements in critical program documents,

(4) insufficient evaluation and testing of the ILS planning and logistic supportability of systems, and (5) a potentially complacent attitude by decisionmakers.

Unless these needs and problems are addressed by DOD, the positive impact of the new policy initiatives will never fully materialize. The actions needed will require people and money, both scarce resources. However, we see this as a necessary step if DOD really intends to minimize the problems of high support costs and low readiness rates so common in today's complex/sophisticated weapon systems.

RECOMMENDATIONS TO THE SECRETARY OF DEFENSE

We recommend that the Secretary of Defense

--develop new or modify current data reporting procedures to provide the information needed for performing LSAs,

--establish logistic support research and study programs to develop improved quantitative methods for assessing (1) the adequacy of logistic support plans, resources, and support-related parameters and (2) the benefits of design changes in the acquisition process to improve the supportability of a system,

--provide detailed guidance to ensure that critical program documents (for example, MENS, request for proposals, and contracts) contain the language needed to obtain systems which are designed to be supportable, and

--provide for improved testing and evaluation of the supportability of systems before they are deployed.

AGENCY COMMENTS

DOD agreed with our findings, conclusions, and recommendations. (See app. III.) In commenting on the need for logistic support research and study programs, OSD stated that direction was sent in September 1980 to the military departments to initiate a research and development program for improvement of weapon system support. Regarding the need for guidance, DOD pointed out that some implementing guidance has been included in DOD Directives 5000.39 and 5000.40. This guidance, however, is not in the detail needed, as discussed on page 24.

CHAPTER 4

HUMAN RELIABILITY--A MAJOR FACTOR WHICH HAS NOT BEEN ADEQUATELY CONSIDERED IN SYSTEM DESIGN

Failures of deployed systems are often caused by human-induced errors. There are indications that the percentage of failures due to human ineptitude or poor human reliability 1/ may be quite high. The increasingly complicated nature of modern military systems together with shortages of qualified military personnel suggests that human-induced errors both in operation and maintenance of systems will increase unless more attention is given to this problem in the design and development phases of the acquisition process.

Military specifications, standards, and handbooks on human factors do not adequately consider human limitations such as skill levels, proficiency, availability, environmental stress, and fatigue. Also, there are no common methodologies or data sources for forecasting skill levels of future military personnel, and there does not appear to be sufficient emphasis on testing systems from a human reliability standpoint.

HUMAN-INDUCED MALFUNCTIONS MAY BE A VERY SERIOUS PROBLEM

The human limitations of the operator and maintainer can cause system failures. The extent of this problem, however, cannot be accurately estimated from data in current failure reporting systems. Based on interviews we conducted and studies we reviewed, we are convinced that a large number of system failures are the result of human error. We found a DOD and contractor study which share this position. Both estimate that human errors account for at least 50 percent of the failures of major systems.

The problem of human-induced failures may very well become worse. Attendant to the increasingly complicated nature of systems are the lower education and aptitude levels of personnel now entering the services, the shortages and high turnover rate of experienced personnel which leads to very

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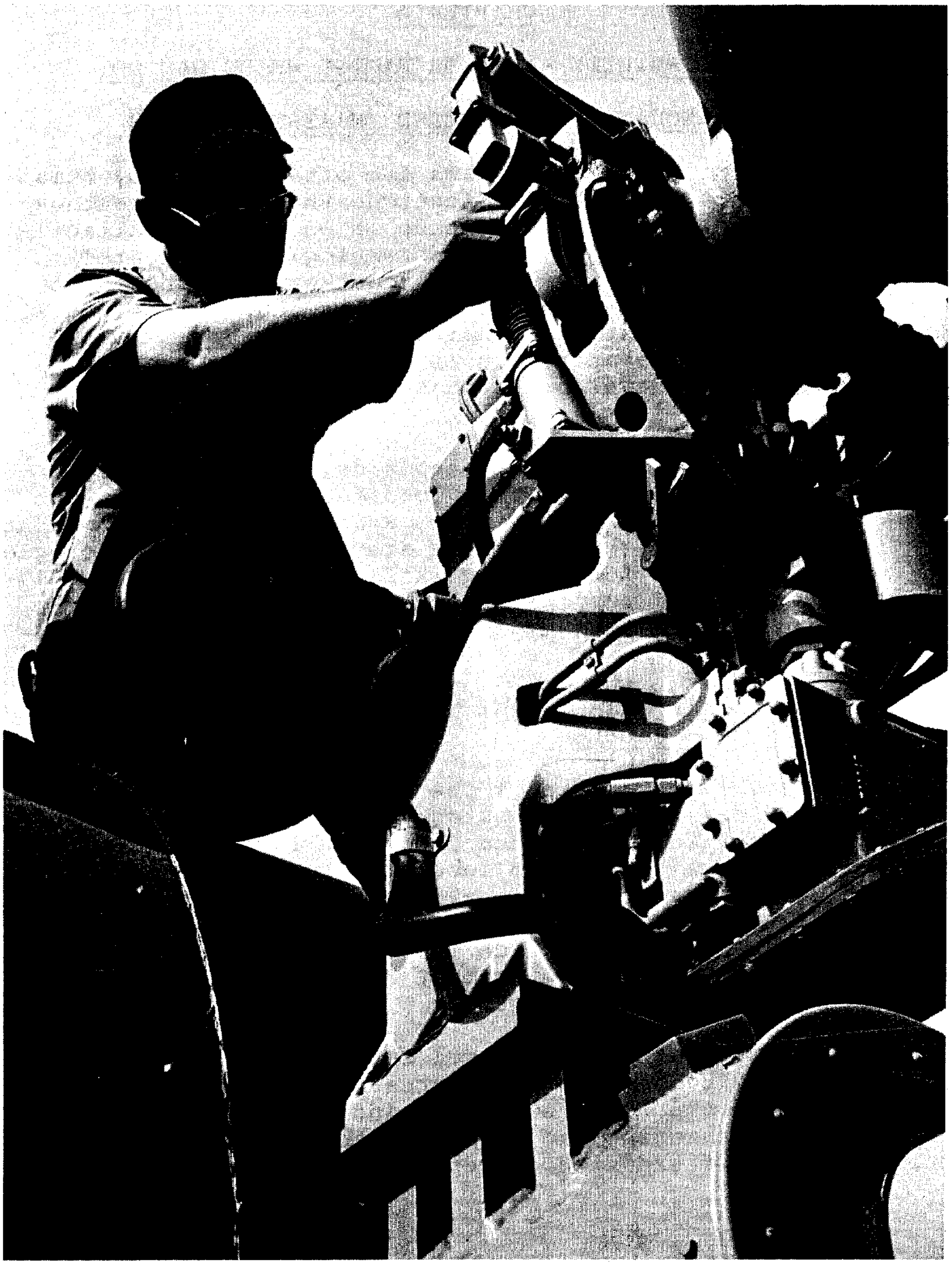
1/Human reliability as used here is defined as the probability that human error (by either the operator or the maintainer) will not cause a system failure or malfunction.



