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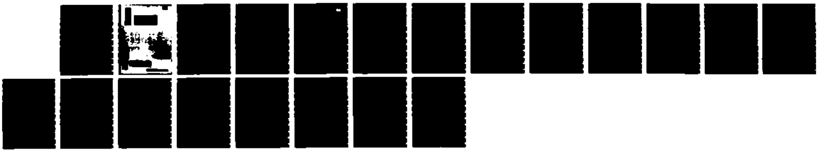

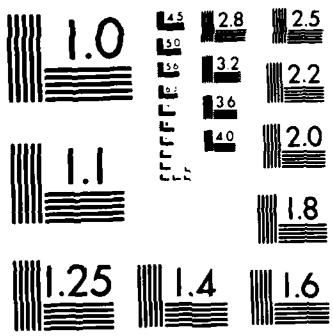

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DEPOT MAINTENANCE IN THE 1990's

July 1986

Alfred H. Beyer
Connelly D. Stevenson

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The 1990's will bring about major changes in depot maintenance – the weapon technologies supported, the repair methods employed, the composition of the work force, and the roles of the depots themselves. Underlying those changes will be increasingly larger requirements for funds to perform the repairs and to modernize and equip the facilities. To assure that the funds are invested in areas most beneficial to the Department of Defense, we believe the Assistant Secretary of Defense (Acquisition and Logistics), ASD(A&L), needs to increase his participation in their allocation. We recommend that the ASD(A&L) develop the capability to evaluate the .easonableness of depot maintenance budgets and outyear programs; a procedure for assessing the depot maintenance requirements for Military Construction funding; and a method for tracking requests for depot modernization and new equipment funding.

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Executive Summary

DEPOT MAINTENANCE IN THE 1990's

The 1990's will bring about major changes in depot maintenance – the weapon technologies supported, the repair methods employed, the composition of the work force, and the roles of the depots themselves. Accompanying those changes will be large requirements for funds to perform the repairs and to modernize and equip the facilities. To assure that the funds are invested in areas most beneficial to the Department of Defense, we believe the Assistant Secretary of Defense (Acquisition and Logistics), ASD(A&L), needs to increase his attention to their allocation.

This constitutes a significant addition to the ASD(A&L)'s traditional roles of developing depot maintenance policy and monitoring its implementation. The emerging trends in depot maintenance call for a shift in emphasis. Future defense budgets are unlikely to support the growth in funding the Military Services have planned for maintenance depots. As more high-technology weapons systems enter the inventory, the competition among the depots – to upgrade capabilities, to be the most modern, or to have some special capability that assures survival – will increase. The result will be a stream of tough decisions about depot construction, modernization, and workload priorities that cut across Military Service lines.

To enhance his participation in depot maintenance resource allocation decisions, the ASD(A&L) needs to be readily able to access Military Services' plans and requirements and to have the analytic tools to assess them. We recommend that the ASD(A&L) develop:

- The capability to evaluate, early in the planning, programming, and budgeting process, the reasonableness of depot maintenance budgets and outyear programs, drawing extensively upon prior-year production and performance data.

- A procedure for examining the depot maintenance requirements for Military Construction funding, assessing the value of those requirements, and monitoring the funding support they receive during the planning, programming, and budgeting cycles.

- A method for being aware of the requests for depot modernization and new equipment funding, evaluating the merits of those requests, and tracking the funding they receive.

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DEPOT MAINTENANCE IN THE 1990's

PROGRAM OVERVIEW

Depot maintenance is big business. End items and components are maintained at 33 organic facilities – Army Depots, Naval Air Rework Facilities (NARFs), Naval Shipyards, Marine Corps Logistics Bases, and Air Force Air Logistics Centers (ALCs) – and at numerous contractor facilities. More than 160,000 people are employed at the organic facilities alone. They support a global inventory of military equipment that includes 36,000 combat vehicles, 580 ships, 24,000 aircraft, and 660,000 wheeled vehicles, all of staggering diversity.

Less than a decade ago, the total funding of the Department of Defense's (DoD's) depot maintenance program was approximately $6 billion. By fiscal year 1982 (FY82), that cost had grown to $10 billion, and in FY86, it totaled more than $13 billion, well on its way toward an estimated $20 billion in the early 1990's. Table 1 shows that growth, starting with FY78. While the outyear estimates are subject to wide fluctuation, their continued escalation is being fueled by many factors, including the great number of new weapons systems that entered the DoD's inventory during the 1980's.

