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IMPROVING DEPOT REPAIR CYCLE
MANAGEMENT: A CHALLENGE FOR
SUPPLY AND MAINTENANCE

Report AL614R1

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August 1987

James H. Perry
Inta A. Silins
Kelvin K. Kiebler

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LOGISTICS MANAGEMENT INSTITUTE
6400 Goldsboro Road
Bethesda, Maryland 20817-5886

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<p>The DoD relies extensively on the depot repair process as the most responsive, least costly source for reparable secondary item components needed to provide peacetime material readiness and to ensure wartime sustainability of the operating forces. The inventory investment in reparable items to support this depot repair process is determined, in large part, by the time required to repair an unserviceable component - the Depot Repair Cycle Time (DRCT). This investment currently totals about \$5 billion across the DoD. DRCTs in DoD are excessive when compared to reasonable processing time standards and to comparable successful private sector repair operations. Those lengthy DRCTs are caused by early induction of unserviceable components in quantities far greater than the allocated depot repair capacity to process them expeditiously. As a result, once inducted components often wait to begin repair and, in turn, are further delayed at points during the repair process. Further impacting DRCTs is inadequate spare parts support for the component repair effort, a general imbalance between supply and maintenance cost considerations, a lack of awareness of the importance of DRCT in its impact on inventory investment, and deficient management control and performance measurement systems which do not provide the requisite visibility of the individual segments of the DRCT to allow for effective problem identification and resolution.</p> <p>This report recommends a DoD-wide program to improve depot repair cycle management and to reduce DRCTs. This broad Repair Process Improvement Program (RPIP) includes more valid definition and forecasting of DRCT, increased shop-scheduling flexibility and control employing</p>						
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smaller induction quantities inducted closer to actual repair, enhanced materiel support of the depot repair process, a rebalancing of supply and maintenance considerations with a focus on minimizing total logistics cost, and the development and use of a more complete system of management objectives and performance measurement.



A-1

APPENDIX F

STUDY SCOPE

To accomplish the objective of the study, our research approach included both empirical analyses using line-item data provided by selected wholesale managers, and site visits, interviews, and examination of aggregate operating data. To provide a DoD baseline for comparative purposes, we identified the specific wholesale managers indicated in Table F-1. Each of these activities was requested to provide a limited random sample of 50 reparable items being repaired in organic depots and 50 line items being repaired by outside repair facilities under contract to DoD. For this limited item sample, we obtained inventory file data on demand, file Depot Repair Cycle Time (DRCT), and wholesale inventory levels together with the requisite transaction data necessary to compute actual DRCTs.

Given the limited sample size, care must be taken in generalizing the specific results of the empirical analysis to the larger DoD reparable base. However, the data sample provided the foundation for site visits to the wholesale managers and allowed us to more easily focus discussion on those factors contributing to the DRCTs. Our data sample results helped us to address basic management policies and procedures used for managing the repair process at the wholesale inventory manager level, including program planning, measurement systems for capturing and forecasting DRCT, induction methods and repair quantities, asset visibility and control, and performance monitoring.

TABLE F-1
WHOLESALE MANAGERS IN STUDY

Army	Tank Automotive Command (TACOM)
Air Force	Oklahoma City Air Logistics Center (ALC) Sacramento ALC
Navy	Ships Parts Control Center (SPCC)

Following our review of DoD wholesale inventory manager policies and procedures for managing the DRCT, we visited related organic and DoD contractor repair facilities to evaluate their roles in the overall repair process including the impact of their systems and management techniques on DoD DRCTs. Table F-2 indicates the specific organic and contractor repair facilities visited. During these site visits we interviewed key managers and examined aggregate operating data, focusing on induction procedures, scheduling systems and policies, internal depot movement, use of engineering standards, system flexibility to react to changes in wholesale inventory manager requirements, parts support, and performance goals and measurement systems.

TABLE F-2

ORGANIC AND DOD CONTRACTOR REPAIR FACILITIES VISITED

<p>Army Air Force</p>	<p>Anniston Army Depot Oklahoma City ALC Sacramento ALC Contractor C Contractor D</p>
<p>Navy</p>	<p>Long Beach Naval Shipyard San Diego Naval Electronics System Engineering Center Contractor A Contractor B</p>

Finally, we selected a limited number of private sector firms with a comparable repair mission for review. Our criteria for selecting these firms were a proven reputation for excellence in managing the repair process and a repair structure and mission that we felt was comparable to the DoD depot repair mission. The firms selected utilize depot repair as a major source of supply for designated components. This repair source supports either internal operational requirements directly, is used to resupply inventories of repairable components held to support internal operations, or is the primary source of resupply for distribution inventories of repairable items held to meet customer demand. During our site visits to these firms, we concentrated on the major factors that were largely responsible for lengthy DoD DRCTs in an effort to determine those private sector methods used to overcome these deficiencies which were of greatest potential benefit to DoD.

Executive Summary

IMPROVING DEPOT REPAIR CYCLE MANAGEMENT: A CHALLENGE FOR SUPPLY AND MAINTENANCE

The DoD relies on depot repair as the major source of resupply for over 300,000 components to support customers directly and to replenish wholesale inventories. The time taken to return, accumulate, induct and physically repair these components at the depot level is called the Depot Repair Cycle Time (DRCT).

The length of the DRCT is one of the greatest influences on the inventory investment levels of expensive reparable components. The longer the DRCT, the higher the inventory investment. In FY86, the inventory investment to support the depot repair pipeline exceeded \$5 billion. Longer DRCTs also cause larger investments in initial provisioning for new weapon systems and in safety levels. In addition, the length of the DRCT is an important determinant of peacetime materiel readiness and combat sustainability. Depot repair is not only the primary source of resupply for reparable components; it is also the most economic and responsive means for satisfying materiel support requirements.

DRCTs in the DoD are much longer than those experienced by well-managed private sector repair operations. Actual DRCTs in the Army and Navy are far longer than reasonable standards. In the Air Force, the averages are close to established standards, but item to item they vary significantly from them.

A number of factors contribute to excessive DRCT in DoD. First, early induction or induction of quantities in excess of the near term capacity of the repair depot unnecessarily extends DRCT length. Once inducted, the components must wait for initial repair action to begin. Second, parts required for repair of components often are not available. Inducted components can wait long periods of time for them. Third, the current depot repair process is imbalanced when viewed from a total supply and maintenance cost perspective. The desire for repair schedule discipline, workforce stability, and depot operating efficiency generally prevails, even when the associated inventory investment costs cannot be justified. That imbalance results in a system with little flexibility to accommodate ever-changing

repair needs. For example, there are more than \$250 million of components undergoing depot repair for which there is no longer a near term need. At the same time there are many components in short supply still waiting to be inducted for repair. Finally, the length of the DRCT receives little attention in existing performance measurement systems. Except in the Air Force, DRCTs used to determine repair and procurement budgets are not based on or evaluated against standards.

DoD can significantly improve depot repair cycle management and reduce DRCTs through a series of policy and procedural changes. We recommend that the Assistant Secretary of Defense (Production and Logistics) implement a DoD Repair Process Improvement Program to:

- Provide a more realistic DRCT definition, develop standard times for all DRCT segments, and use those standards, in conjunction with actual DRCT, to project repair and procurement budgets.
- Delay induction of items into maintenance until repair can begin and then induct only enough items to utilize the repair capability scheduled.
- Use both projected program and historical usage data to improve forecasting of parts needed to support depot maintenance.
- Focus management attention on both inventory investment and repair costs and on more responsive work planning.
- Reorient the current system of management objectives and performance measurement to include meeting DRCT standards.

Each day of DRCT results in a DoD inventory investment of more than \$60 million. We believe implementation of these recommendations could reduce overall DRCT by at least 10 percent. A reduction of this magnitude would directly generate one-time savings of \$350-500 million in spares procurement. Resultant annual savings in inventory holding costs would amount to approximately \$75-100 million. In addition, the reduction in DRCTs would generate a one-time savings in wholesale safety levels and recurring reductions in the initial provisioning requirements for new systems.

The implementation of these recommendations will require the coordinated action of both supply and maintenance managers at all levels – a significant challenge. However, the opportunity for significant dollar savings and improved support makes the challenge worth tackling.

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CHAPTER 1

INTRODUCTION

DEPOT REPAIR CYCLE TIME

The Department of Defense relies extensively on a complex network of organic and contractor facilities to repair secondary items designated as depot-level reparable or recoverables. Those repair facilities are the major sources of supply for some 300,000 different items to replenish wholesale inventories and provide direct customer support. The time required to complete the depot repair cycle, starting with the time the initial demand for the replacement of an unserviceable item is entered in the supply system and ending when the repaired or serviceable asset is available to the supply system for use, is called Depot Repair Cycle Time (DRCT).

As outlined in DoD Instruction (DoDI) 4140.24, DRCT includes five segments: the time required to process the retrograde component through base supply, the *shipment time to the designated storage/overhaul point*, the time to move the component from supply to maintenance, the processing time through the depot repair facility, and the time to return the serviceable asset to the supply system. While management information systems differ among the Services,¹ actual line item measurement of DRCT begins for the Army and Navy with the redesignation of assets from an unserviceable status to an in-repair status and ends with the redesignation of assets from an in-repair status to a serviceable status. In the case of the Air Force, the measured DRCT begins with the processing of the unserviceable component through base supply. The total DRCT includes, therefore, administrative segments, waiting time segments, and actual repair time segments.

IMPORTANCE OF DEPOT REPAIR CYCLE TIME

Effective management of DRCT is a critical element of wholesale inventory management for several reasons. The wholesale inventory investment in reparable components required to support the depot repair pipeline, called the Repair Cycle

¹In this study we evaluated DRCT in the Army, the Navy, and the Air Force; all references to Services are to those branches.

Level (RCL), is significant. In FY86, this investment exceeded \$5 billion dollars. The RCL is directly affected by both the length of the DRCT and by the projected usage rate for the reparable component. The duration of the DRCT, the focus of this study, is vitally important because the length of the DRCT directly affects the size of the investment in reparable assets in three separate areas. First, in initial provisioning, the length of the DRCT impacts the initial procurement of assets required to initialize the system. Second the length of the DRCT affects the wholesale safety level required to buffer the repair process against uncertainty in demand. Finally, the length of the DRCT determines the continuing steady-state investment in reparable assets needed to support the repair process. Thus, the length of the DRCT is one of the most critical factors affecting wholesale inventory investment levels for reparable components.

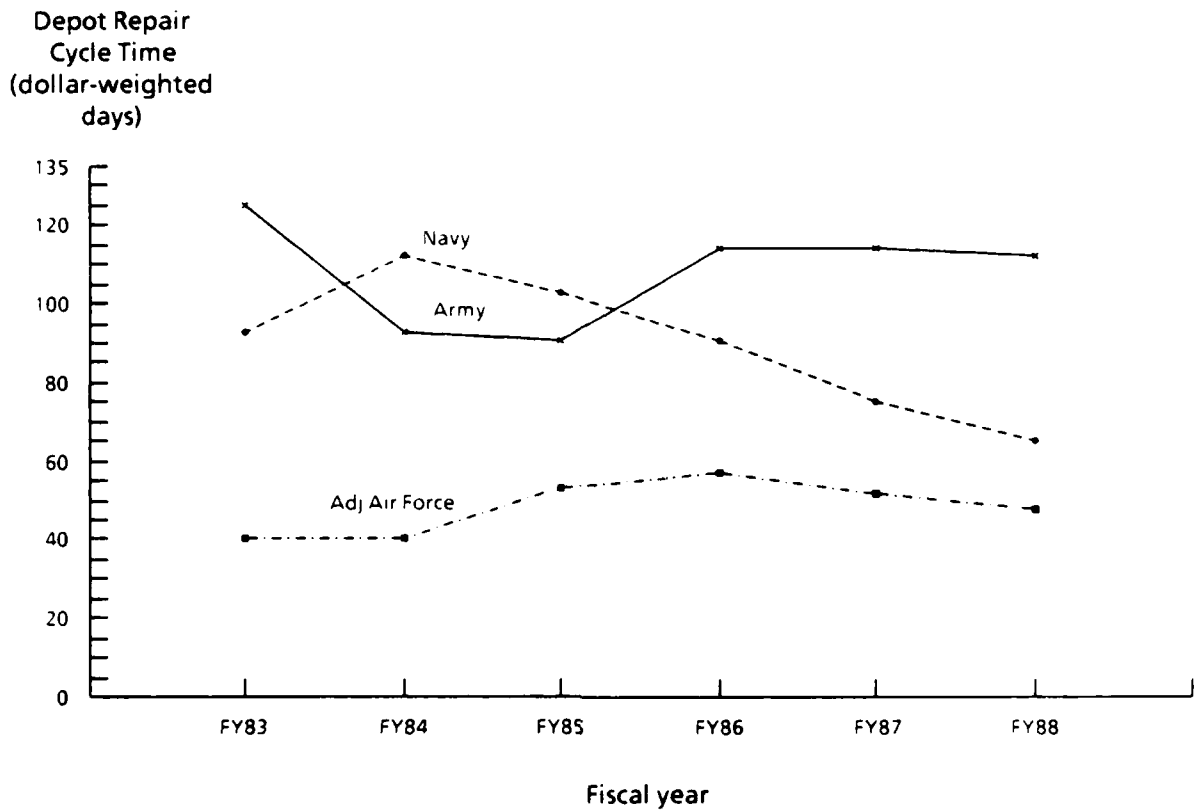
In addition to affecting wholesale inventory investment levels, the DRCT is also a critical element in the peacetime readiness and wartime sustainability of the operating forces. Depot repair is the main source of resupply for expensive, often critical reparable components and normally provides more than 70 percent of the serviceable assets needed to support recurring wholesale customer requirements. As such, it represents the most economic (cheaper to repair than to buy), the most expedient (quicker to repair than to buy), and the most responsive (adapts more quickly to changing requirements) source for filling peacetime and wartime materiel support requirements.