A LARGE NUMBER OF WEAPON SYSTEM FAILURES MAY BE THE RESULT OF HUMAN ERROR.

SOURCE: DEPARTMENT OF THE NAVY

low overall experience levels, and the effect of greater use of complex/sophisticated automatic checkout and built-in test equipment. For a system to operate successfully, the designer must fully consider the following types of characteristics of the personnel who will operate and maintain the system when it is eventually deployed:

--Muscular strength and coordination.

--Body dimensions.

--Perceptions and judgment.

--Sensory capacities.

--Native skills and capacity to learn new skills.

--Optimum workload.

--Basic requirements for comfort, safety, and freedom from environmental stress.

THE IMPACT OF PEOPLE ON SYSTEMS

The following quote, taken from an Army technical memorandum, indicates the importance of the operator's and maintainer's relationship to an item of hardware.

> "People are the only responsible agents in the system. No matter how small the roles assigned to people, they are responsible roles. People determine whether the system is ready to operate, what it is to do, how and when it is to do it, when and what variations in performance are to occur, and what constitutes adequate or complete performance. People decide, control, guide, change, and evaluate. They are expected to anticipate, detect, compensate for, and explain any undesirable variations in performance. And their errors assume a significance commensurate with their responsibilities."

Although human-induced failures adversely affect operational availability, the failures are usually charged to system unreliability. A failure or an unscheduled delay is considered to be human initiated only if the human can be clearly identified as the "causative agent" leading to the failure or system inoperativeness. Many human-initiated malfunctions, however, are not clearly identifiable. This lack of recognition is not an easily cured malady. The hardware failure usually occurs before the human-induced action is detected and it (the failure) is a quantifiable entity making it easy to report. In general, the five types of human errors which cause most failures can be identified as follows:

--Failure to follow procedures. 1/

--Incorrect diagnosis of particular situations.

--Misinterpretation of communications (written or verbal).

--Inadequate support, tools, equipment, and environment.

--Insufficient attention or caution.

HUMAN RELIABILITY CAN BE IMPROVED OR DEGRADED BY DESIGN OF EQUIPMENT

Poor design, particularly of support, maintenance, and checkout equipment, can significantly increase the probability of system failures once the system is deployed.

The following very brief itemization is representative of the types of problems that can be directly related to the design of the system or its support equipment compared to the capabilities or aptitudes of operators/maintenance personnel:

--Indicator meters and readouts not readily visible.

--Parts not accessible or special tools required.

--Multiple-interactive adjustments required.

--Visual aids and wiring diagrams which are overly complex.

--Labeling and coding instructions unclear.

--Faulty equipment setup awkward for operator use or maintenance action.

1/It should be noted that human nonadherence to procedures may be detrimental to system performance and produce mission failures, but these procedural errors do not necessarily induce equipment failures.

We found several specific examples of system designs significantly increasing the probability of human-induced errors. On the P-3 and S-3 aircraft programs, a large number of deficiencies identified when these systems were first deployed were identified as operator errors induced by poor design of the aircraft's display and control components. An antitank weapon system is another example. In firing the weapon, the normal operator is unable to keep still long enough to accurately direct the missile to the target.

We believe there has been considerable effort to adapt man to the constraints built into the hardware instead of using manpower factors as design criteria. Until OSD published the memorandum, "Manpower Analysis Requirements for System Acquisition," August 17, 1978, there was no specific DOD-wide guidance on manpower planning for new systems.

A review of past and existing military specifications, standards, and handbooks on human factors and human engineering reveals that most of them deal exclusively with the human physical characteristics and design interface. Although they furnish a basis for design of the immediate interface between man and machine, they do not provide the broader manpower factors data (for example, skill levels, proficiency, availability, rotation rates, cost, and so forth) necessary to evaluate alternative designs to determine the optimum design for minimum cost of ownership and maximum effectiveness. The recently revised DOD Instruction 5000.2, March 19, 1980, does address skill requirement as a "consideration and constraint" in system design.

INSUFFICIENT EARLY PLANNING FOR HUMAN RELIABILITY

In pursuing the question of why deployed systems seem to be afflicted by so many human-related problems, we found that there are no commonly accepted methodologies or sources of data which the services can use to forecast skill levels of potential military personnel in the upcoming 5- to 10-year period. Without such basic data, it is difficult for hardware developers to properly estimate human reliability and consider it in the design of a system.

The need for improved personnel planning data has been recognized within DOD. In 1977 the Navy initiated the Hardman Program to develop methodologies for determining manpower requirements associated with systems being developed and procured. In February 1978 the Army's Operational Test and Evaluation Agency informed the Army Vice-Chief of Staff that the neglect of human characteristics in planning and testing has caused serious and costly problems. In August 1978 the Assistant Secretary of Defense (Manpower, Reserve Affairs, and Logistics) informed the secretaries of the military departments that they "should place greater emphasis on controlling and forecasting the effects of our weapon systems on manpower and personnel needs."

In November 1978, the Army Materiel and Readiness Command instructed its program managers and development commands to prepare a human factors engineering analysis for presentation at the preliminary review of each Army Selected Acquisition Review Council milestone. Army's Human Engineering Laboratory was tasked to provide assistance. To our knowledge, that is the only human factors-dedicated organization which now has a more or less direct access (through the Office of the Army's Deputy Chief of Staff for Personnel) to the acquisition management process.

TESTING PROCEDURES HAVE NOT GIVEN HUMAN RELIABILITY ADEQUATE EMPHASIS

In our review of how much human reliability emphasis is applied during testing, we received the following from the military services test organizations.

--In many cases, dedicated human reliability testing is permitted only on a "not-to-interfere" basis.

--In the early stages of system testing, participants are usually drawn from contractor technicians, engineers, and other contractor personnel. This practice could easily result in biased outcomes as contractor personnel are often more skilled and experienced than the military personnel who will ultimately use the system.

--When human reliability has been acknowledged during testing, the attention was normally dedicated to the performance of equipment operators versus maintenance personnel. Maintenance considerations have generally been minimal, if considered at all. In the area of maintenance the concern seems to be in structuring training courses, not examining designs for things like accessibility, degree of difficulty, and so forth.

--Even when a system reaches the testing stage, program managers do not get easily motivated by nonhardware limitations presented by human engineering.

Anthropometric (man's physical size) measurements are always considered during testing, but intangibles such as perception limitations, man's performance under stress or fatigue, and workload limitations are not commonly appreciated.