The role of the Office of the Secretary of Defense in the DoD's depot maintenance program has generally been focused on prescribing overall policy and then monitoring its implementation. In concert with that role, the Military Services have independently managed and operated their own depot maintenance programs. Those activities have included planning, programming, and budgeting; work force training; workload scheduling; cost and production accounting; facility development; and productivity monitoring – all the functions that are associated with the management and operation of a large industrial complex.

TABLE 1. DEPOT MAINTENANCE FUNDING BY FISCAL YEAR

FISCAL YEAR	FUNDING ($ BILLIONS)
1978	6.3
1980	7.2
1982	10.1
1984	12.0
1986	13.2[a]
1988	14.9[a]
1990	17.8[a]

[a]Estimates.

In the following sections, we examine some of the factors that will affect the DoD's depot maintenance program in the 1990's.

FACTORS AFFECTING OUTYEAR PROGRAMS

The increasingly sophisticated worlds of microelectronics, composite materials, lasers, and other recent technologies are having a substantial impact on how and where the DoD maintains its weapons systems. The combined effects of the complexity of the newer weapons systems, their advanced technologies, and the modularity of their design are accelerating the trend toward two levels of maintenance. Under the two-level concept of maintenance, weapons systems are returned to operational status by replacing defective components in forward areas and subsequently repairing them in the rear. The complexity and technology of many weapons systems dictate that those repairs take place in a depot, usually located in the continental United States. The overall result of this two-level process is that substantially more weapons systems maintenance will be done in depots, thereby establishing even closer links between depot performance and combat operations. (This trend toward the depots having a major role in component rework programs is already well established. In FY86, components will comprise almost 33 percent of the Navy's aircraft workload and more than 50 percent of the Air Force's.) In the following paragraphs we examine the issues of complexity and technology in more detail.

Complexity

The explosion in weapons system complexity can be best illustrated by examining it briefly from three different perspectives – the variety and number of components in a particular system, the amount of technical documentation required, and the growth of embedded computers.

A 1983 issue of Logistics Spectrum[1] provided some interesting statistics on the Navy's Mark 98 TRIDENT Fire Control System. It stated that the Mark 98 contains 42 power supplies, 7 power converters, 862 mechanical relays, 650 display modules, and more than 15,000 electronic modules, among numerous other components.

The Army has found that the amount of technical documentation that it requires to operate and maintain the M1 tank totals approximately 40,000 pages, more than double the number of pages for the M1's immediate predecessor, the M60, and a four-fold increase over the earlier generation M48.

The Winter 1985 edition of the Air Force Journal of Logistics[2] estimates that the number of computers embedded in DoD weapons systems is increasing exponentially – from approximately 10,000 in 1980, to 60,000 in 1984, to 160,000 in 1988, to 280,000 in 1990. Accompanying that increase will be a corresponding

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[1]Harry Rosenberg, "Maintenance Considerations for TRIDENT Fire Control Systems," Logistics Spectrum, Winter 1983, Volume 17, Number 4 (Huntsville, Alabama: Society of Logistics Engineers), pp. 7–13.

[2]James D. Pierce and Winifred E. Okumura, "New Technologies – Their Impact on Air Force Depot Repair," Air Force Journal of Logistics, Winter 1985 (Washington, D.C.: U.S. Air Force), pp. 28–32.

growth in the number of hardware and software technicians needed to keep those computers operational.

For systems such as the Mark 98 and M1, and for those with embedded computers, the depots will be the key source of maintenance. Field maintenance organizations will have neither the skills, the tools, the repair parts, nor the test equipment to perform many of the needed repairs.

Weapons system complexity will also have an effect on the work force of the depots. As those weapons systems procured in the early and mid-1980's begin to place larger maintenance demands upon the depots, we will see the depot work force become increasingly white-collar. Private industry in the United States is experiencing a similar revolution in the makeup of its work force. General Motors, for example, estimates that by the year 2000 almost 50 percent of its work force will be inspectors, technicians, or monitors.[3] The DoD should anticipate a similar type of upheaval in its depot maintenance work force.

Technology

While the locations and structures of DoD's depot maintenance activities are not expected to change significantly during the coming decade, the sophistication of the technologies supported certainly will be revolutionary.

The use of composite materials in air, land, and sea systems to bring about or enhance structural integrity, corrosion resistance, and weight reduction will certainly increase. Although the Air Force's advanced tactical fighter will not join the DoD inventory until the late 1990's, it is estimated that composites will comprise up to 60 percent of the aircraft's structural weight. That aircraft is merely a forerunner of other systems on the drawing board.