MAJOR ISSUES

This study examines two major depot repair management issues: today's DoD DRCTs are far longer than can be reasonably justified and the repair process is often cumbersome and inflexible. Figure 1-1 shows that the dollar-weighted² DRCTs projected for FY87 range from 52 days in the Air Force to 114 days in the Army. While the DRCTs have fluctuated in the short term, they have not consistently decreased over time. The Air Force's DRCT increased significantly between FY84 and FY86 but is projected to decrease through FY88; the Army's DRCT increased

²A dollar-weighted DRCT day is calculated by determining the dollar value of 1 day of demand and multiplying it by the DRCT (in days) to find the dollar value of the RCL. the summation of the RCL dollar values divided by the summation of dollar values of 1 day of demand yields the dollar-weighted DRCT days.

dramatically between FY85 and FY86; and the Navy's DRCT declined between FY84 and FY86 and is projected to continue that decline for the next 2 years.



Note: Values shown for FY83, 84, 85, and 86 are based on half-year actual and half-year projected data. FY87 and FY88 values are fully projected. Air Force data has been adjusted to exclude base supply processing time and retrograde time to provide comparability with Army and Navy data.

FIG. 1-1. DEPOT REPAIR CYCLE TIME

The DRCT standard (the "should take" DRCT) that we developed from sample Service data is shown in Figure 1-2. That figure shows the actual Service DRCTs in FY86 exceed those "should take" DRCTs by about 5 percent in the Air Force and by 200 percent or more in the Army and the Navy. For the Army and Navy, "should take" DRCTs also differ significantly from the DRCT projections lodged in ICP inventory management files and used to determine materiel budget requirements for the wholesale depot repair cycle, the associated safety level buffer for the repair cycle, and wholesale procurement requirements. Throughout the study we refer to these requirements as "materiel budget requirements" or simply "requirements".

While those comparisons are based on a limited data sample, our analysis of other data and discussions with inventory management and maintenance personnel lead us to believe this general situation is representative of the larger DoD inventory. The magnitude may vary by materiel category, but it is clear that actual DRCTs are longer than "should take" DRCTs. Further, even where aggregate DRCT standards are consistent with actual DRCTs, we found substantial variation between standard and actual DRCTs at the individual item level. Finally, as presented in Table 1-1, the DRCTs realized by a number of successful private sector firms surveyed are significantly lower than those of DoD. While these private sector repair operations generally repair a smaller component volume than DoD depots and typically receive failed components directly from the user, they have a repair process and mission similar to the DoD depot repair system.

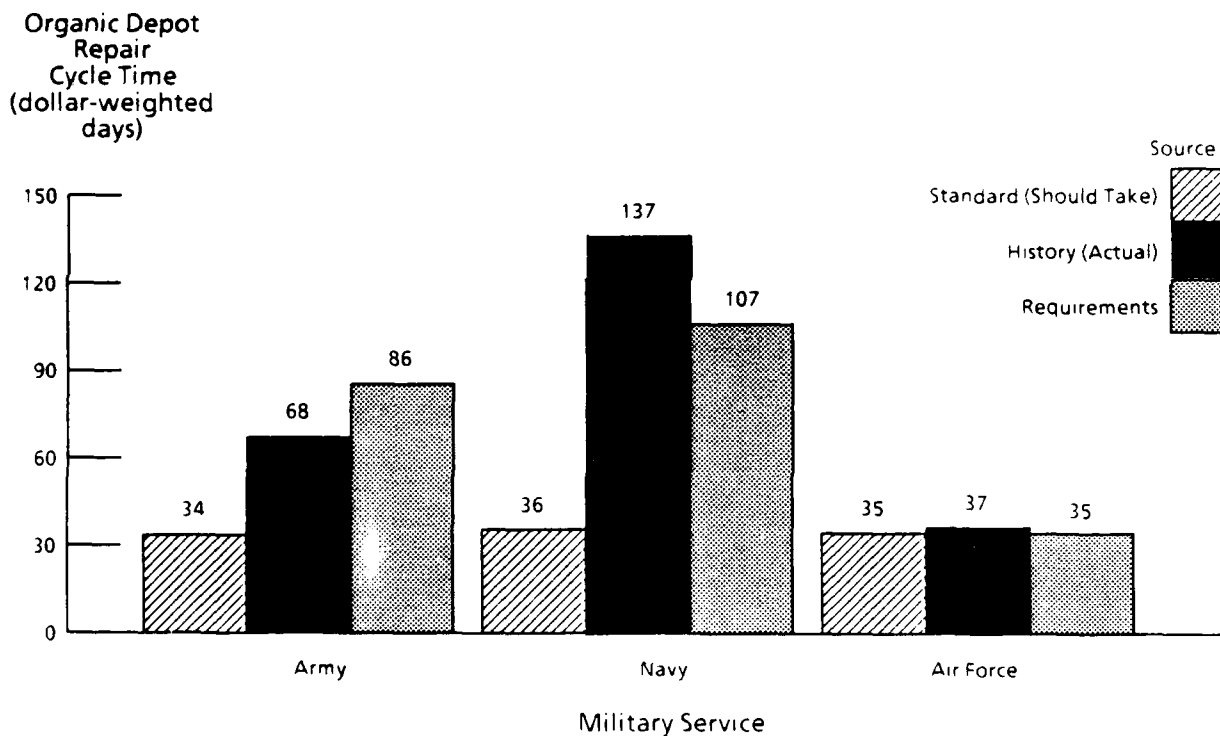


FIG. 1-2. COMPARISON OF SAMPLE FY86 ORGANIC DEPOT REPAIR CYCLE TIME

TABLE 1-1

PRIVATE SECTOR REPAIR CYCLE TIMES

Airline	7 Days
Trucking Company	10 Days
Utility	17 Days
Computer Service Firm	7 Days

The second major issue examined in this study is the the current DoD depot repair process, which is often cumbersome and inflexible in execution. Because supply management and maintenance management objectives and organizational constraints differ, the DoD depot repair process does not currently respond adequately to changing requirements. For example, the Services have no near-term need for more than \$250 million of unserviceable components currently in depot repair and at the same time many items that are needed to fill wholesale inventory deficiencies are still waiting to be inducted for repair. In aggregate terms about 7 to 10 percent of on-going DoD depot repair is devoted to reparable components no longer needed to fill wholesale inventory requirements although that percentage is as high as 30 percent for some budget categories or activities.

STUDY OBJECTIVE

This study has two objectives. First, it seeks to find ways to reduce current excessive DoD DRCTs to a more realistic level consistent with "should take" standards. Such a reduction in DoD DRCT can be attained through more effective planning, scheduling, induction, component control, parts support, and performance monitoring, and it will result in significant savings. As the DoD DRCT is reduced, a one-time saving in secondary item procurement is realized because fewer serviceable components are required to support demand during the repair process. This savings not only reduces the overall investment in reparable components but also reduces the cost to hold these inventories. Given today's DRCT and the related RCL investment, each day of DRCT represents an inventory investment of more than \$60 million across the DoD. A reduction in the FY87 DRCT of only 10 percent would thus generate a one-time procurement savings of approximately \$350-500 million and given that overall inventory investment reduction, annual holding cost savings

of approximately \$75-100 million would also be realized. In addition, the reduction in DRCTs would also generate a one-time saving in wholesale safety levels and recurring reductions in the initial provisioning requirements for new systems.

The second study objective is to recommend techniques and policies to achieve more responsive, more flexible repair cycle management – a management better equipped to deal with changing requirements.

In evaluating DoD depot repair cycle management, we initially identified five key system elements that we believe are central to the effective and efficient management of any repair process:

- DRCT definition and measurement
- Shop scheduling and control
- Materiel support
- Supply/maintenance balance
- Performance measurement.

In total, these five key system elements form the framework for our analysis of current DoD depot repair cycle management and are the foundation for our recommendations.

SUMMARY CONCLUSIONS AND RECOMMENDATIONS

Conclusions

- *DRCT Definition and Measurement.* Each Service defines DRCT differently. Critical segments of the depot repair process are excluded, while other segments are inconsistently defined and measured. Where DRCT standards are used, such as in the Air Force, they differ from actual DRCT at the line-item level as shown in our sample data. Where such standards are not used, actual DRCTs are significantly higher than the "should take" values we constructed. In general, actual times are not validated for reasonableness and the actual DRCT processing time is given limited attention by supply and maintenance managements.
- *Shop Scheduling and Control.* Current depot shop scheduling and control procedures are inefficient and result in DRCTs that are excessive. The actual times not only exceed the standard "should take" times we developed from Service data but also far exceed DRCTs experienced in the private sector. These lengthy DoD DRCTs are being driven by several scheduling

factors. First, early induction of components that then may wait for an extended period before repair begins lengthens the DRCT. Second, induction of large quantities of components, numbers that far exceed depot processing capability, also unnecessarily increases DRCTs. Finally, in the case of contractor repair, additional administrative delays associated with the contracting process adversely affect the DRCT.

- *Material Support.* Material support – the availability of repair parts – is generally inadequate and contributes directly to excessive DRCTs and to scheduling/control problems.
- *Supply/Maintenance Balance.* The current DoD depot repair process – the maintenance component – is highly imbalanced in its treatment of inventory costs versus repair or maintenance costs. Repair efficiency, scheduling stability, and workload leveling are typically emphasized without adequate consideration of emerging wholesale requirements or their impact on inventory investment costs – the supply component. As a result, depot repair cycle management is largely inflexible and unresponsive to changing requirements and the associated DRCT is too long. Some depot repair resources are devoted to repairing items no longer needed to fill current wholesale inventory requirements, while at the same time, existing wholesale inventory deficiencies remain unfilled even though unserviceable assets are available for repair.
- *Performance Measurement.* Performance measurement is inadequate because many supply and maintenance managers fail to properly understand or appreciate the importance of DRCT and its relationship to inventory investment. Further, existing management systems do not provide the necessary visibility of actual DRCT by segment nor the ability to readily compare and evaluate actual DRCTs relative to established standards. Finally, performance measurement indicators do not focus on the length of DRCT segments as an important factor in overall supply/maintenance effectiveness.

Recommendations

To overcome the deficiencies in today's DoD depot repair cycle management, to reduce DRCTs, to make the repair cycle management process more responsive, and to reduce the overall inventory investment associated with the depot repair effort, we recommend that the Assistant Secretary of Defense (Production and Logistics) [ASD(P&L)] implement a broad, Departmental-level, Repair Process Improvement Program (RPIP) to:

- Improve the validity of DRCT data by providing a more realistic DRCT definition, developing standards for all segments of DRCT, and using both standards and history to project DRCT requirements
- Increase shop scheduling flexibility and control by reducing induction quantities and delaying induction action until repair can actually begin
- Enhance materiel support for the depot repair process and delete awaiting parts time as an authorized DRCT segment
- Rebalance the current depot repair system to minimize total logistics costs by focusing management attention on both inventory investment and repair costs and by more responsive workload planning
- Reorient the current system of management objectives and performance measurement to recognize the critical importance of the depot repair cycle both to readiness and to the overall costs of materiel support.