CONCLUSIONS

There are indications that human ineptitude or poor human reliability may cause over 50 percent of all weapon system failures. The increasingly complicated nature of modern military systems together with internal military personnel problems suggests that human-induced errors both in operations and maintenance could also increase unless more attention is paid to this problem during design and development. Weapon system designs have been dictating manpower requirements. What is needed is a continuing interface between the system designers and the manpower planners with manpower requirements influencing system design and vice versa.

If the design of systems is to adequately consider all the human limitations (including skill levels, proficiency, availability, environmental stress, and fatigue), military specifications, standards, and handbooks must address these factors. Existing documents do not. Also, common methodologies and sources of data are needed to forecast skill levels of potential military personnel 5 to 10 years in the future. This information, which would be extremely valuable to system designers and testers, is currently not available.

Finally, there does not appear to be sufficient emphasis on testing systems from a human reliability standpoint particularly in the developmental stages of the acquisition process. This could result in design errors requiring expensive modifications after the system is deployed.

RECOMMENDATIONS TO THE SECRETARY OF DEFENSE

We recommend that the Secretary of Defense

--modify human factor specifications, standards, and handbooks used in system design so that they adequately address human limitations, such as skill levels, proficiency, availability, environmental stress, and fatigue, which can result in human-induced system failures,

--develop common methodologies and data sources for use by system designers in forecasting skill levels of military personnel 5 to 10 years in the future, and

--ensure that all major systems are subjected to adequate testing and examination from a human factors standpoint, throughout the acquisition process, particularly in the developmental stages.

AGENCY COMMENTS

DOD agrees with our findings, conclusions, and recommendations. (See app. III.) In commenting, DOD emphasized the need for continuing interaction between system designers and manpower planners with this circular process providing a better framework for the system designers.

CHAPTER 5

QUALITY ASSURANCE--MINIMIZING THE GAP BETWEEN DESIGN RELIABILITY AND FIELD RELIABILITY

The reliability intended to be designed into a system is often not being achieved in the field. It is the task of quality assurance to help minimize this gap. We found that there is a lack of adequate guidance for program managers on how to influence design from a quality assurance standpoint. Also, files on contractors' quality histories have not been fully established and the cross-service product quality deficiency reporting requirement has not been fully implemented. Also, there is a shortage of engineers in the Government who are qualified to address quality assurance.

THERE IS A GAP BETWEEN DESIGN RELIABILITY AND FIELD RELIABILITY

DOD has been placing greater emphasis on reliability in recent years, particularly in the late 1970s. This emphasis is reflected first in policy revisions including the new DOD Acquisition Directive 5000.40, "Reliability and Maintainability," issued July 8, 1980. Not only has there been greater policy emphasis, but implementation of these policy changes can be seen in the strengthening of contract requirements, testing procedures, and program reviews.

Some of the hard earned reliability improvements in the design are, however, being lost in the manufacturing process or in the operating environment resulting in a gap between the design reliability and the field reliability. An example of this is 150,000 projectile fuses purchased by the Navy. These fuses were developed to obtain commonality with fuses used by North Atlantic Treaty Organization nations. The fleet was unable to use these fuses because the tolerance levels were such that the fuse would not fire from a gun that was not perfectly maintained, a near impossible task in a shipboard environment.

While DOD recognizes that this gap exists, the extent of the problem is very difficult to quantify, particularly in the complex/sophisticated weaponry of today. Correction of the problem, however, must start at the very beginning of the acquisition process with the design of the system. Because of the importance of quality in system designs, we looked at DOD's efforts in the area of quality assurance.

CRITICALITY OF QUALITY ASSURANCE

It is the task of quality assurance to help minimize the gap between the reliability designed into a system (inherent reliability) and the reliability experienced when the system is deployed (achieved reliability). DOD defines quality assurance as:

> "A planned and systematic pattern of all actions necessary to provide adequate confidence that adequate technical requirements are established; products and services conform to established technical requirements; and satisfactory performance is achieved."

With the technological advances of recent years, the criticality of quality assurance has increased significantly. Sophisticated techniques are being used to test the quality and reliability of components early in the system's development. With DOD's increasing emphasis on problem prevention instead of detection, quality now must become involved in the early phases of the acquisition cycle.

Quality assurance provides confidence that, for example:

--The tolerances called for in machining are cost effective.

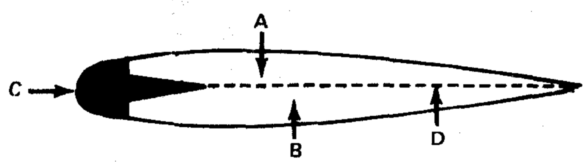
--The material to be used is compatible with the manufacturing process.

--The parts to be manufactured from the drawings can be tested to confirm compliance with the design.

Recent designs of helicopter main rotor blades further illustrate the criticality of quality assurance. The designs for these blades have used composite material bonded to a metal spar under heat and pressure.

FIGURE 4

COMPOSITE HELICOPTER ROTOR BLADE CONSTRUCTION



In this particular illustration two separate pieces of composite material, (A) and (B), are to be bonded to metal spar (C) and to each other. The critical test is examination of the bond seam (D) to ensure there are no voids where the blade might begin to come apart under the high stresses imposed on helicopter blades.

When the X-ray examination was attempted, it was discovered that the bonding material specified in the design was of such a composition that X-ray photography would not work. Since no alternative type of testing was available, the design had to be changed to specify a different bonding material that could be X-rayed.

In this illustration, the importance of adequate quality assurance testing, and therefore of testability, is clearly demonstrated. The significance (or criticality) of the required design change is a matter of timing. The more complete a system assembly becomes before a subsystem or component is found to be defective or untestable, the more expensive the corrective action or replacement will be.

DIFFICULTIES IN ADDRESSING QUALITY ASSURANCE

When a manager does wish to address quality assurance, he faces several problems. First, efforts on the front end of a design process to address quality assurance cost money. Also, although failure to expend the effort may result in lower reliability and increased support costs, the benefits are difficult to quantify. The savings do not manifest themselves in acquisition dollars but in support dollars. Second, there is a lack of role and responsibility definition for design evaluation from the quality assurance viewpoint. Third, the program manager may lack confidence in the quality assurance staff due to a scarcity of sufficiently qualified personnel, especially engineers.

Lack of design evaluation guidance and incomplete policy implementation

While the DOD Directive 4155.1 (Quality Program), revised in 1978, recognizes the importance of quality assurance, OSD has not yet taken certain steps which are critical to successful implementation of the policy. Part of the problem may be a serious staffing shortfall in the quality assurance function at OSD where only one person is devoted to the policy aspects of quality assurance. This individual is understandably limited in how much he can accomplish. Quality assurance concerns arising during his absence go unaddressed. Efforts to unify regulations and to provide detailed guidance to the services are hampered. For example, regarding implementation of the revised directive:

--Directive 4155.1 recognizes the need to influence system designs by requiring specifications in contracts of the required quality characteristics. OSD has given the program manager the responsibility for reviewing contractors' designs for quality assurance but has not provided guidance on how this is to be done.