[3]Captain Andrew J. Ogan, "Megatrends and Military Logistics," Logistics Spectrum, Fall 1985, Volume 19, Number 3 (Huntsville, Alabama: Society of Logistics Engineers), pp 18–22

The use of microelectronics in DoD weapons systems is undergoing a similar explosion. With the advent of the very-high-speed integrated circuit (VHSIC) chip, the potential for improvements in reliability, miniaturization (space and weight savings), and operational speeds is almost beyond comprehension. In a January 1985 article in Air Force Magazine, Colonel Frank Moore, Commander of the U.S. Air Force Avionics Laboratory, provides an example of the potential of the VHSIC chip by relating it to use in aircraft avionics.[4]

> The existing F-15 radar signal processor weighs fifty pounds, contains 5000 integrated circuits (chips), and needs 1,600 watts of power. Doing its job with VHSIC chips would require one thin circuit board containing only 45 chips, weighing a total of only three pounds, and requiring only fifty watts... the use of such a card would reduce the number of connectors in the radar signal processor (connectors are responsible for a great many failures in avionics) by a factor of one hundred to one.... this could increase the reliability of the aircraft's avionics by a factor of ten and cut maintenance in half.

Colonel Moore goes on to explain that an F-16 aircraft contains 58 avionics "black boxes" each weighing 50 pounds. He believes that those 58 boxes could be replaced by only 43 VHSIC line-replaceable modules (the 3-pound cards), making forward-deployed repair (through card replacement) fast and easy.

Similar examples could be cited for the growing use of lasers and fiber optics in weapons systems. Altogether, these new and sophisticated technologies portend an extremely dynamic and challenging depot maintenance environment.

The tide of technology that is sweeping through the depot maintenance community is not restricted to the weapons systems being supported. It extends also to the maintenance processes, procedures, and equipment employed in that support. Flexible manufacturing systems, robotics, computer-integrated manufacturing, numerically controlled machines, and distributed numerically controlled systems

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[4]James W. Canan, "Coming On and Coming Up," Air Force Magazine, January 1985, Volume 68, Number 1 (Arlington, Virginia: Air Force Association), pp. 34–42

are no longer on the horizon. They are available now, and they are becoming increasingly more affordable.

Furthermore, recent advancements in information technology are providing many opportunities for major breakthroughs in logistics management. The cost and time required to process and transmit data are dropping significantly, opening up possibilities for dramatic changes in the way DoD supports and maintains weapons systems during war. For example, state-of-the-art communications systems will link test equipment in the depots to the units in the field; technical data will be stored centrally and made available instantaneously to remote field maintenance activities; and diagnostic troubleshooting and artificial intelligence computer routines resident at central locations will be utilized by forward units. Finally, it is already possible for technicians at depots (or contractor plants) to observe (on television screens) and guide repairs being conducted in the field.

In summary, we envision many changes in depot maintenance over the next 10 to 15 years, with most being a direct result of the increased weapons system complexity and the advanced technologies incorporated into those systems. In the next section, we examine the impact of those changes on depot maintenance resources.

IMPACT ON RESOURCES

The growth in the cost of DoD's depot maintenance programs from $13.2 billion in FY86 to more than $20.0 billion in the early 1990's cannot be attributed solely to the complexity and sophisticated technology of DoD's weapons systems. For the past several years, the DoD has aggressively modernized its combat forces, substantially increasing the number and types of weapons systems and end items in its inventory. These newer weapons systems and end items, together with the older weapons systems remaining in the inventory, will also stimulate the projected growth in the depot maintenance program.

Accompanying that growth will be increasing requirements to modernize and equip the depots. The technology content of the newer weapons systems is simply a product of the revolution in electronics and in material and information sciences that has occurred over the past 10 to 15 years. Depots must be capable of diagnosing, overhauling or repairing, and testing weapons systems and end items whose principles of operation and construction materials were the objects of scientific investigation and discovery only a few years previously. Simultaneously, the depots must prepare (many already are) to substantially improve both the quality and productivity of their performance. Numerically controlled machines linked by computer to perform precision, nonassembly line processes; remotely operated, continuous feeding welding machines; and robots programmed to perform hazardous environment industrial operations are but a few of the "factory-of-the-future" industrial innovations that the depots must adopt in order to participate in the promised productivity explosion – regardless of the technology content of the weapons system being repaired. The realization of this quantum improvement in industrial support capability will require an investment of several billion dollars to fund the construction and procurement of new facilities and equipment; the recruitment, training, and retention of a work force with information or knowledge skills rather than manual skills; and the development of management systems that can integrate the workload planning, industrial processes, materials flow, etc.