These broad DoD actions should be undertaken within the general framework of both a revised systems approach and specific new policies relating to depot repair, a general framework that provides clear overall direction for improvement without limiting the flexibility of the Military Services to make those specific procedural changes most appropriate to a given operating environment.

REPORT FORMAT

The remainder of this report includes two summary chapters and a series of detailed appendices. The summary chapters provide a concise, yet complete, treatment of the problems addressed, the conclusions reached, and, perhaps most important, the detailed recommendations made to improve repair cycle management in the DoD and to reduce DRCTs. Except where specifically indicated, the discussion applies exclusively to the organic depot repair process and the associated organic DRCT.

In Chapter 2 major findings, conclusions, and recommendations are presented. Chapter 3, in turn, consolidates those recommendations and provides a listing of policy changes that should be considered. The appendices provide more detailed analyses and discussion in support of the summary observations. Appendix A discusses the definition of DRCT and the methods used by the Services to measure it. Appendix B presents results of the line item analysis of sample data. Both overall DRCT and major internal segments of DRCT are examined. The appendix also draws comparisons of inventory management file DRCT used to develop budget

requirements and actual DRCT, relates these times to appropriate engineering standard times, identifies those major factors contributing to excessive file DRCTs and related inventory requirements, and suggests policy and procedural improvements. Appendix C, in turn, deals with the unique problems associated with use of contractor repair by DoD wholesale inventory managers. Issues such as asset visibility and control, contracting methods, administrative delays, and measurement of vendor performance are highlighted. Appendix D provides the results of our review of private sector repair cycle management policies, systems, and procedures. Each firm reviewed is briefly profiled, and based on that general corporate overview, we then describe the approaches used by successful private sector firms to deal with the major factors currently impacting DRCTs. Appendix E presents specific technical recommendations relating to the definition and measurement of DRCT and to the use of standards to monitor and validate actual processing times. Finally, Appendix F documents the methodology and data utilized in the study.

CHAPTER 2

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

INTRODUCTION

This chapter presents the major findings, conclusions, and recommendations of the study. The discussion, which is based on the detailed data and analyses presented in the appendices, treats five key elements we find central to effective and efficient management of the repair process:

- DRCT Definition and Measurement
- Shop Scheduling and Control
- Materiel Support
- Supply/Maintenance Balance
- Performance Measurement.

Many of our findings and recommendations are applicable in some measure to each of the three Services we studied. However, the degree to which a given problem exists in a particular Service varies significantly, and those Service-level differences are highlighted in the discussion in the appendices. We believe that, generally, the current Air Force depot repair management approach is the most realistic and effective one and requires least revision.

DRCT DEFINITION AND MEASUREMENT

The overall DoD DRCT used in generating replenishment procurement requirements, programming depot maintenance resources, and planning depot workload is established through the definition and measurement of each of the segments that comprise the repair cycle. We found that the definition of DRCT is not consistent across the Services and does not include all of the segments that we believe are essential steps in the repair process. In addition, differences in DRCT measurement among the Services contribute significantly to the difficulty in evaluating Service DRCTs. Finally, based on a sample of line-item data, we found

that actual DRCT differed significantly from DRCT computed from data in the inventory management file and from established DRCT standards.

First, current DRCT definitions are incomplete. We identified three periods of time in the repair process – two involving organic repair and one involving commercial repair – that are not uniformly included in Service DRCT definitions: (1) the time needed to accumulate unserviceable assets before inducting them into the repair facility, when batch induction quantities are used; (2) the time immediately preceding repair but after the unserviceable assets have been inducted into repair (scheduling buffer); and (3) administrative time required to authorize repair and funding for commercial repair. Accumulation time is needed to fully account for the time it takes to accumulate a specified batch of unserviceable assets for induction into the repair process. Where sufficient Condition Code¹ "F" (not ready for issue) assets are available, this accumulation time is zero. However, where repair efficiencies dictate batch repair and where sufficient Condition "F" assets are not immediately available, the accumulation time segment of DRCT provides the necessary time to accumulate this repair batch.

Once the unserviceable assets inducted for repair are received in maintenance (condition "M" assets), scheduling time is required before the start of actual repair. This shop scheduling time is used to ensure specific work center capacity and labor skills are available to begin a given repair effort and the associated "buffer" of Condition "M" assets, which makes up this shop scheduling period, ensures an efficient and smooth flow of assets into the repair process. For items being repaired commercially by contractors, some administrative time is needed to determine the scope of the repair, estimate repair costs, and receive repair authorization. All of these essential, time-sensitive activities merit management attention. If these three time segments are included in DRCT, the general administrative time prior to induction (now included in DRCT) could be eliminated since it will be specifically accounted for.

Second, DRCT measurement differs across Services. The most significant measurement difference among the Services is the treatment of those time periods when repair is being delayed awaiting the receipt of piece parts (AWP). A portion of

¹ Materiel Condition Codes are used to designate the material condition (for example, ready for issue, not ready-for-issue, undergoing repair, awaiting parts, etc.) of a repairable component. Throughout this report we refer to these codes as "Condition Codes" or simply "Condition."

this AWP time may be designated as Condition Code "G" (awaiting parts). Table 2-1 shows the effect of AWP in three examples taken from our data. It presents the standard ("should take"), the requirements as shown in the inventory management file, and the history (actual) DRCTs and then deducts the AWP time. It shows that AWP time can be a large percentage of the repair time and whether it is included in DRCT directly affects the requirements determination. Both the Army and Navy include any time awaiting parts in the measurement of the DRCT although the Army generally does not formally change the Condition Code to "G." The Air Force does not use awaiting parts time in developing and applying the processing standards used to generate requirements.

TABLE 2-1
IMPACT OF AWAITING PARTS ON DRCT

Description	Example 1	Example 2	Example 3
Standard (days)	19	6	22
Inventory management file (days)	40	92	95
History (days)	48	27	104
History without AWP (days)	24	25	28
Reduction (days)	24	2	76
Reduction in RCL value (\$)	\$242,328	\$3,860	\$16,188
Percent AWP added to history	100	8	271

Current DoD policy does not specifically address the issue of including AWP time in the DRCT. It does, however, specify the elements of the repair process that are authorized for inclusion in the DRCT, and they do not include AWP time. The main argument for including AWP time in the DRCT is that in the real world, AWP time does occur and the DRCTs used to compute the RCL should reflect real experience. According to that reasoning, excluding AWP time understates the RCL and will degrade supply support.

Three primary arguments are offered for excluding AWP time from the DRCT and the computation of the RCL. First, its inclusion increases the DRCT and thus generates the need to procure additional reparable assets. Those assets are much more expensive than the piece parts used to repair them. The most cost-effective

way to reduce DRCT, then, is to improve the availability of less-expensive piece parts. Second, studies indicate that the shortage of repair parts for specific reparable assets is random and irregular and consequently not in synchronization with the RCL requirements. The historic DRCT is determined after the reparable asset has completed the depot repair cycle, i.e., has been returned to supply as ready for issue (RFI). By that time, the specific piece part shortage has usually been eliminated (or the asset would not have been repaired). However, at the time it is measured, if AWP time is included, the DRCT will show the need for additional assets. Those additional assets will not be received by supply for approximately 2 years (the normal average leadtime). At that time, not only will the original parts shortage have been eliminated but the new assets may create an excess of materiel requirements. Third, inclusion of AWP in the DRCT can divert management attention from the real problem: the lack of needed piece parts.

The inclusion of AWP time in the DRCT tends to mask the problem of piece-part availability rather than forcing its solution and it substantially increases the investment level for reparable assets. Therefore, a more prudent approach is to measure the AWP time in aggregate as well as on a specific line-item basis to focus management attention on the severity of the problem and concentrate management resources on its solution.

Third, DRCT used in projecting requirements is often inconsistent with past history or reasonable "should take" times. In examining the DRCTs for each of the Services, we evaluated three different measures of repair cycle time: standard, or "should take," time, actual time based on historical transactions, and the times maintained by the Inventory Manager (IM) and used for requirements computation. Table 2-2 shows an aggregate comparison of those three times for each of the Services, where the standard (or "should take") times are based on a combination of engineering time standards and specified processing time goals and the actual times represent historical transactions of actual repair orders. Where "should take" times did not exist for the full depot repair cycle (as in the Army and Navy), we constructed those times. We had access to estimated or projected "hands on" maintenance time for the Army and Navy items in our sample. We also had Army repair workday standards covering the actual repair process, and we adjusted them to reflect nonworkdays and processing time once repair is complete to generate a "should take" standard for the Army. Using the general ratio of "hands-on" maintenance

time to the total DRCT standard time in the Army, we extrapolated from Navy "hands-on" maintenance times to generate a DRCT "should take" time for the Navy.

TABLE 2-2
COMPARISON OF STANDARD DRCT TO HISTORY AND REQUIREMENTS
(In dollar-weighted days)

Service	Standard (days)	History (actual)		Requirements	
		Days	As a percent of standard	Days	As a percent of standard
Army	34	68	200%	86	253%
Air Force	35	37	106	35	100
Navy	36	137	381	107	297

Both the Navy and the Army actual repair times are significantly in excess of the standard time, while the Air Force differences at the aggregate level are small. In the comparison, the Navy's actual times were more than three times greater than the standard. Even when the IM reduced actual transaction times in the requirements computation by approximately 30 days on average, actual times still were in excess of the standard time by a factor of almost three. For the Army, the actual time was twice that of the standard time. In addition, the DRCT in the Army inventory management file was even greater than the actual time.

Table 2-2 shows that the Air Force standard time is close to the actual history. Yet, when we examined the sample items individually, we found that actual repair times varied, both over and under the estimated time for the individual item. Figure 2-1 shows the variations in individual Air Force items. When compared with historical times, line-item standard times differ to some degree in all but one case.

In summary, current DoD depot repair cycle management is based on an invalid DRCT. First, it is founded on an incomplete definition of DRCT since that definition fails to uniformly recognize certain DRCT segments that are central to the overall repair process flow. In particular, unserviceable asset accumulation time and shop scheduling buffer time are necessary time segments in the DRCT definition