--The quality history files on contractors, required in Directive 4155.1, have not been fully established. Files on some contractors still have not been set up. This system is intended to prevent the awarding of contracts to contractors with poor quality performance records.

--The cross-service product quality deficiency reporting, required in Directive 4155.1, has not been fully automated. The Army and the Air Force are the only two DOD components to have accomplished this. Also, a central data bank for consolidating the DOD component reports into one report has not been set up. This would greatly facilitate the transfer of information on quality problems among all DOD components.

Regarding implementation of the new policy emphasis on quality assurance in the design process, we examined the standard quality specification which is mandatory for use by DOD agencies in all major acquisition contracts--MIL-Q-9858A, "Quality Program Requirements." We found it to be old and in need of revision. Originally promulgated in 1959, it was revised and reissued in 1963. It has not been significantly changed since. The primary concern of the document is quality control: the in-process inspection of work and correction of problems discovered during production. Design is addressed as an area of consideration in the summary of the specification but is not referred to again, except as a matter for corrective (rather than preventive) action. This clearly does not recognize changes toward designed-in quality which have occurred in the acquisition process and the quality discipline since 1963.

In recognition of deficiencies in the specification, OSD has proposed adoption of a draft revision to a North Atlantic Treaty Organization quality publication. The Organization's quality assurance procedure repeatedly emphasizes the need to aggressively control design and development.

On the positive side, we found that OSD has established a standardization project run by the Army. The objectives of the project are to minimize the differences among service-level implementation policies and regulations and to unify DOD's basic approach to quality assurance.

Need for additional and better qualified staffing

Dealing with today's advanced weapon systems is difficult in all aspects, including the attainment of adequate quality assurance during the acquisition cycle. In the second DOD Conference on Quality Assurance Management in March 1980, the introductory remarks include this comment:

> "The increasing complexity of our weapon systems and equipment has caused a corresponding complexity in the tasks facing quality assurance personnel."

The majority of the DOD quality assurance work force has had little training in quantitative analysis or design disciplines and often lacks the technical expertise to deal with complex systems. Also, this work force has decreased 45 percent over the last 10 years while increased complexity and number of contracts has driven the workload requirements up. Pay comparability has been cited as a cause for much of the turnover problem in both recruiting and retention.

RECENT EMPHASIS ON QUALITY ASSURANCE

There is an increasing awareness at the higher levels of DOD and the services that quality is a problem and that many changes must take place if better quality systems are to be produced. We noted earlier that some actions are being taken such as the Army's quality assurance standardization project. (See p. 39.) Following are examples of others.

Actions have been initiated to help alleviate quality assurance staffing problems. These actions include the following.

--The DOD Quality and Reliability Assurance Career Board published a handbook in March 1980 with information on careers in the field to attract more people.

--DOD is also working with the Office of Personnel Management to review the current job classification standards in the quality assurance field. For example, the Navy is promoting the establishment of a new engineering classification, the quality assurance engineer.

The move to upgrade job descriptions and corresponding pay levels, however, is recent and is expected to take 2 years to complete. In the meantime, internal training programs at the service levels are being relied on to improve the quality assurance staff.

--The Army has three intern programs for the quality assurance work force and has recently expanded the engineer program from 18 weeks to 1 year of classroom training.

--The Navy has a 3-year old quality engineer intern program with most of the training accomplished by contractors in accordance with Navy requirements and specifications.

--The Air Force is developing an intern program for acquisition quality assurance personnel which should be underway shortly.

Regarding the need to justify the expenditures necessary for adequate "front-end" quality assurance, one service plans to develop an itemized checklist to allow a program manager to identify the cost of successively more intensive levels of attention to quality assurance during the acquisition cycle.

NEED FOR NEW TERMINOLOGY

There is general confusion as to the meaning of quality, quality control, and quality assurance. We suggest a phrase of increasing popularity, "product assurance," as the beginning of the solution. Product assurance has been defined as follows:

> "PRODUCT ASSURANCE is the application of interdisciplinary skills to accomplish the preventive and conformance activities necessary to assure: that requirements are properly specified, that the design will achieve these requirements and that the ultimate product and/or services will perform their intended functions in the operational environment for the period specified."

This quote, taken from the Air Force Systems Command's 1979 "Quality Horizons Final Report," sums up the concept of an interdisciplinary approach to quality which now is in use, in part, by most of the services. Product assurance goes beyond quality control and beyond quality assurance to incorporate reliability, maintainability, and other related disciplines.

CONCLUSIONS

Increasing complexity/sophistication of weapon systems has already led to quality considerations going beyond traditional concerns with quality control into participation in the transition from concept to design. While the importance of quality assurance in the design process is becoming well recognized, the influence quality assurance will have on design is being diluted by a number of factors which need to be addressed by OSD.

First, the focal point of all program efforts--the program manager--has been given much direction about quality, but little help or incentive in pursuing it. He has been directed to evaluate designs for quality and is now in need of comprehensive guidance on how this is to be done. The principal quality assurance specification does not meet this need.

Second, the quality history files on contractors have not been fully established and the cross-service product quality deficiency reporting requirement has not been fully implemented. Until these actions take place, selection of contractor(s) to develop a new weapon system cannot adequately consider contractors' quality histories.

Finally, there is a shortage in DOD of engineers adequately trained in quality assurance. Actions are needed to address this situation and strengthen the quality assurance work force. Some changes are being made, but they do not appear to be sufficient considering the needs.

RECOMMENDATIONS TO THE SECRETARY OF DEFENSE

We recommend that the Secretary of Defense

--produce comprehensive guidance as to how designs should be evaluated for quality assurance,

--ensure that the quality history files on contractor are fully established and that the cross-service product quality deficiency reporting requirement is fully implemented, and

--strengthen the quality assurance work force so as to permit their active involvement in the design phase of the acquisition process.

AGENCY COMMENTS

DOD agrees with our findings, conclusions, and recommendations. (See app. III.)

LOCATIONS VISITED DURING REVIEW

UNITED STATES

OSD

--Assistant Secretary of Defense (Manpower, Reserve Affairs, & Logistics), Washington, D.C.

--Under Secretary of Defense for Research & Engineering, Washington, D.C.

--Office of the Joint Chiefs of Staff, Washington, D.C.

Army

--Headquarters, Army Forces Command, Fort McPherson, Georgia.

--Headquarters, United States Army Materiel Development and Readiness Command, Alexandria, Virginia.

--Headquarters, United States Army, Washington, D.C.

--Headquarters, United States Army Training and Doctrine Command, Fort Monroe, Virginia.