The results of a recent Navy study (Navy Aviation Depot Modernization Program) provide a good illustration of the extent of industrial modernization needed within the DoD. In 1983, the Navy examined the condition of the facilities and industrial equipment at its six NARFs. The results of that examination are enlightening and portend substantial expense: over 50 percent of the facilities needed to be upgraded substantially, with 15 percent categorized as "inadequate for intended function"; and more than 33 percent of the industrial equipment was more than 16 years old, with 25 percent of all equipment exceeding 21 years of age.

In developing a strategy for getting well, the Navy assumed that the airframe workload would decrease and the component/engine workload would increase, paralleling the expected wartime work profile. As part of the component workload, the Navy included the depot-level reparables from several new aircraft types, such as the F/A-18, AV-8B, SH-60, and V-22A. Finally, the Navy selected a 12-year period during which it would rebuild the capabilities of its aircraft depots. Over that period, the Navy estimated that it would need $1.25 billion in Military Construction funds and $800 million in equipment modernization funds to develop the needed capabilities. (Incidentally, both of those funding levels greatly exceed recent Navy funding for the capital improvement of both the NARFs and shipyards combined.)

While the Navy's aviation depots were identifying the need for a $2 billion improvement in industrial capability to meet the demands of the 1990's and beyond, the Air Force Logistics Command was simultaneously planning to improve the capabilities of its ALCs.

For the past 10 years, the Air Force has employed a Technology Repair Center (TRC) concept whereby work in 20 technologies, such as electrical components, hydraulics, and landing gears, is spread among its ALCs. Under the TRC concept, only four technologies are assigned to more than one ALC, with two – instruments and aircraft-related components – assigned to five. The remaining technologies are assigned to just a single ALC. Now, in an attempt to minimize the vulnerability associated with having all capability for any technology sited at only one depot and to balance peacetime workload to foster satisfaction of wartime demands, the Air Force plans to discard the TRC concept, redistributing the technologies among the depots, with only four technologies assigned to a single depot.

Although the cost of this planned workload realignment was not made available, it undoubtably will be large. Furthermore, that cost can be viewed as the price that the Air Force must pay to reverse its 10-year-old decision to implement the TRC concept, which also carried a substantial price tag.

Concurrently, the Army is making substantial investments to support some of its newer technologies that have been commonplace within the Navy and Air Force for many years. Areas such as microelectronics, automatic test equipment, and software are just three examples where the Army is developing capabilities that already exist elsewhere in the DoD.

Another illustration of DoD's growing requirement for capital investments in depot maintenance is the Asset Capitalization Program. Initiated in 1981, it provides the depots with the funds to replace outdated or unproductive equipment. DoD funding for the Asset Capitalization Program, from FY83 through FY86, is shown in Table 2. The program's growth by a factor of 2.5 within 4 years reflects both an increased awareness of its potential, as well as a recognized need for upgrading depot equipment.

TABLE 2. ASSET CAPITALIZATION PROGRAM

(Millions of Dollars)

MILITARY SERVICE	FISCAL YEAR			
	1983	1984	1985	1986
Army	N/A[1]	62	83	84
Navy[2]	N/A	131	299	325
Air Force	N/A	114	180	191
TOTAL	240	307	562	600

[1]Not available.
[2]Includes Marine Corps funding.

LONG-TERM CONSIDERATIONS

We believe that in the 1990's, major changes will take place in depot maintenance – changes in the weapon technologies supported, in the repair methods and processes employed, in the composition of the work force, and in the roles of the depots themselves. Most of those changes will occur as the Military Services respond to increased weapons systems complexity and to the sophistication of the technologies embedded in the systems themselves as well as that required to maintain them. The cost of the changes, both to perform the repairs and to modernize and equip the depots, will be substantial, however.

The primary management responsibility for accommodating the forthcoming changes in depot maintenance must continue to reside with the Military Services. They have long demonstrated their ability to successfully develop the requirements, program the workload, schedule the repairs, train the work force, monitor the quality, and fulfill many other depot management responsibilities. The role of the Assistant Secretary of Defense (Acquisition and Logistics), ASD(A&L), in these and related activities should be that of supporting the Military Services, much as it has been for the past several years.