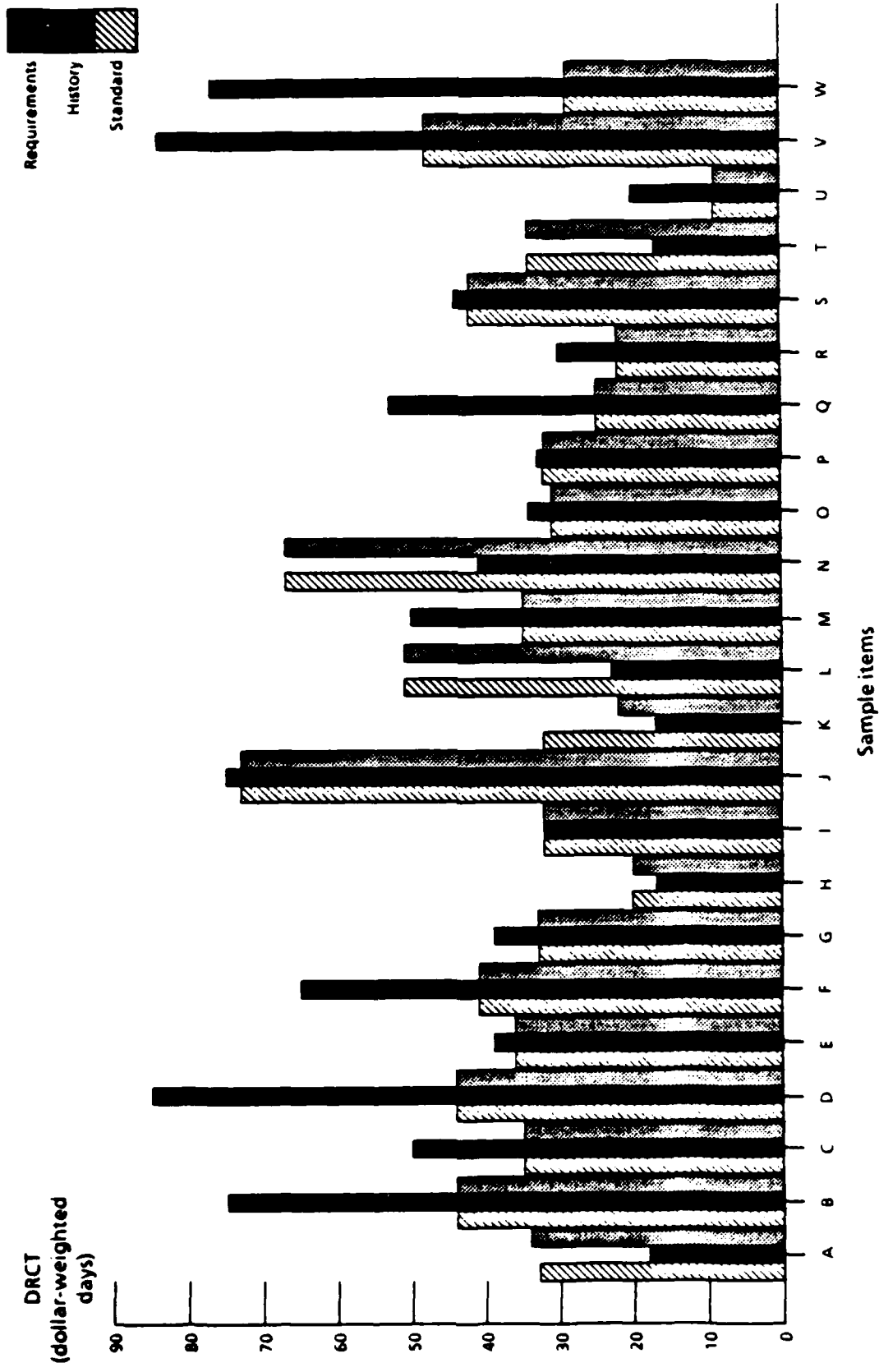


FIG. 2-1. AIR FORCE DEPOT REPAIR CYCLE TIME

but are not uniformly recognized in the current organic depot process. For commercial repair, necessary administrative time to estimate repair costs and receive funding and repair authorization is needed. Second, the line-item data used in this study suggest deficiencies in projecting realistic DRCT requirements at the line-item level. For the Army and the Navy, aggregate sample data comparisons of DRCT using mean values indicate significant differences between actual repair history (over a 2-year period) and the DRCT forecasts used to develop inventory requirements. For the Air Force, where engineering standards are used in conjunction with repair history to directly determine DRCT inventory requirements, these aggregate differences are much smaller. A comparison of limited actual Air Force line-item historical data with the related engineering standard for the line item, however, revealed some differences at the line-item level. Thus, we conclude that DRCT projections used to develop budget requirements and to build the repair workload schedules needed for effective depot planning often differ from the repair history.

To develop more realistic DRCT definitions and to increase the validity of DRCT projections, we recommend that the Assistant Secretary of Defense (*Production and Logistics*) [ASD(P&L)] RPIP:

- Expand the current organic DRCT definition to add accumulation time and shop scheduling time to provide a realistic projection of processing requirements. Also delete the current organic DRCT segment called "administrative" time. (Appendix E presents a more detailed discussion of the proposed DRCT.)
- Expand the current DRCT definition for commercial repair to recognize the administrative time required to "cost out" repair costs and receive repair authorization. (Appendix E presents a more detailed discussion of the proposed DRCT.)
- Designate Condition Code T to cover that portion of the DRCT when assets are in-transit between resupply and maintenance. This occurs following induction of unserviceable assets between condition F and Condition M and following completion of repair (between condition M and a serviceable condition such as A, B, or C).
- Develop line-item standards to address each separate segment of the DRCT. These standards may be engineering standards or performance norms as appropriate to a given segment. (Appendix E presents a detailed discussion

of the recommended standards for each segment of the recommended DRCT.)

- Use DRCT standards to develop policy goals toward which management action should be directed. These time standards should ultimately be recognized goals for both budget review and execution purposes. Actual budget formulation may be based on either the time standard or actual history, however any deviation from time standard goals must be validated and explained.
- Employ both actual history and engineering standards to ensure that DRCT forecasts are valid at the line-item level. Regardless of whether a history or an engineering/constant standard is used as a baseline forecast of DRCT, the other element must be routinely and actively used to evaluate both DRCT baseline accuracy and reasonableness at the line-item level. This recommendation requires the development or the enhancement of current information processing systems and the use by the IM of those sources of information to ensure DRCT file validity.
- Exclude AWP time as an authorized segment of the DRCT. While we believe that AWP can have a substantial adverse impact on supply support and should be recorded and measured separately to provide management with an indicator of the magnitude and duration of parts support problems, the high volatility of AWP conditions over time across items used to support *the depot maintenance process causes erroneous wholesale investment in DRCT requirements when AWP time is included in DRCT.*

SHOP SCHEDULING AND CONTROL

Our observations and discussions with depot personnel on the formulation methods used to arrive at standard times lead us to conclude that the standard times appear to be reasonable estimates of "should take" time. They are arrived through industrial engineering methods or knowledgeable practitioner estimates. As a result, since the estimates seem reasonable, we conclude that in aggregate for the Army and the Navy, the actual repair process is taking considerably longer than should be expected. The same holds true for some of the individual Air Force items sampled. In our visits to selected major commands involved in component repair for each of the Services, we examined the repair process from the time the requirement is identified and the item is assigned to a depot, repaired in depot maintenance, and returned to wholesale supply. We found that the repair process is significantly affected by scheduling and control policies, procedures, and practices that contribute to excessive DRCTs.

A key contributor to lengthy repair cycle times is the induction quantity. Before the maintenance function is ready to begin repair, it requests the supply function to move (induct) unserviceable materiel into the maintenance shops. Either at the time the request for induction is made or once the materiel is received by maintenance, the clock is turned on and DRCT begins. We observed that the induction quantity frequently exceeds the immediately available repair capacity, thus creating a backlog of production. That backlog of production is awaiting repair capacity and yet is being charged for maintenance repair time, and that time is incorporated into historical transaction data. Table 2-3 illustrates the effect of induction quantity on DRCT. Examples shown in that table are taken from Army, Navy, and Air Force data. Unserviceable units are typically inducted into maintenance in one large lot and then released for actual repair in smaller lots as previous units are completed. The DRCT is a computed average of the times for each unit.

TABLE 2-3

IMPACT OF INDUCTION QUANTITIES ON DRCT

Example 1			Example 2		
Quantity inducted	Quantity completed	DRCT (days)	Quantity inducted	Quantity completed	DRCT (days)
59	-	-	21	-	-
	10	102		4	198
	12	124		2	205
	10	161		1	219
	3	185		1	240
	9	197		3	246
	1	200		2	273
	10	228		2	287
	2	231		2	289
	1	379		1	294
			1	296	
			1	297	

TABLE 2-3

IMPACT OF INDUCTION QUANTITIES ON DRCT (Continued)

Example 3			Example 4			
Quantity induced	Quantity completed	DRCT (days)	Quantity induced	Quantity completed	DRCT (days)	
20	1	7	31	3	18	
	1	8		1	28	
	3	15		1	36	
	1	19		1	42	
	2	20		1	56	
	1	21		10	59	
	6	24		1	70	
	2	26		4	109	
	1	28		5	122	
	2	29		2	182	
			24	1	34	
				2	38	
				2	51	
				12	58	
				1	85	
				1	87	
				4	111	
Example 5			Example 6			
Quantity induced	Quantity completed	DRCT (days)	Quantity induced	Quantity completed	DRCT (days)	
14	3	49	11	1	58	
	1	56		1	65	
	5	70		1	72	
	5	75		1	74	
	5	75		1	74	
13	2	64	11	1	78	
	1	66		1	85	
	3	71		1	88	
	5	79		1	99	
	5	79		1	99	
14	2	36	11	2	106	
	3	42		1	110	
	4	62		1	113	
	4	107		1	115	
	1	112		1	120	
14	2	52	11	2	128	
	5	58		1	134	
	3	87		1	139	
	3	99		2	140	
	1	114		1	142	
			1	157		

TABLE 2-3

IMPACT OF INDUCTION QUANTITIES ON DRCT (Continued)

Example 7			Example 8		
Quantity inducted	Quantity completed	DRCT (days)	Quantity inducted	Quantity completed	DRCT (days)
30	3	27	30	4	3
	4	28		4	6
	4	29		7	7
	3	30		3	8
	3	34		6	10
	5	35		2	13
	2	36		3	14
	3	38		1	19
	3	40			

Because the Army and Navy use historical data to compute the DRCT and those data are in turn used to compute materiel budget requirements, induction of quantities beyond the capability of maintenance to repair in a reasonable period increases the inventory investment. For the Air Force, which uses engineering time standards, or "should take" times, as the DRCT, the capability of maintenance to repair inducted assets in a reasonable time has no impact on the materiel budget requirements computation. However, items for which the actual DRCT exceeds the standard DRCT may have an adverse impact on supply support.

A second major contributor to lengthy repair cycle times is the timing of inductions into maintenance. Inductions that are made early, in advance of "hands-on repair," cause unnecessarily lengthy DRCTs. We found that for some items, the Army and the Navy make inductions into maintenance 30 days and 90 days, respectively, in advance of actual repair. At a Naval shipyard visited, inductions were found to be occurring within 5 days of the start of a new quarter, with an estimated 50 to 60 percent of all quarterly requirements inducted in the first 30 days. The average time awaiting available capacity to actually perform the repair work was found to be 37 days. The timing of the Army inductions significantly added to DRCT as well. Unserviceable items were moved into maintenance up to 30 days in advance of the scheduled start date for repair. Condition codes for this materiel were changed to Code "M" (in maintenance), and the time was charged to the DRCT. The Air Force induction process is scheduled in

2-week intervals; however, because it uses standard DRCT rather than actual DRCT to develop requirements, early inductions have no impact.

We also observed cases in which long repair time for subassemblies significantly delayed the repair of the end item component and therefore increased DRCT. As an example, a turbine engine is repaired at one Army activity but one or more of its components are repaired at a second activity. Subsequent to disassembly, the components must be packed and shipped to the second activity. After they are repaired, they must again be packed and shipped to the original maintenance activity for assembly in the engine. All of that time is included in the Army DRCT. Similar delays for long-repair-time subassemblies occurred to some extent at all of the activities we visited. In an alternative approach the Air Force maintains a pool of replaceable subcomponents for primary secondary item components so that long leadtime subcomponents can be replaced directly and primary or major component repair can continue uninterrupted. This procedure shortens the DRCT experienced for the major component.

In the case of contractor repair, shop scheduling and control problems are compounded by the nature of the workloading process. Complaints from contractors we visited focus on the inaccuracy of the workload forecast both in terms of the individual part numbers and the expected volume of repair. However, they consider the accuracy of the mix of parts coming in to be less important than the achievement of a stable repair volume from month to month. These contractors plan their work centers and personnel skill requirements around general repair categories rather than specific part number repairs and seem well prepared to handle the variety of unplanned repairs. When the incoming workload volume is erratic, however, *scheduling problems that develop necessitate overutilization or underutilization of equipment and workforce.* These contractors typically create a gradual backlog of unserviceable assets to even out the flow of work to the shops and staffs to satisfy the low end of capacity requirements.

The administrative delay associated with writing the repair contract also affects contractor repair DRCT. For items contracted on Basic Ordering Agreements, prevalent for Navy repair contracts, the repair of unserviceable assets must be authorized by a written order as the assets are received by the contractor. The administrative time required to write the order is a part of the DRCT for contractor-repaired items. This process adds weeks – in some cases months – to the

DRCT of individual items. Additional administrative delays are being experienced for items contracted under "tear down and inspect" type contracts. For those items, the order-writing process is not completed until the item has been physically moved into repair, disassembled, and inspected to determine the exact repair required. While that method may enhance the absolute accuracy of pricing, it increases DRCT because the required repairs must be priced by the contractor and approved by DoD before repair can begin. We found that lengthy administrative actions preceding commercial repair were not a significant problem for the Air Force. For our sample items, the Air Force used requirements-type contracts that do not require the lengthy order-writing process.

When viewed in total, we believe the current DoD depot repair cycle management does not provide the information and controls necessary to effectively execute the established repair schedule without significant processing delays and idle inventory assets. Our analysis clearly indicates that induction schedules are executed too early and that induction quantities scheduled for repair are typically too large when these shop schedules are compared to the ability of the depot repair activity to actually complete repairs. Because of early induction of unnecessarily large induction lots, measured DRCT is longer than necessary and does not realistically portray the time needed to repair the given component in a shop environment properly scheduled and controlled. As a result, DoD is overinvesting in reparable components.