--United States Army Materiel Readiness Support Activity, Lexington, Kentucky.

--United States Army Human Engineering Laboratory, Aberdeen Proving Grounds, Maryland.

--United States Army Materiel Systems Analysis Agency, Aberdeen Proving Grounds, Maryland.

--Headquarters, 4th Infantry Division, Fort Carson, Colorado.

--United States Army Tank Automotive Materiel Readiness Command, Warren, Missouri.

--United States Army Missile Command, Huntsville, Alabama.

--United States Army Infantry Center, Fort Benning, Georgia.

--Headquarters, United States Army Electronics Research and Development Command, Adelphi, Maryland.

--United States Army Troop Support and Aviation Materiel Readiness Command, St. Louis, Missouri.

Navy

--Office of the Chief of Naval Operations, Washington, D.C.

--Headquarters, Naval Material Command, Washington, D.C.

--Naval Air Systems Command, Washington, D.C.

--Naval Electronics Systems Command, Washington, D.C.

--Naval Sea Systems Command, Washington, D.C.

--Naval Supply Systems Command, Washington, D.C.

--Headquarters, Commander-in-Chief, U.S. Atlantic Fleet, Norfolk, Virginia.

--U.S. Naval Surface Forces, Atlantic Fleet, Norfolk, Virginia.

--U.S. Naval Air Forces, Atlantic Fleet, Norfolk, Virginia.

--U.S. Naval Submarine Forces, Atlantic Fleet, Norfolk, Virginia.

--Commander Operational Test and Evaluation Forces, Norfolk, Virginia.

--U.S. Naval Ship Engineering Center, Norfolk Division, Norfolk, Virginia.

--U.S. Navy Fleet Analysis Center, Corona, California.

--U.S. Marine Corps Headquarters, Deputy Chief of Staff for Installations and Logistics, Arlington, Virginia.

Air Force

--Headquarters, United States Air Force, Washington, D.C.

--Air Force Logistics Command, Wright-Patterson Air Force Base, Ohio.

--Air Force Systems Command, Andrews Air Force Base, Maryland.

--Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio.

--Headquarters, Air Force Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio.

--Headquarters, Air Force Tactical Air Command, Langley Air Force Base, Virginia.

--Air Force Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio.

--Air Force Flight Test Center, Edwards Air Force Base, California.

Contractors

--McDonnell Aircraft Company, St. Louis, Missouri.

--General Dynamics, Fort Worth, Texas; Pomona, California.

--Bendix Corporation, Teterboro, New Jersey.

--Bell Helicopter Textron, Fort Worth, Texas.

--IBM, Federal Systems Division, Manassas, Virginia.

--Hughes Aircraft Company, Culver City, California.

--Chrysler Corporation, Warren, Michigan.

Other U.S. locations

--CACI, Inc., Arlington, Virginia.

--Defense Audit Service, Washington, D.C.

--Defense Logistics Agency, Washington, D.C.

--Defense Systems Management College, Fort Belvoir, Virginia.

--Society of Logistics Engineers, Washington, D.C.

EUROPE

--Headquarters, U.S. European Command, Stuttgart, Germany.

Army

--Headquarters, U.S. Army Europe, Heidelberg, Germany.

--Headquarters, U.S. Army VIII Corps, Stuttgart, Germany.

--Headquarters, 3rd Infantry Division, Wurzburg, Germany.

1. Headquarters, 3rd Infantry Division Artillery, Wurzburg, Germany.

2. 2nd Infantry Brigade, Hohenfelds, Germany.
   1st Battalion, 10th Artillery, Scheinfurt, Germany.
   3rd Squadron, 7th Cavalry Regiment, Scheinfurt, Germany.

3. 3rd Brigade A Schaffenburg, Germany.
   703rd Direct Support Maintenance Battalion, Kitzingen, Germany.
   3rd Aviation Battalion, Kitzingen, Germany

--Headquarters, 17th Field Artillery Brigade, VII Corps Artillery, Augsburg, Germany.

1. 1st Battalion, 18th Artillery, Augsburg, Germany.

2. 1st Battalion, 36th Artillery, Augsburg, Germany.

3. 1st Battalion, 30th Artillery, Augsburg, Germany.

--Headquarters, 1st Armored Division, Ansbach, Germany.

1. 3rd Brigade, Bamberg, Germany.

2. 501st Aviation Battalion, Ansbach, Germany.

3. Division Support Command, Ansbach, Germany.

4. 1st Battalion, 94th Artillery, Grafenwohr, Germany.

5. 1st Battalion, 37th Armor, Ansbach, Germany.

6. Headquarters, Division Artillery, Ansbach, Germany.

Navy

--Headquarters, U.S. Naval Forces Europe, London, England.

--Headquarters, U.S. Sixth Fleet, Gaeta, Italy.
--Commander, U.S. Sixth Fleet Battle Forces, aboard U.S.S. Independence (CVA-62), Naples, Italy.

--Headquarters, U.S. Sixth Fleet Maritime Surveillance and Reconnaissance Force, Naples, Italy.

--Headquarters, U.S. Sixth Fleet Attack Submarine Force, Naples, Italy.

--Officers and crew members of U.S.S. Independence (CVA-62), U.S.S. Mahan (DDG-42), and U.S.S. Memphis (SSN-691), Naples, Italy.

Air Force

--Headquarters, U.S. Air Force Europe, Ramstein, Germany.

--Headquarters, 17th Air Force, Sembach, Germany.

1. The 86th Tactical Fighter Wing, Ramstein, Germany.

2. The 36th Tactical Fighter Wing, Bitburg, Germany.

3. A-10 Unit, Sembach, Germany.

OTHER RELEVANT GAO REPORTS

ISSUED BETWEEN JANUARY 1979 AND NOVEMBER 1980 1/

Date	Number	Title
11/13/80	C-PSAD-81-4	Improvements in Performance and Reliability Should Govern Future Procurement of Army's Copperhead Projectile (Classified)
10/24/80	C-LCD-81-1	Navy's Antisubmarine Warfare Capability--Is It Sufficient? (Classified)
9/30/80	PSAD-80-72	Are Management Problems in the Acquisition of Aircraft Gas Turbine Engines Being Corrected?
9/16/80	LCD-80-102	Survey of the Readiness of Minutemen Missiles
9/4/80	LCD-80-106	Survey of DOD's Management of Automatic and General Purpose Electronic Test Equipment
8/21/80	LCD-80-78	Opportunities for Future Improvement of Government Logistics Management
8/20/80	LCD-80-89	F-16 Integrated Logistic Support: Still Time to Consider Alternatives
7/22/80	FPCD-80-58	Actions to Improve Parts of the Military Manpower Mobilization System Are Underway
6/30/80	PSAD-80-61	Implications of Highly Sophisticated Weapon Systems on Military Capabilities

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1/Instructions for obtaining copies of our reports are on the inside front cover of this report. To obtain copies of classified reports, security clearance information must be provided along with a demonstrated need-to-know.