However, we believe depot funding, both to perform the repairs and to modernize and equip the depots, will be the primary issue in the 1990's and that the ASD(A&L) needs to increase his participation in the funding process. Our reasons are numerous, but four predominate.

First, the current budget environment offers little promise that all of the depot maintenance outyear requirements will be funded. This will necessitate cross-Service decisions on construction, modernization, and workload priorities – just the types of decisions that the Military Services have demonstrated time and again that they are unwilling to make.

Second, the competition for Military Construction, Asset Capitalization Program, and other facility and equipment improvement funding will be intense over the next 10 to 12 years. The Military Services will be under a great deal of pressure to upgrade their depot capabilities, particularly in the new technology areas. They may even see development of specific capabilities as vital to the long-range competitiveness and viability of a specific depot. If past practices are any indicator of the future, the Military Services will make many of these types of investment decisions without adequate consideration of the workloads or capabilities of the other Military Services, or the capabilities of contractors. The results will be unnecessary redundancy and excessive capacity – at great cost.

Third, not only will the competition for facility and equipment funding be intense, but the funds being sought will be substantially greater than those required in the past. The new technologies, both in the weapons systems and in the diagnostic, repair, and test processes, come with very high price tags. The new $20 million composites repair facility at NARF North Island, California, is a good illustration.

Finally, DoD has developed a depot maintenance infrastructure that shows numerous signs of being excessive and nonresponsive. Private industry in the United States has recently been forced to examine critically how it does business. In many areas, the results were startling. Corporations closed plants, reduced their work force, trimmed product lines, etc., with minimal effect on sales, while at the same time increasing profits. One of the common shortcomings of those corporations was complacency – in their management, in their business practices, and in their investment strategies. Many of these same symptoms are already present in DoD's maintenance depots. For example, irrespective of the trend toward two levels of maintenance, the depot repair cycle for many components is much too lengthy. Repair of some Army helicopter engines is averaging more than 190 days, and gear boxes may be in depot rework for 160 days or longer. In peacetime, repair cycles of such duration require large, expensive pipeline inventories – routinely measured in millions of dollars per day. In wartime, the cost will be lack of responsiveness of the depots to combat requirements.

The Military Services will almost certainly counter the above arguments by citing the many activities of the Joint Logistics Commanders (JLC). The JLC have chartered several ad hoc and continuing organizations to improve the management of depot maintenance. The most prominent such organization is the Joint Depot Maintenance Analysis Group, which reviews new systems as they are introduced into the DoD inventory and recommends where those systems should be repaired. The JLC also sponsors a Joint Service Depot Maintenance Industrial Military Construction Review Panel, which seeks to avoid construction of unnecessarily redundant industrial capability, and the Joint Technology Exchange Group, which brokers information on technology initiatives. The effectiveness of these and other JLC organizations is not at issue; they provide valuable advice and assistance to the Military Services. However, their orientation always has been, and will continue to be, to seek consensus among the Military Services. As a consequence, the JLC has repeatedly avoided the types of funding decisions that we see dominating the 1990's.

The bottomline is quite clear. Unless the DoD strengthens its ability to oversee and influence the outyear depot maintenance programs, it will underwrite, at substantial cost, the development of unnecessary capabilities and excessive redundancies and further entrenchment of a depot maintenance infrastructure that already shows many signs of being excessive.

RECOMMENDED ACTIONS

To meet the depot maintenance funding challenges of the 1990's, particularly those with significant cross-Service implications, we believe that the ASD(A&L) needs to fundamentally change the way in which he carries out his depot maintenance responsibilities. He needs to place early and extensive analysis of proposed programs and depot modernization requirements at the forefront while continuing his policy development and program monitoring roles. Specifically, we recommend that the ASD(A&L) develop:

- The capability to evaluate, early in the planning and budgeting process, the reasonableness of depot maintenance budgets and outyear programs, drawing extensively upon prior year production and performance data.
- A procedure for examining the depot maintenance requirements for Military Construction funding, assessing the value of those requirements, and monitoring the support they receive during the planning, programming, and budgeting cycles.
- A methodology for being aware of the requests for depot modernization and new equipment funding, evaluating the value of those requests, and tracking the support they receive.

These actions will focus the attention of the ASD(A&L) on funding requirements and decisions, leaving the execution of those decisions to the Military Services. We believe that this orientation is on target. It concentrates ASD(A&L) resources on the future—plans, programs, and budgets—not on the past. It also stresses those issues that most influence depot maintenance efficiency, productivity, and effectiveness.

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