To increase shop scheduling flexibility and control and to reduce excessive DRCTs we recommend that the ASD(P&L) RPIP:

- Limit the time period between induction and the beginning of repair to the minimum period necessary to allow for reasonable materiel drawdown and shop scheduling. In a subsequent section dealing with supply and maintenance balance, we address the overall repair planning process. Based on a 30-day repair schedule (as discussed there), the monthly repair schedule should be provided by the Inventory Control Point (ICP) to the depot based on an asset cut-off no earlier than 90 days prior to the month covered by the repair schedule. Once in receipt of the repair schedule the depot can begin materiel planning and capacity scheduling actions. Actual induction, however, should occur no earlier than 5-days prior to beginning repair action. During that 5 day period, the depot could complete the necessary final scheduling and materiel positioning that would enable the depot to start actual repair action.

- Limit induction quantities to the minimum quantity necessary consistent with the true economics of the repair process and the ability of the system to manage and control multiple lots effectively. In today's processing environment we believe that induction quantities should be routinely limited to a quantity no greater than one week's worth of demand (or one-fourth the monthly repair schedule quantity) in the absence of specific justification for a larger induction quantity based on documented maintenance tradeoffs. We believe that over time as internal repair processing becomes more flexible, as set-up times are reduced, and as the ability of the system to manage a more disciplined, continuous flow through repair is increased, the induction quantity can be limited even further.
- Extend the concept of enhanced materiel support for the depot repair process to greater explicit consideration of key components that could be held in inventory and used in a "remove and replace" mode for units undergoing repair when repair process times on these components are lengthy, thereby reducing overall DRCT and associated logistics costs.
- Develop an enhanced depot repair management information system to monitor actual induction timing and quantities to ensure compliance with the revised policy.
- For commercial repair, develop tailored, pre-positioned repair contract instruments that focus on general component categories, provide minimum/maximum repair levels, and include a priced task-breakdown schedule for common repairs to facilitate timely induction by the contractor. Multiyear, fixed-price, indefinite delivery type contracts should be considered. Extension of these flexible contract instruments to repair contracts with incentive clauses would further improve system efficiency.

MATERIEL SUPPORT

Another key factor contributing to excessive DRCTs is the level of materiel support. Lack of repair parts was regularly cited as contributing to extended repair cycle times. The lack of repair parts is felt in one of two ways. First, in some cases, unserviceable items are dropped from the schedule and not inducted into repair if the needed repair parts are not expected to arrive in the time scheduled to do the repair. That practice is particularly prevalent in the Air Force where parts availability is one consideration in deciding whether to schedule a component for repair. While this situation does not affect the length of DRCTs, it does have a negative effect on the IM's supply position. Given the lack of repair parts to successfully complete a given repair schedule, however, we believe that materiel availability verification prior to actual induction is preferable to the methods common in the Army and Navy where repair parts availability is considered only after induction has taken place. In

either instance, materiel support may suffer; however, by delaying the induction until known parts requirements have been satisfied, the impact on DRCT is minimized. A materiel shortage discovered after induction, however, also has a direct impact on actual DRCTs.

For the Navy, a small sample of depot transactions for one activity showed that on the average, items were placed in Condition Code "G" (awaiting parts) for 38 days. The true impact on Navy DRCT for these items was even greater since there is usually additional AWP delay before changing condition codes. In the case of the Army, while changes to Condition Code "G" are not usually made for items awaiting parts, data on specific items with parts problems show that materiel delays significantly increased DRCT for some items in our sample. Further, we noted instances in which an excessive number of items were inducted and parts from the excess items were used to maintain on-going repair. This Army practice of overinduction of components for planned borrowing of parts not only masks materiel support deficiencies but further extends the DRCT and the RCL investment because these cannibalized units are held in Condition Code "M" as though they were being repaired to meet a valid wholesale system requirement and the actual DRCT experienced is included in Army inventory management file DRCT projections. Delays because of parts problems also affected Air Force support although the lack of parts has no effect on measured DRCT since engineering standards are used in place of historical data and AWP time is not included in the standards. One procedure that clearly impacts repair parts support to depot component repair is the failure to reserve, or "fence," available parts that have been positioned to support the repair process. While these parts should be made available selectively to fill high priority, end-use, maintenance-related requisitions, we believe they should not be made available to fill lower-echelon stock-replenishment requisitions. Other factors potentially contributing to inadequate materiel support include severely restricted timeframes in which to acquire piece parts, inadequate parts support inventory levels, and ineffective methodologies for determining piece part requirements.

We conclude from our analysis that materiel support for the DoD depot repair process is often inadequate. In fact, many of the problems experienced in shop scheduling and control are related to the inability of the current system to reasonably guarantee an acceptable level of parts support. In some cases these materiel support problems are clearly obvious by examining line item repair history

and by noting that measured Condition "G" (AWP) times run as high as 25 percent of the total DRCT. In other instances where Condition "G" is not routinely employed to denote AWP time, the effect of poor materiel support is reflected in extensive cannibalization of parts from items awaiting repair in order to maintain on-going repair of inducted components or even in the inability to execute required asset repair and to induct available assets. These piece part problems are evident both in systems that rely solely on past demand history to project required piece parts and in systems that use a combination of demand history and program data to generate piece parts requirements. Moreover, the problems persist even though typically two echelons of local inventory are available to the depot to support repair in addition to back-up wholesale piece parts assets. Further, today's management information systems do not provide the necessary visibility and information to support the structured analysis of existing support problems that could identify systemic contributing factors. Thus, it appears that effective materiel support is a function of the policies and procedures used to determine local inventory range and depth for supporting piece parts inventories, forecasting methods, materiel positioning, and the timing of depot requisitioning based on asset availability.

To enhance materiel support for the depot repair effort and to reduce excessive DRCTs we recommend that the ASD(P&L) RPIP:

- Re-examine the use of program data versus historical usage data as the foundation for piece part forecasts. While the choice of program-based or usage-based data will not eliminate the piece parts forecasting problem, we believe a mix of program-based and usage-based data is ultimately more effective than either method alone. Further, the volume and make-up of the repair effort will determine the extent to which program data can be reasonably applied. Where program data are used, quality controls must be established to ensure that actual parts consumption data are consistent with Bill of Materiel data prior to input.
- Evaluate alternative inventory range and depth strategies for improving piece parts support. This review should include both nondemand based stockage and the use of a shortage cost that includes both the cost of maintenance line delay/stoppage and the potential end item cost resulting from the unavailability of the repairable component. While our study did not permit a further examination of this issue, we believe that by selectively augmenting piece parts inventories, the overall DRCT requirement can be reduced sufficiently to reduce the *overall* total cost of investment in both piece parts and repairable components. When the costs of maintenance delays, rescheduling, and idle capacity are considered, that selective piece

part augmentation becomes even more attractive. Finally, the proven success of the private sector firms surveyed in eliminating materiel support problems points to enhanced inventory range and depth as a means for reducing DRCT and *overall* inventory requirements.

- Develop procedures to verify the availability of those projected piece parts requirements for a given repair schedule prior to the actual induction of the unserviceable assets.
- Develop and implement alternative condition code processing procedures for those unserviceable assets that are inducted solely for borrowing of parts to ensure that such inductions are not a part of the measured DRCT.
- Reserve piece parts inventories held to support the depot repair process.
- Develop data systems to provide the visibility and information required to effectively evaluate specific instances of materiel support problems. These enhanced management information systems should provide the capability not only identify and analyze specific performance deficiencies for a given item or activity but should also facilitate the recognition and resolution of systemic problems impacting the depot repair process.

SUPPLY/MAINTENANCE BALANCE

The determination of repair requirements (how much and when required) is a supply (inventory manager) decision; the decision to schedule (or not schedule) an item for repair is a joint supply and maintenance decision; the decision of when and in what quantities to physically induct items is a maintenance decision. The maintenance decisions are based on explicit or implicit cost considerations that are oriented largely to production efficiency and that include protecting the stability of the shop schedule, minimizing machine setups, facilitating the scheduling process, and improving overall shop utilization. As a result, maintenance concern for repair efficiencies tends to outweigh its concerns for supply support and inventory investment, often because these latter considerations have not been quantified and in some instances simply are not known by maintenance personnel at the depots. Further, we found that the repair efficiency decisions themselves were not always based on calculated analysis but rather on heuristic estimates that may or may not be borne out by actual analysis. Increased inventory investment will result from extended DRCTs, and total logistics support costs are likely to be higher than necessary.

In addition to higher overall logistics support costs, a second major effect of the imbalance that exists between supply and maintenance components is the potential for misallocating resources. DoD depot resources are not currently applied most effectively, and thus, DoD's ability to respond to new and changing requirements is severely hampered. Data from item stratifications show that numerous items with current requirements have available unserviceable assets that are not being repaired while many items without current requirements are being repaired. Depots are not always repairing the items with the most pressing requirements.

In looking at depot repair cycle management, we observed the scheduling process from the perspective of both the ICP IM and the maintenance shop planner, starting at the time the requirement is identified, including the time the component is scheduled and repaired, and ending with the component being returned to the wholesale supply system. The IM translates the repair requirements coming out of the inventory management system into workload schedules for the organic and contractor repair depots. Depending on the Service, these workload schedules are projections for time periods covering 3 months (Air Force), 6 months (Navy), or 1 year (Army) and are a result of a negotiation process between the IM and the depot maintenance management. From a long-range planning and programming perspective, both the IM and the maintenance shop planners recognize the need for depot capacity planning and workload analysis, and their efforts should be continued. However, we believe that line item repair schedules should be oriented to a short-term period that is closely tied to current wholesale inventory requirements. In the majority of cases today, the total requirement for the planning period is uniformly and evenly spread using level loading to generate a level or smooth workload schedule. Monthly, biweekly, or weekly schedule reviews are also jointly conducted by supply and maintenance personnel. However, in examining the induction processes at the depot, we saw that schedule reviews generally result in minimal changes to the prior workload schedules and that the initial workload planning schedules are being used as a guide to actually inducting unserviceables into maintenance. These schedules result in the induction of large quantities which, once inducted, serve to unnecessarily tie up capacity and limit the ability of the depot repair system to respond to changing new requirements.

System responsiveness is also limited by the lack of orientation to replanning outside the present requirements and workload scheduling process. While

emergency requirements for immediate end use customers are typically inserted into maintenance schedules without undue delay, no equivalent reaction is available for nonemergency requirements for wholesale inventory replenishment. Once an item is scheduled for workload, it either remains in the schedule notwithstanding a decrease (or elimination) in the requirement or the time period required to delete the item is excessive. Similarly, new requirements identified after the most recent workload schedule is established either may not be added to the maintenance schedule even though unserviceable assets are available and capacity and parts support are adequate or the addition of these new requirements may be delayed extensively. Overall, this procedure results in unneeded items being repaired at the expense of items that have legitimate requirements and the loss of flexibility needed by the IM to maintain valid maintenance repair priorities to meet current emerging wholesale inventory requirements.

Thus, our analysis of current DoD depot repair management leads us to conclude that the current system is heavily unbalanced when both supply and maintenance costs and operating priorities are considered. In order to ensure workload stability, to minimize repair setup times, to facilitate shop scheduling, and to improve capacity utilization, the depot repair activity prefers to maximize the in-process inventories of items either inducted but not yet in repair or actually undergoing the repair process. This objective, clearly consistent with maintenance priorities and objectives, tends to result in larger quantities inducted earlier and in an unwillingness to alter shop schedules or repair quantities unless absolutely required. Most of the schedule adjustments are made either to accommodate emergency add-ons in support of emerging operational requirements or to offset the lack of unserviceable assets or piece parts to support a given repair schedule. In very few instances are depot shop schedules adjusted responsively to reflect changing wholesale inventory requirements. On the other hand, the IM is responsible for maintaining responsive customer support while minimizing the investment in inventory. Small induction quantities, scheduled/rescheduled on a short-term basis as required to meet changing requirements and projected over the minimum DRCT necessary, are desirable attributes of the depot repair process from the IM viewpoint.

Today's DoD depot repair system is clearly oriented to maintenance objectives at the expense of supply objectives. Moreover, no evidence supports the contention that the so-called "repair efficiencies" being realized from today's biased system in

any way offset the additional costs incurred in unnecessary inventory investment. As a result, the total logistics support costs associated with depot repair may be higher than necessary.