Date	Number	Title
6/12/80	PSAD-80-43	Issues Identified in 21 Recently Published Major Weapon System Reports
6/6/80	LCD-80-65	Operational and Support Costs of the Navy's F/A-18 Can Be Substantially Reduced
5/9/80	PSAD-80-40	Is the Joint Air Force/Navy Alternate Engine Program Workable? GAO Thinks Not as Presently Structured
4/14/80	C-FPCD-80-3	Overview of the Manpower Effectiveness of the All-Volunteer Force (Classified)
4/1/80	LCD-80-48	Logistics Management Issues Staff Study
2/20/80	FPCD-80-10	Attrition in the Military--An Issue Needing Management Attention
2/15/80	FPCD-80-31	The Navy's Pilot Shortage: A Selective Bonus and Other Actions Could Improve Retention
2/7/80	LCD-80-30	Increased Standardization Would Reduce Costs of Ground Support Equipment for Military Aircraft
1/29/80	PSAD-80-20	XM-1 Tank's Reliability is Still Uncertain
12/11/79	LCD-80-2	Improving the Effectiveness of Joint Military Exercises--An Important Tool for Military Readiness
12/11/79	FPCD-80-6	Estimates of Available Hours for Military Personnel in Wartime Distort Force Requirements and Planning
11/26/79	C-FPCD-80-1	Active Duty Manpower Problems--Barrier to Mission Accomplishment (Classified)

Date	Number	Title
11/13/79	C-PSAD-80-2	Army Operational Test and Evaluation Needs Improvement (Classified)
11/8/79	PSAD-80-6	Impediments to Reducing the Costs of Weapon Systems
11/6/79	LCD-80-11	Modernizing the Air Reserve Force--More Emphasis on Logistics Support Needed
10/30/79	C-LCD-80-2	A-10 Aircraft Logistics Support Can Be Better Matched with Operational Requirements (Classified)
10/12/79	LCD-80-5	DOD's Material Readiness Report to the Congress--Improvements Needed to Better Show the Link Between Funding and Readiness
9/28/79	LCD-79-414	Alternatives to Consider in Planning Integrated Logistics Support for the Trident Submarine
9/11/79	PSAD-79-99	Manufacturing Technology--A Cost Reduction Tool at the Department of Defense that Needs Sharpening
8/20/79	LCD-79-423	Letter Report on GAO's Concerns with the Readiness of U.S. Forces (Classified)
8/9/79	PSAD-79-95	Army Procurement of 10kW, 60Hz Gas Turbine Generators is Highly Questionable
7/31/79	FPCD-79-13	DOD Oversight of Individual Skill Training in the Military Services Should be More Comprehensive
7/11/79	FPCD-79-58	Critical Manpower Problems Restrict the Use of National Guard and Reserve Forces
6/28/79	FPCD-79-3	Can the Individual Reserves Fill Mobilization Needs?

Date	Number	Title
6/25/79	PSAD-79-86	Effectiveness of DOD's Development Test and Evaluation
5/17/79	FPCD-79-40	Problems in Getting People Into the Active Forces After Mobilization
5/10/79	LCD-79-407	If Army Helicopter Maintenance Is to Be Ready for Wartime, It Must Be Made Efficient and Effective in Peacetime
4/25/79	PSAD-79-64	Digests of Major Weapon System Reports Issued January and February 1979
4/25/79	LCD-79-404	Can the Army and Air Force Reserves Support the Active Force Effectively?
4/23/79	LCD-79-406	The United States Air Force Tactical Air Command--Is It Ready? Can It Fulfill U.S. Commitments to Rapidly Increase Its Forces in Europe?
4/28/79	PSAD-79-44	The Effectiveness of the F-14A/Phoenix Weapon System Is Marginal at Best Against the Current and Postulated Threat (Classified)
2/20/79	PSAD-79-9	Observations on Office of Management and Budget Circular A-109--Major System Acquisitions by the Department of Defense
2/12/79	LCD-78-430	Readiness of Conventional U.S. Air Forces in Europe--Selected Aspects and Issues
2/6/79	LCD-78-417A	Marine Amphibious Forces: A Look at Their Readiness, Role, and Mission
1/24/79	FPCD-78-82	DOD's "Total Force Management"--Fact or Rhetoric?

THE UNDER SECRETARY OF DEFENSE

WASHINGTON, D.C. 20301

RESEARCH AND ENGINEERING

11 DEC 1980

Mr. W.H. Sheley, Jr.
Acting Director, Procurement and Systems
Acquisition Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Sheley:

This is in reply to your letter to the Secretary of Defense regarding your draft report on "Ownership Considerations Need More Emphasis in Weapon Systems Design", OSD Case #5538, GAO Code 951516.

We have reviewed the draft report and believe it is excellent and well-balanced. DoD agrees with GAO in the need to strengthen these activities. The report accurately represents our recent efforts to increase the emphasis on ownership and support considerations during the development of DoD systems. The report discusses the degree of difficulty associated with many of the areas of logistics analysis and projection as well as the difficulty in testing a system's logistics supportability. The report also recognizes recent policies issued by DoD to emphasize these very important considerations and the fact that there has not been sufficient time to accrue full benefit from these recent policy changes. The DoD has initiated many activities to follow-up on the new logistic support policies.

The attached comments have been informally discussed with your staff. They serve to clarify some of the significant observations and recommendations in the report. We would appreciate your incorporation of these views in the final report.

We appreciate the opportunity to comment on the draft report and are willing to discuss further with the GAO staff any of the points contained herein.

Sincerely,

Walter B. LaBerge
Principal Deputy

Attachment
a/s

COMMENTS ON OSD #5538

GAO Draft Report "Ownership Considerations Need More Emphasis in Weapon System Design"

GAO Recommendation: "Develop new or modify current maintenance data reporting procedures to provide the information needed for performing logistic support analysis."

OSD Responses: Concur in principle.

There is a need for additional and better historical data to support the performance of logistic support analysis. It is not clear that in all cases this data should be drawn from a maintenance data system. For example, the Air Force is addressing this specific problem with a project entitled "Product Performance Feedback System." This project deals with analysis results rather than data products. Across the wide scope of DoD missions and systems there are a number of different solutions which will address this specific problem. In some instances a new or improved maintenance data system may be the answer, in other situations other alternatives may be preferable. The new Department of Defense Directive on reliability and maintainability (DoDD 5000.40) requires DoD in-service data collection systems to report the measured values of system R&M parameters which relate to readiness, maintenance manpower and logistics support cost. While each Service's implementation may be different, the need for this data has been recognized.