To provide proper overall focus and a more balanced perspective on the DoD depot repair process, we recommend that the ASD(P&L) RPIP:

- Establish a maximum repair schedule period that covers no more than 30 days. This 30-day repair schedule period will reflect actual requirements generated from the inventory management files and will not be a smoothed or "level-loaded" schedule. The period is based on the current system capabilities and a quarterly updating cycle for wholesale inventory levels and would utilize an asset cutoff no earlier than 90 days before the period covered by the monthly repair schedule.
- Minimize interim changes to the monthly execution schedule by limiting such changes to Mission Capability (MICAP)/Casualty Report (CASREP)/other Issue Priority Group I (IPG I) requisitions or to changes in wholesale inventory requirements which change the repair requirement by more than 25 percent.
- Evaluate current maintenance concepts, inventory management procedures, and materiel control/movement systems to ensure that the low-cost mix of maintenance, inventory, and transportation resources is being applied
- Bring wholesale inventory managers and repair managers together to assess proposed policy and procedural changes, and team local depot maintenance personnel (production controllers and schedulers) and local materiel planners where feasible to bring greater focus to the repair effort.

PERFORMANCE MEASUREMENT

Lack of adequate measurement tools and established performance goals also contribute to the lengthy DRCTs we observed. While the importance of an effective depot repair process is gaining wider management attention, data to evaluate DRCTs are not uniformly available. The IM does not generally have enough data to question the length of repair times reported by the depot and therefore accepts those times as the best that can be done. Further, without this type of information, it is difficult to establish performance goals at the ICP. Similarly, repair depot personnel in some cases are not aware of the importance of DRCTs and their relative effect on inventory investment and supply performance. In general, repair personnel only monitor and control maintenance manhours and related costs and efficiencies.

Moreover, we did not find the management data and reports needed to provide performance measurement information on the overall repair process, establish meaningful performance goals to bridge both supply and maintenance performance, and perform cost/benefit tradeoffs. For example, current data systems used to monitor depot repair cycle performance do not typically provide the capability to develop specific materiel support goals, to adequately monitor actual repair execution (timing/quantities) relative to planned performance, or to assess the sensitivity of inventory investment costs and repair costs to performance improvements.

This lack of management focus, coupled with the inability to effectively monitor and evaluate the overall depot repair process, clearly contributes to lengthy DRCTs and to system inefficiencies. Wholesale inventory managers typically accept the DRCTs as given and have neither the technical expertise nor the information required to challenge them. Repair managers generally emphasize repair costs, capacity utilization, and level workload scheduling as primary objectives and have neither the management incentive nor the visibility of processing time performance necessary to properly focus on DRCT. Thus, we conclude that the role of DRCT in the overall repair process is seriously unappreciated. Neither management objectives nor performance measurement systems address this issue, and the related investment in reparable components is not seen as a factor in assessing the effectiveness of the repair process.

To provide more realistic performance assessment, to improve operating efficiency, and to reduce excessive DRCTs, we recommend that the ASD(P&L) RPIP:

- Include DRCT as a major depot performance indicator.
- Revise current information management systems to record data on each segment of the DRCT, including the segments internal to the maintenance activity and make this information easily accessible both to production planners and schedulers and, equally important, to Inventory Managers. The original repair program, changes thereto, actual production and reasons for overproduction and underproduction should be available.
- Specify materiel availability goals and monitor materiel support for depot repair as a separate element of performance measurement for the stock point supporting depot repair.
- Use processing time standards to monitor overall repair times within the maintenance flow and also to assess performance by segment (move, queue,

setup times) in maintenance and in the required processing segments (move, pack, store, etc.) external to the depot maintenance facility. Further, develop actual-versus-standard comparisons and make them available in structured management reports for use by wholesale Inventory Managers, production controllers, and local materiel planners. Using these comparisons, require continuing after-the-fact performance analysis of repair histories to determine why standards are not met and to formulate remedial policies and procedures as required.

- Extend the DRCT monitoring and evaluation system to include vendor repair where it is cost-justified.

CHAPTER 3

IMPROVEMENT INITIATIVES AND POLICY PROPOSALS

REPAIR PROCESS IMPROVEMENT PROGRAM

The analysis presented in this report cites a series of interrelated issues in management of the DoD depot repair cycle process. To resolve those issues, to reduce DRCTs, and to reduce the overall inventory investment associated with the DRCT, we believe that DoD must:

- Improve the definition and measurement of DRCT
- Increase shop scheduling flexibility and control
- Enhance materiel support for the depot repair process
- Rebalance the current depot repair system to minimize total logistics costs
- Reorient the current system of management objectives and performance monitoring to recognize the critical importance of the DRCT both to readiness and to the overall costs of inventory investment.

These broad DoD actions should be undertaken within the general framework of a revised systems approach to depot repair, a general framework that provides the clear overall direction for improvement without limiting the flexibility of the Military Services to make those specific procedural changes most appropriate to a given operating environment. It will be the degree of commitment and the comprehensiveness of the overall direction for change that will ultimately guarantee success and not the individual operating details of specific procedural revisions. Accordingly, we propose that the ASD(P&L) implement a broad, DoD-level, Repair Process Improvement Program (RPIP) to improve the management of the depot repair process. This Office of the Secretary of Defense (OSD) RPIP should be based on a recognition of the key interrelationships in the depot repair process. It is vitally important that the process of repair be examined as an integrated system, recognizing the complexities and shared organizational responsibilities as well as the dynamics of the key variables that affect the efficiency of the overall process. Further, proposals to improve the DoD depot repair process and to reduce DRCT

must be evaluated as a consistent package of interrelated recommendations that establish a general direction for system enhancement. While understanding the specific areas of deficiency and specific detailed recommendations advanced to improve the system is important, perhaps the more significant focus should be concentrated on the overall direction or thrust of the total approach by the DoD to depot repair of secondary items.

DEPOT REPAIR CYCLE POLICY RECOMMENDATIONS

The recommendations made in Chapter 2 to improve the efficiency of the DoD depot repair process and to reduce DRCTs represent a mix of management initiatives, process or systems changes, and specific policy revisions. To assist in identifying and acting on those recommendations which require policy development, those recommendations that are specifically oriented to policy revision are as follows:

- DRCT Definition and Measurement
 - ▶ Expand the current DRCT definition to include accumulation time and shop scheduling time.
 - ▶ Designate Condition Code T to cover the period of DRCT where assets are in-transit between the supply storage point and the maintenance activity.
 - ▶ Expand the current DRCT definition to include the period required for funding approval and repair authorization for contracted repair.
 - ▶ Develop line item standards to address each segment of the DRCT.
 - ▶ Use both actual history and line item standards to validate DRCT projections.
 - ▶ Exclude all AWP time as a segment of DRCT. Record AWP time as a separate management information element using Condition Code G.
- Shop Scheduling and Control
 - ▶ Provide repair schedules to the depot with an asset cut-off no earlier than 90 days prior to the period covered by the schedule.
 - ▶ Provide monthly (30-day) repair schedules to the depot.

- ▶ Limit induction quantities to a maximum of 7-days worth of demand (or one-fourth of the monthly schedule quantity) unless a larger induction quantity is specifically justified on a line item basis.
- ▶ Induct no earlier than 5 days prior to beginning repair.
- ▶ Limit modifications to the monthly induction schedule to MICAP/CASREP and other IPG-I requisitions or changes in wholesale inventory requirements that generate repair quantity changes in excess of 25 percent.

IMPROVED ASSET PRODUCTIVITY

A central concept common to many of the observations and recommendations in this report is the need for increased emphasis on asset productivity by DoD logistics management. Logistics assets in the DoD include a broad range of resources from inventories of spare parts to stock point warehousing personnel and equipment to maintenance and repair personnel, equipment, and facilities. In total, management's ability to increase the productivity of this mix of logistics resources that will determine the ultimate logistics support costs and level of customer service achieved by the DoD logistics system. We believe it is imperative that DoD management increase the productivity of its existing logistics resource base by using currently available assets more intensively. To make these logistics resources "work harder," the DoD logistics managers must look for ways to reduce delays, improve throughput times, and increase flow rates in all areas of the logistics system. As illustrated in this report, the potential benefits from improved processing efficiency and increased asset productivity are impressive. Moreover, these improvements typically do not hinge on new systems, new policies, or additional investment; rather, they evolve from increased management emphasis on, and attention to, the basics of logistics operations. As an illustration, we describe three current operating areas directly related to DRCT management that we believe warrant further examination – stock point workload scheduling and processing priority, stock point processing time standards, and retrograde flow policy.

Workload Scheduling and Processing Priority

From the perspective of the DoD stock point supporting depot repair operations, the receipt, storage, and issue of both unserviceable and serviceable reparable components is only one segment of a larger warehouse management effort. To facilitate workload planning and the operational management of this overall

warehousing function, the Services establish processing priorities (and associated performance timeframes) to guide the stock point or warehouse manager in allocating labor and equipment resources. In this workload scheduling priority scheme, the priority placed on the receipt and storage of incoming unserviceable reparable assets is typically less than that assigned to the receipt and storage of serviceable assets (including consumables). Reparable induction actions are typically processed as among the least important issues made by the stock point. Moreover, the receipt and storage of repaired assets by the stock point are given the same basic priority as other stock point receipts for stock.

These workload scheduling and processing priorities must recognize two factors – operational, or customer support, impacts and logistics support costs. The current stock point priority system is largely oriented toward customer support; logistics support costs are secondary if they are considered at all. We showed that the total DoD investment in one day of DRCT is about \$60 million. In view of those logistics support costs, the stock point priority scheme does not make good business sense in many instances. For example, why should the processing of a low dollar-value routine stock receipts (with adequate assets already in inventory) be afforded higher priority than the issuing and movement of an expensive unserviceable reparable asset into the induction/repair cycle? It would appear that the investment tradeoffs (receipt leadtime versus DRCT) would favor the induction processing effort. As another example, consider the stock point's issuing of a routine low-dollar value customer requisition (destined for inventory at a lower inventory echelon in the DoD distribution network) versus receiving and expensive reparable component into stock point inventory from repair. Again, the tradeoffs would appear to favor emphasis on the reparable receipt and the related reduction of DRCT at the expense of the customer requisition issue and ordering and shipping time to a lower inventory echelon.

Given the potential dollar savings associated with the reduction of DRCT, we believe further examination of these logistics tradeoffs to improve the asset productivity of expensive reparables is clearly desirable. In some cases, operational issues and customer support requirements will preclude such tradeoffs. However, in many instances we believe tailored or selective management of the basic logistics flows will significantly improve overall asset productivity and substantially reduce current logistics support costs with no adverse customer impact.

Processing Time Standards

Beyond the issue of workload scheduling and processing priority is the related question of processing time standards in the DoD logistics system. Our analysis of successful private sector logistics organizations, particularly those companies that have made substantive improvements in their logistics systems and are now recognized for their logistics excellence, points to a concerted effort to reduce processing time standards in many areas of the logistics flow. As products have become more complex and costly, materiel costs in many firms have increased relative to direct labor costs. Clearly, this is true as well for much of the DoD logistics system as reparable components and subassemblies and piece parts have become more complex and expensive. Further, the cost of logistics automation continues to decline as technological capabilities in information processing continue to drive down processing costs. The net result of these relative shifts in the costs of logistics resources is that our current logistics processing time standards (for example, receipt-to-storage standards, issue-to-shop standards, transportation standards, etc.) may be outdated and invalid. In many areas, including procurement leadtime and DRCT, which have been the subjects of two recent LMI studies, the current cost tradeoffs strongly imply that processing time standards should be reduced and that the savings in inventory investment would far outweigh the additional costs associated with people, equipment, and automation needed to achieve that reduction. For example, we recommend that, given today's processing environment, a standard processing time for transfer of unserviceable assets from storage to maintenance of 6 calendar days be used. A reduction of one day in that processing segment across DoD would generate about \$60 million – a savings far larger than the cost to achieve the reduction. Therefore, we recommend that the basis or validity of current logistics processing time standards be examined in an effort to further streamline logistics processing in the DoD and to improve asset productivity.

Retrograde Flow Policy

A final operating area where basic processing procedures warrant review is the current policy for retrograde flow of unserviceable components. A major difference noted in an examination of successful private sector repair operations was the ability of the private sector supply and maintenance organizations to flow unserviceable components directly into the repair facility and often directly into the actual repair

process. The accumulation of unserviceable components in a storage or repair facility and the follow-on induction by the maintenance organization of these items was not employed by any of the private section firms visited because, in their view, this procedure slows the repair turnaround time and requires a more extensive investment in reparable items. For a segment of the DoD reparable inventory, where predictable and sufficient demand exists to warrant a continuing repair schedule, we believe a change to current retrograde flow policy is potentially beneficial and warrants further analysis. For these items, the flow of unserviceable components should be directly to the repair facility scheduling buffer and receipt should be reported to the cognizant wholesale manager. Scheduling and funding procedures should be positioned to allow a smooth movement of these items into actual repair. This method, already used in some DoD contractor repair operations, would avoid the delays associated with the current multi-step retrograde flow and will reduce the inventory investment required to support the depot repair process.

SUMMARY

We recognize that the policy and procedural recommendations made are extensive. Many of them involve basic conceptual changes in the DoD approach to depot repair; some require significant changes in materiel movement and control procedures; others involve changes to existing management information systems used for collecting and portraying management data; and some imply revised performance standards and objectives. Successful implementation of the recommendations will require both time and a concerted, coordinated effort on the part of both supply and maintenance policymakers. In many cases, the functional performance in one area may suffer in order to achieve a more effective overall system for managing depot repair. Clearly, some functional goals must be reevaluated in light of an emphasis on overall horizontal processing efficiency, and supply/maintenance costs must be reassessed in light of total logistics costs associated with depot repair. Because most of the recommendations cross functional areas, adoption of these changes will not be easy. Nevertheless, we strongly believe that the program outlined provides the best avenue to meaningful improvement in depot repair cycle management and that in view of the potential benefits, these cross-functional issues and tradeoffs must be addressed.

The benefits of such changes should not be taken lightly because the magnitude of potential savings is striking. We are convinced that given today's

depot repair process with early induction of large quantities, extensive process delays, inflexible schedules, poor materiel support, lack of management focus, poor management visibility, and absence of meaningful performance standards, DRCT requirements can be reduced by at least 10 percent by adopting the package of recommendations made here. While that reduction would be realized incrementally over time as improvements are implemented, the end result would be a one-time reduction in DoD inventory requirements of approximately \$350-500 million.

As the DRCT is reduced, existing assets originally procured to support the longer repair pipeline become available for repair to offset projected attrition requirements. As these unserviceable assets are repaired to cover attrition requirements, a one-time savings will be realized in reduced new procurement requirements. This saving should be viewed as a potential gross savings in that additional systems development, operating, and, perhaps, labor costs may be required to achieve it. Beyond the one-time saving to DoD, reduced DRCTs will also generate continuing annual savings in inventory holding costs of \$75-100 million dollars per year.

On balance, the potential benefits to DoD highlighted above clearly outweigh the costs of change and we strongly support them. Our analysis of successful private sector repair operations demonstrates what can be achieved through a properly balanced, focused repair process based on the tenets we have identified. We find nothing inherent in the DoD depot repair system that precludes similar results in the DoD environment. It is in the areas of capacity planning, shop scheduling and control, materiel support strategy, balance, and perspective that deficiencies exist and these deficiencies can be overcome, thus providing DoD an opportunity for excellence in depot repair management.

APPENDIX A

DEPOT-LEVEL REPAIR CYCLE OVERVIEW

THE DEPOT-LEVEL REPAIR PROCESS

The DoD depot-level repair process is the major source of supply for wholesale serviceable depot-level reparable (DLR) secondary items after initial provisioning. The depot repair process currently generates approximately 75 to 90 percent of the wholesale serviceable components required to meet recurring demands, with the remaining 10 to 25 percent being obtained through new procurement or customer returns of serviceable items. The efficient management of the depot repair process is extremely critical because it is by far the least costly, most responsive source of reparable components needed to support both peacetime operational readiness and combat sustainability.

The total depot repair process is complex and requires the coordinated and timely efforts of people in different functional areas and organizationally separated activities. The DoD depot-level repair process (for end items and components) encompasses 33 major organic depot maintenance facilities employing 160,000 personnel and a growing number of contractor repair sources; it requires \$14 billion in resources annually and supports a DoD inventory of weapons systems and equipment valued at more than \$300 billion.

The depot-level repair cycle for reparable components starts with the removal of an unserviceable item at the organizational/intermediate-level maintenance (O/IM) activity after that item has been determined to be "not reparable this station" (NRTS) and turned in to supply. Supply automatically evacuates the item to the appropriate wholesale maintenance facility (organic or contractor) when authorized or reports to the appropriate wholesale Inventory Control Point (ICP) for disposition instructions. The unserviceable items are shipped by commercial-organic transportation to the designated supporting stock-point/contractor receiving activity for processing and reporting to the ICP.

Prior to this time, the ICP has developed a long-range repair program based on two forecasts: demands and the generation of recoverable unserviceable assets. This

long-range program provides the basis for determining piece part and subassembly requirements in advance (procurement leadtime, order and shipping time, and repair leadtime away), reviewing depot maintenance capacity, and budgeting. A near-term repair execution program (often called a workload schedule) is also developed in coordination with the depot maintenance activities. The combination of a funded execution program (a funded contractual instrument is required in the case of a contractor), the availability of recoverable unserviceable assets, and the availability of required piece parts or subassemblies provides the prerequisite for induction into the maintenance activity.

Given the necessary prerequisites, the maintenance activity or the ICP usually initiates induction (based on the in-place workload schedule). Items that are to be repaired by contractors may have to be inspected before the final contractual instrument is prepared. When the repair activity completes the repair, the item is usually returned to the supporting stock point or depot storage activity for packing, packaging, stowing, and reporting the serviceable item to the ICP. Urgent requirements may be shipped directly from the contractor to the customer. This time period associated with the movement and repair of the unserviceable asset and its return to serviceable status is called Depot Repair Cycle Time (DRCT) and is discussed in more detail below.

Reparable assets are assigned condition codes to indicate to the inventory manager the condition of the item: unserviceable ("F" condition); has been inducted into a repair facility ("M" condition); or is in serviceable condition ("A" condition). Condition "G" is used to designate those assets returned from maintenance to storage that are not being worked because of parts shortages. Measurement of DRCT is often keyed to changes in condition codes and what activities are included in each segment. Figure A-1 provides a generalized summary timeline of the depot repair cycle process.

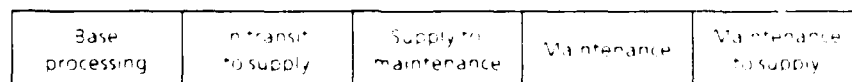


FIG. A-1. GENERALIZED SUMMARY TIMELINE FOR THE DEPOT REPAIR CYCLE

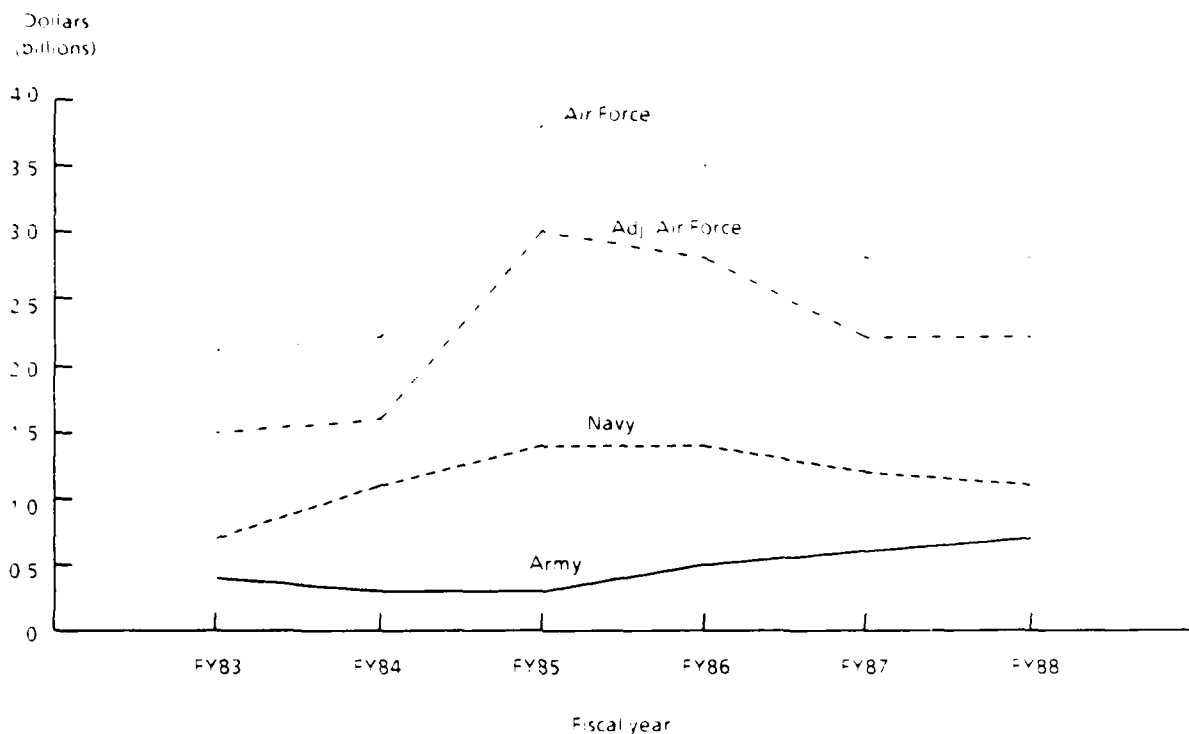
DRCT should be contrasted with the inventory requirement associated with the depot repair pipeline. When a secondary item is initially provisioned, sufficient

assets must be procured to not only fill serviceable inventory levels but also to fill the repair pipeline – the DRCT multiplied by the projected demand rate – required to complete depot repair for the item. Thus, once an item is beyond the provisioning phase, the steady-state repair process in concept will generate serviceable assets at a rate consistent with the rate of usage (less depot condemnations or washout which generates attrition requirements) and the on-going inventory requirement to support the depot repair process will be equal to the length of the depot repair pipeline (the DRCT) multiplied by the projected demand rate. This is called the depot repair cycle level (RCL) and is discussed in greater detail below.

THE DEPOT REPAIR CYCLE LEVEL

In order to provide retail customers with serviceable components while the unserviceable items are being repaired, the ICPs are authorized a depot RCL of unserviceable assets. That level is based on the number of demands that will be satisfied from recoverable unserviceable asset returns generated during the repair cycle, or DRCT. At a given demand rate, the longer the DRCT, the greater the RCL asset investment. The initial provisioning pipeline is similarly affected by the length of the DRCT.

In FY86, about \$5.5 billion was invested in the wholesale RCL to support the depot repair process. Figure A-2 shows the RCL investment based on the budget estimate submissions of the Army, Navy, and Air Force. The value of the Army RCL was \$523 million compared to \$1,434 million for the Navy and \$3,535 million for the Air Force. The Air Force RCL includes approximately 14 days to cover the retrograde time from the base to the depot because the Air Force computes requirements for reparable items on a worldwide basis. Adjusting the Air Force RCL to be similar to the Army and Navy would reduce the investment to approximately \$2.9 billion. The proposed Army RCL investment for FY88 increases to \$685 million while the proposed Navy and Air Force investments decrease to \$1,103 million and \$2,191 million (adjusted), respectively.



**FIG. A-2. DEPOT REPAIR CYCLE LEVEL VALUE
Army, Navy, Air Force Budget Estimate Submissions**

THE DEPOT REPAIR CYCLE TIME

The DRCT is a discontinuous time beginning not earlier than the placement of a demand on the wholesale system and ending with the replaced (turned-in) unserviceable item restored to ready-for-issue (RFI) condition on the records of the wholesale inventory manager. The DRCT shown in Figure A-1 includes several different types of activities, including retrograde processing, administrative processing, and actual maintenance processing.

Retrograde Time

Retrograde time begins when an item is determined to be beyond the repair capability of an organizational intermediate maintenance activity and ends when an unserviceable item is received at a depot and is recorded as on-hand in an unserviceable reparable condition at that location on the ICP's records or the date on which a commercial/interservice depot maintenance activity receives the item.

Administrative Time

Administrative time begins when an unserviceable item is received at the depot and is recorded as on-hand in unserviceable repairable condition at that location on the ICP's record or the date a commercial/interservice depot maintenance activity receives the item; it ends on the date the condition code is changed from "F" to "M." Administrative time includes the time required by the ICP depot to schedule depot maintenance and to prepare documentation prior to induction. Administrative time is a discontinuous segment of the DRCT in that it excludes several segments. It excludes any condition Code F time during which no repair requirement has been identified and any scheduling time prior to the receipt of an unserviceable repairable item.