GAO Recommendation: "Establish logistic support research and study programs to develop improved quantitative methods for assessing (1) the adequacy of logistic support plans, resources, and support related parameters, and (2) the benefits of design changes in the acquisition process to improve the future logistic supportability of a system."

OSD Responses: Concur.

On September 3, 1980 direction was sent from OSD to the Secretaries of the Military Departments to initiate a Research and Development program for improvement of weapon support. The scope of this program will include logistic concept development, hardware techniques and design tradeoffs, and weapons system demonstration projects.

GAO Recommendation: "Provide guidance to insure that critical program documents (for example, mission element needs statements, request for proposals and contracts) contain the language needed to obtain systems which are logistically supportable."

OSD Responses: Concur.

Both DoD Directive 5000.39 and 5000.40 both provide implementation guidance on considerations that should be included in various program documents related to support. For example, 5000.39 requires that manpower and logistic resource constraints be identified in the MENS; that contract requirements for full-scale development clearly define baseline operational scenerios, a baseline maintenance concept, and readiness and wartime employment objectives; and that a preliminary manning document and supporting analysis be available by the production decision point. DoDD 5000.40 includes the requirement to specify, in the conceptual phase, the system life profiles and tenative goals for the appropriate system R&M, and the requirement to translate R&M threshold objectives into mimimum acceptable values in contracts for both contractor and government furnished equipment during the full-scale development phases. We will, over the next several years, evaluate the application of this guidance to determine its strenths and weaknesses and will issue supplemental guidance as appropriate.

GAO Recommendation: "Provide for improved testing and evaluation of the logistic supportability of systems before they are deployed."

OSD Response: Concur.

As discussed in the draft report, OSD and the Services have had a joint study underway since March 1979 to address the area of operational suitability evaluation. The first phase of this study examined problems involved in test and evaluation of logistic supportability. The phase one study results summarized in the GAO report point out the many constraints and difficulties involved in implementing existing DoD policies requiring operational suitability evalution. Guidelines for improvements in supportability evaluation are being developed in the second phase of the study.

GAO Recommendation: "Revise the Logistic Support Analysis Military Standard to emphasize that logistic supportability is now as important as cost, schedule and performance and must receive appropriate emphasis in system design."

OSD Response: Concur in principle.

The Military Standard is now under revision to bring the standard into agreement with the new logistics policies. However, the Military Standard is not the best document to provide priorities to the program manager. Other policy directives, including DoDD 5000.1 and DoDD 5000.2 as recently revised, now contain such an emphasis statement. Particular emphasis will be given to the development of logistic analysis guidelines during the critical concept and advanced development phases, where system level tradeoffs affecting cost, schedule and performance are made. We believe this will provide the appropriate implementation guidelines.

GAO Recommendation: "Modify human factor specifications, standards and handbooks used in system design so that they adequately address all human limitations including skill levels, proficiency, availability, environmental stress and fatigue which can result in human-induced system failures."

OSD Response: Concur.

GAO Recommendation: "Develop common methodologies and data sources for use by system designers in forecasting skill levels of military personnel 5 to 10 years in the future."

OSD Response: Concur in principle.

The forecasting of skill levels is necessary as an input to the system definition effort, however, the skill level is the result of many things including the projected training and the training that is required as a result of system definition. We agree that this circular process should be better addressed and provide a better framework for the system designers.

GAO Recommendation: "Ensure that all major systems are subjected to adequate testing and examination from a human factors standpoint."

OSD Responses: Concur.

This recommendation should be clarified. The use of the word testing might infer that more "after-the-fact" emphasis is recommended. A preferred solution is to provide emphasis at all stages of the system's development from initiation to conclusion.

GAO Recommendation: "Produce comprehensive guidance for program managers as to how a design should be evaluated for quality assurance."

OSD Responses: Concur.

The establishment of this guidance is only one part of the solution to the identified problem. In addition to guidance, the proper management emphasis is also required.

GAO Recommendation: "Implement the data feedback system on contractor quality histories, and insure that the cross-service product quality deficiency reporting requirement is carried out."

OSD Response: Concur.

The cross-service reporting system was established in 1979, but all services/ agencies have not yet implemented the program. The Army has completely functioning program and the Air Force is close behind.

GAO Recommendation: "Strengthen the quality assurance workforce so as to permit their active involvement in the design process."

OSD Response: Concur.

OSD General Comments:

GAO Observation (pages vi): "Government quality assurance engineers are in short supply and lack adequate training."

OSD Comment: Engineers in general are in short supply and engineers working in quality assurance are no exception. These are qualified engineers who work in the quality assurance area but who may need more training in quality assurance subjects.

GAO Observation (page 32): "The MENS statements are to contain logistics considerations, but only the Air Force has issued guidance..."

OSD Comment: The Army published a letter of instruction for MENS preparation on January 7, 1980. This instruction provides detailed guidance for preparation and submission of MENS.

GAO Observation (page 54): "The DoD acquisition directives (5000 series), however emphasize repeatedly that the concerns of the manager ought to be cost, schedule, performance, and more recently, supportability."

OSD Comment: This observation does not recognize the discussion of quality/ reliability and maintainability contained in DoDI 5000.2 Specific discussion is in paragraphs C.8.2 and C.9.

GAO Observation (page 57): ". . . on how to review designs for quality assurance, we examined the standard quality specification which is mandatory for use by DoD agencies -- MIL-Q-9858A. . ."

OSD Comment: Mil-Q-9858A is for contractual application only, it does not apply to "in-house" DoD activities. The document is currently under revision as part of the NATO AQAP-1 activity.

GAO Observation (page 61): "We suggest a phrase of increasing popularity, "product assurance," as a beginning of the solution. Product assurance has been defined as..."

OSD Comment: The definition as presented in the draft GAO report was taken from the Air Force Systems Command 1979 "Quality Horizons Final Report." It is just an opinion of what should be defined as the integrated subject of quality, quality control, quality assurance, reliability, etc.

GAO Observation (page 75): "Examples of military equipment reported by the services to be undependable and difficult to support and operate."

OSD Comment: Details on these problem statements should be changed.

TOW Problem: Problem statement is not correct. The Army is procuring a new type battery and employing TOW vehicle power conditioners, thus the problem has been eliminated duirng the past 18 months.

DRAGON Problem: Although there have been some component malfunctions (defective thrusters) these problems were detected prior to deployment and use, and thus cannot be said to be said to be contributing to misses.

Track Problem: Change to read: The end connectors and track pads for this track must be replaced at 1500-2000 miles and the entire track between 5000 and 6000 miles. The track cost approximately $23,000 per set. The track pads can be replaced without rebuilding the track and allows the extension of track life described above.

SUMMARY OF SPECIFIC COMMENTS

MADE BY

OUR PROCUREMENT ADVISORY PANEL

1. One of the serious problems affecting ownership considerations in the acquisition process is a lack of continuity in program management--there is a new program manager (a military officer) about every 3 to 4 years. The program manager is most concerned about what happens on his "watch" and thus is not inclined to place emphasis on factors such as supportability, human reliability, and quality assurance where the benefits are realized when the system is deployed. Perhaps a civilian should be designated as project manager and kept in that position until the system is deployed.

2. Contractors have the "know-how" to design more supportable systems. If the Government would give the contractor the financial incentive and responsibility, the system designed would be much more supportable and the financial investment will be returned in reduced operating and support costs.

3. Contracts need to contain language which provide the contractor with qualitative and quantitative requirements that force designers not to ignore supportability.

4. The Government must encourage the application of new technology to the design of the weapon system support systems (for example, test and diagnostic equipment) to improve supportability.

5. The logistic support analysis does not necessarily have to be complex and costly. The analysis needs to be tailored to the specific needs of the weapon system development program using simplified models and a good knowledge of design alternatives as a substitute for complex software.

6. There are serious semantic problems in the whole area of support. There is no common or generally agreed upon set of terms and definitions in the area of supportability. DOD should revise its glossary.

7. There are too many directives, specifications, regulations, and so forth. A major effort is needed to reduce the number.

8. Much attention needs to be given to how designers can design for supportability.

9. The Office of Management and Budget's Circular A-109, approved in 1976, should result in the design of more supportable systems as it provides a basis for review and comparison in the source selection process. Ownership considerations cannot be disregarded in such a process.

10. There is a need to establish a uniform methodology for estimating personnel-related cost factors associated with life-cycle cost projections.

11. No one is looking into the fatigue factor that goes along with combat. How much can an operator or maintainer take before giving up? This needs to be considered in system design.

12. Military personnel should be assigned to contractor facilities to help familiarize themselves with weapon systems being procured. This could greatly reduce the number of human-induced failure in systems.

13. The wrong people are designing manuals and training courses. Engineers write the manuals used by high school students.

14. The Government is going to encounter serious difficulties in devising and initiating an objective, meaningful, timely, and equitable basis for reporting contractor quality histories.

15. There is a need for well written and definitive manufacturing instructions which are understandable at the worker level. This is extremely important and is not always the case. The effect of human factors in the day-to-day production cycle in the manufacturing processes is vital. Units that are difficult to assemble, test, rework, reassemble, and retest encounter many problems.

16. Direct design evaluation for quality assurance by program offices in DOD is not cost effective. The program office should be more concerned about evaluating the contractor's quality assurance program rather than the system design.

17. A committee needs to be established to redefine the roles of the various disciplines which make up

systems engineering. This is necessary to accommodate the new emphasis on supportability.

18. Industry must be made more aware of the problems the military is experiencing with fielded systems. The problems must be defined and engineering analysis done to identify the causes. The current military data reporting systems are inadequate for this purpose.

19. Contractors need to better understand the emphasis to be placed on logistic support in new development programs. There is a need to establish a rating system for use in requests for proposals to convey this emphasis to contractors.

EXAMPLES OF MILITARY EQUIPMENT REPORTED BY THE SERVICES TO BE UNDEPENDABLE AND DIFFICULT TO SUPPORT AND OPERATE

System/equipment	Problem
Army	
TOW (Antitank missile system, ground version)	Battery power supplies were unreliable. As a result, missile launches were jeopardized or guidance was lost during flight.
Dragon (antitank missile system)	Component malfunctions plus human factor problems cause many of these missiles to miss the target.
T142 tank track on M60 series tank	This track must be replaced at 1,500 to 2,000 miles. It is less reliable than its predecessor.
AH-1 "Cobra" attack helicopter	The main rotor hub has significant reliability problems due to frequent failure of feathering axis bearings.
GOER (transport/resupply vehicle)	Extreme bounce generated by vehicle produced serious driver fatigue. Numerous components suffer high rates of failure.
M110 self-propeller howitzer (8 inch)	Numerous hydraulic components problems being experienced since recent modifications added a heavier gun tube. Additional problems exist with road wheels, overheating engines, gun sighting equipment, and projectile ramming systems.
Test and diagnostic equipment used for avionics and electrical subsystems	Equipment is unreliable, requires extensive calibration, and is difficult to repair.

System/equipment	Problem
Navy	
MK-86 gun fire control system on many surface warships	A significantly large number of random failures among the 40,000 plus parts and the inability of supply system to meet these replacement component demands have caused low operational availability.
AN/SPG-55B guided missile control radar on many surface warships	Low reliability, replacement part shortages, and inadequate operator and maintenance training are affecting operational availability.
AN/SPS-40 air search radar on many surface ships	High failure rates of some parts, long time to receive replacement parts, and inadequate number of trained technicians lead to operational availability problems.
Wasteheat boilers on DD-963 class destroyers	Extremely difficult, if not impossible to adequately maintain. Equipment failure would result in partial loss of ship's electrical power, potentially affecting ship's weapon systems.
BQQ-5 sonar on SSN-688 class attack aubmarines	Severe replacement part shortages have caused submarines to experience mission degradation.
MK-18 periscope on SSN-688 class submarines	Fleet has experienced many problems including (1) slip ring failures, (2) poor logistic support, (3) inadequate technical documentation, (4) inadequate maintenance training, and (5) insufficient technical support equipment.
S3A antisubmarine warfare aircraft	Low reliability of many key electronic components have caused low aircraft operational availability rates.

System/equipment	Problem
Air Force	
"Turkey Feathers" on F-15 aircraft	These engine parts are wearing out after about 15 hours of use. They cost $1,000 each, and each aircraft has about 30 of them.
F-100 engine in F-15 aircraft	Problems with reliability and durability, particularly in the "hot section" of the engine, have led to low operational availability rates.
Automatic test equipment for F-15 aircraft	Problems include (1) lack of adequately trained and experienced operators and maintenance personnel, (2) some software incompatability, and (3) low re liability of the built-in test and avionics intermediate shop automatic stations. These problems degrade testing efficiency and ultimately degrade aircraft's operational readiness.
Stability augmentation system in A-10 aircraft	Problems with targeting on the first 201 aircraft and with vibrations and signal interruptions on the last 158 aircraft affect the aircraft's mission effectiveness.
Flight controls in A-10 aircraft	Clearance for the aircraft cables and controls is not sufficient, and foreign objects may jam the controls. This condition may already have contributed to aircraft accidents.
Shelters for A-10 aircraft	Serious shortage of shelters in Europe might adversely affect maintenance of aircraft.
War reserve spare kits/ base level self-sufficiency kits	Shortages of war reserve re-replacement parts and components exist. These kits are needed to keep aircraft and their subsystems operational.

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U.S.MAIL

THIRD CLASS