Maintenance Turn-Around Time

Maintenance turn-around time begins when the condition code of an item is recorded as suspended (in work) or at the "in-work" date reported by a commercial/interservice depot maintenance activity; it ends when an item has been restored to serviceable and issuable condition and is recorded as such on the ICP records.

DoD ORGANIC DRCT MEASUREMENT

DRCT commences when the initial demand for the replacement of an unserviceable item is entered in the supply system and ends when an item has been restored to serviceable and issuable condition and is recorded as such on supply records. However, to the extent that the Army and the Navy do not have asset visibility at the consumer or base level, they typically define DRCT as starting at some point after the initial demand for a replacement. While the basic steps of the depot repair process for each of the Services are similar, differences in the measured DRCTs among the Services are generally a function of the portion of the process each includes in its measurement and the timing used to start and stop specific segments. Table A-1 displays the segments of DRCT measurement for each of the services.

Air Force

Of the three Services in our study, the Air Force is the only one with continuing, line-item asset visibility to the consumer or base level of supply. As such, it is the only Service that starts measuring the DRCT from the point at which

TABLE A-1

TIME SEGMENTS INCLUDED IN RCT MEASUREMENT

Service	Base processing	In transit to supply	Supply to maintenance	Repair	Maintenance to supply
Air Force	Yes	Yes	Yes	Yes	Yes ^a
Army	No	No	No	Yes	Yes ^a
Navy	No	No	Yes	Yes	Yes

^a Excluding packing and actual stowage in location.

the component fails. It includes all activities associated with taking the unserviceable asset through the repair process and concludes when the asset has been packaged and located in a permanent storage site. The Air Force is also unique in that it uses standards for most of the segments of the DRCT used to determine requirements. Where the other Services use only historical data to develop DRCT projections, the Air Force uses either history, a constant factor, or an engineering standard time for each activity in the repair cycle based on the specific situation or time segment involved.

The measured DRCT begins at the point of asset failure where the unserviceable asset is also prepared for return (base processing time) and shipped to the appropriate wholesale depot (in-transit time). When it is received at the wholesale depot, the unserviceable asset is placed into Code "F" Condition and remains in that condition until supply at the wholesale depot receives a request from maintenance to move or "induct" the materiel into the repair facility; at that point, the asset condition code is changed to Code "M." (The period of time the asset remains in storage awaiting induction is not included in the repair cycle time.) Code "M" Condition encompasses the time supply needs to move the unserviceable asset into the repair facility (supply to maintenance time), the time it takes for maintenance to repair the item (shop flow time), and the time it takes for maintenance to move the serviceable asset out of the repair facility, and for supply to perform packaging and preservation and place it in a permanent storage location (maintenance to supply time). The asset may be placed into "G" Condition if awaiting parts, but that time is not included in the measurement used by maintenance to determine the overall DRCT nor is it included in the requirements

process since standards are used. When the serviceable asset is in storage, the condition code is changed to Code "A" and the asset is Ready for Issue (RFI) on the Inventory Manager's record.

Army

The Army measures DRCT from the time at which the unserviceable asset is received in the repair facility. It concludes the measurement when the asset has been repaired and returned to supply. The movement of the unserviceable asset into the repair facility and preservation, packaging, and movement of the serviceable asset to a permanent storage location is not included in the Army's DRCT. The repair cycle time used for requirements computation is based on historical observations.

The unserviceable asset is put into Condition Code "F" when it is received by the wholesale depot, and it remains in that condition until it has been moved to the repair facility at which point the condition code is changed to "M." Upon completion of repair, the condition code is changed to "A" and the serviceable asset is returned to supply. Movement of the unserviceable asset by supply into the repair facility, packaging and preservation, and movement of the serviceable asset to a permanent storage location is not included in the duration of Condition Code "M."

The repair cycle time used for requirements computation consists of the duration time of Condition "M" time. Condition "G" is not used frequently but is included in the repair cycle time when used. Awaiting parts (AWP) time while the component is in Condition "M" is also included.

Navy

The Navy measures the DRCT from the time at which supply inputs the induction request or generates a picking ticket to move the unserviceable asset into a repair facility to the time at which the asset has been repaired, returned to supply, packaged for storage, and located in a permanent storage location. The overall repair cycle time used for requirements computation is based on historical observations. This measured cycle is augmented by a period of required accumulation time that is added to measured DRCT as a constant.

The unserviceable asset is put into Condition Code "F" when received in the wholesale depot and remains in that condition until the repair facility requests

induction. At that time, the condition code is changed to "M" and the asset is moved to the repair facility. The unserviceable asset generally remains in Condition "M" until it has been repaired and the serviceable asset has been returned to supply, packaged for storage, and located in a permanent storage location; at that time the condition code is changed to "A." Condition "M" includes the time to move the unserviceable asset to the repair facility and the serviceable asset back to supply as well as the actual repair time. Time in Condition "G" is included in the repair cycle time up to a predefined limit which is generally of 60 days.

This general procedure should be further defined to recognize specific processing approaches that are generally unique either to the Navy Ships Parts Control Center (SPCC) or to the Navy Aviation Supply Office (ASO). SPCC generally relies more heavily on agreed-to depot workload schedules to plan for and execute depot repair. ASO, on the other hand, generates a significant portion of the depot repair workload through the weekly probe, which matches assets to requirements, and computer program B08, which generates an induction notice to the appropriate depot repair facility. Further, on completion of repair, SPCC typically delays the condition code change to Condition "A" until the asset has been packaged and stored, whereas ASO often makes that condition code change as the repaired item enters the packaging process.

CONTRACTOR DRCT MEASUREMENT

For items moving through contractor repair, the Air Force measures the repair cycle time from the time that the asset fails. The initial steps are the same as for organic repair through base processing time and in-transit time. However, supply-to-maintenance time does not apply because shipment time to the contractor is included in in-transit time. Because the Air Force relies on standard times, the shop flow time standard for contractor-repaired items is the negotiated leadtime on the repair contract. The measurement of the contractor's actual repair time validates the shop flow time, which equates to monitoring on-time delivery on the contract/order. Actual contractor repair time begins when the contractor has both the asset and the funded repair order and, in the case in which the contract calls for Government-Furnished Materiel (GFM), the parts to effect the repair. If the asset arrives before the order arrives, waiting time is not included a a part of repair cycle time.

For the Army, DRCT for items that undergo contract repair includes the time to ship the item from the wholesale depot to the contractor, contractor repair time, and time for shipment back to the wholesale depot. Of the services studied, the Army is the only one that does not ship unserviceable items directly to the contractor; it generally has all unserviceable assets shipped into the wholesale depot before being shipped to the contractor. The measurement of the contractor DRCT begins when the contractor receives the asset and concludes when the repaired asset is received at the Army wholesale depot.

The Navy measures the DRCT for contract repair items starting at the point at which the contractor has the unserviceable asset and funded repair order and ending when the repaired items have been returned to supply, packaged, and stowed. The Navy also uses a system that measures the point at which repair has been completed by the contractor, giving a more precise measurement of the contractor's actual repair time relative to the entire measured DRCT.

APPENDIX B

DoD ORGANIC DEPOT REPAIR CYCLE ANALYSIS

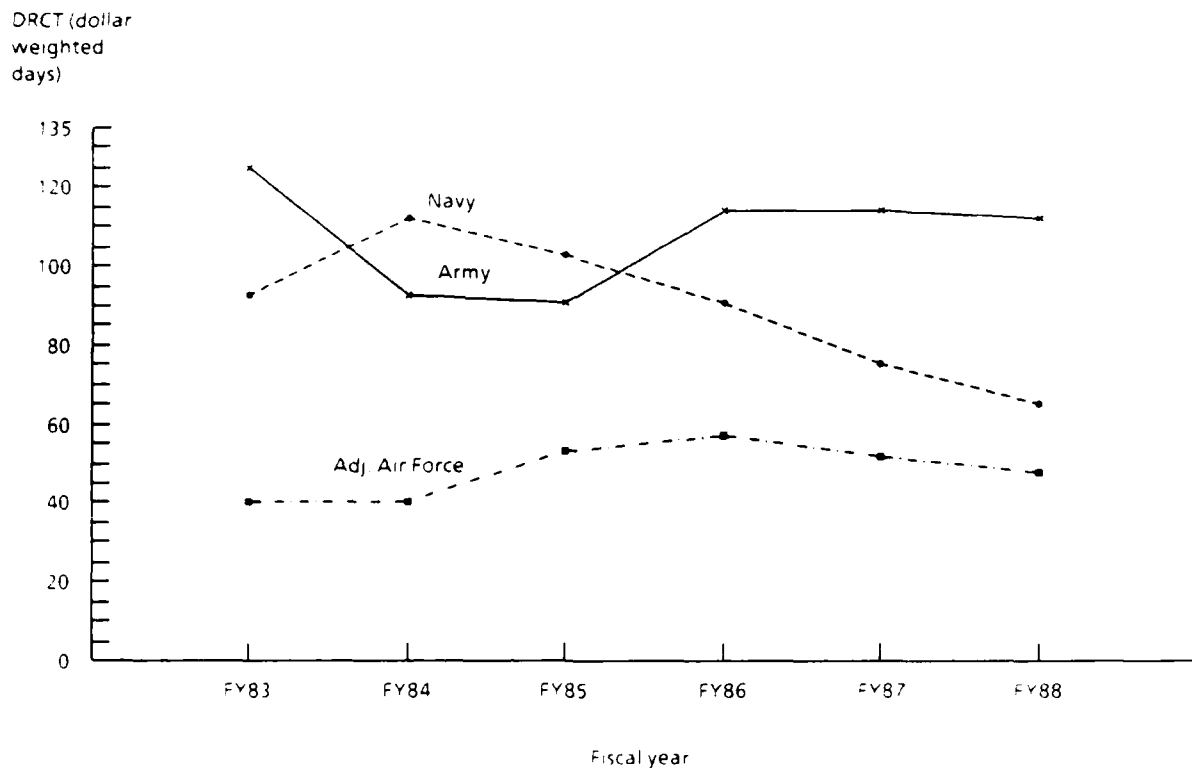
INTRODUCTION

In this appendix, we examine depot repair cycle times (DRCTs) for the Air Force, Army, and Navy. We examine historical data for a sample of items that have been repaired and compare the actual repair times to standard, or "should take," times and to the values the inventory manager maintains in inventory records and uses to compute repair and procurement requirements. As discussed in Appendix A, with the exception of the retrograde time appropriately included in the Air Force DRCT, the Services start and stop measuring DRCT at the same points. Each starts recording DRCT with the change in the Condition Code from "F" to "M" and each ends the measurement with the change in condition from "M" to "A" or "B." Within this common framework, however, differences exist among Services in the timing of these condition code changes.

DRCT occurs in several different forms – the standard, or "should take," time established by the maintenance activity; the historical, or "did take," time; the time reflected in the requirements computations; and finally, the time reflected in the Budget Estimate Submission (BES). The duration of the DRCT is vitally important because the length of the DRCT directly affects the size of the investment in assets for the repair cycle level (RCL) in three separate areas. First, in initial provisioning, the length of the DRCT affects the initial procurement of assets required to initialize the system. Second, the length of the DRCT affects the wholesale safety level required to buffer the repair process against uncertainty in demand. Finally, the length of the DRCT determines the continuing steady-state investment in repairable assets needed to support the repair process.

The length of the DRCT also has a direct bearing on the responsiveness of the supply system and, therefore, readiness and sustainability. Given an existing balance, an increase in DRCT triggers a one-time procurement requirement and a decrease in DRCT postpones the procurement requirement. Examination of the DRCT provides an insight into the controllable factors contributing to the size of the

RCL. Figure B-1 shows the dollar-weighted DRCT days for the Army, Navy, and Air Force as reflected in their BES's. The Air Force DRCT is adjusted to exclude 14 days of retrograde time to be comparable with the Army and Navy. The Air Force DRCT has been consistently lower than that of the other Services – ranging from 40 to 57 days. The Navy's DRCT increased to 112 days in FY84 and decreased dramatically since that time to a projected low of 65 days in FY88. The Army DRCT decreased by approximately 30 days in FY84 and FY85 primarily as the result of eliminating repair administrative leadtime. However, the Army DRCT increased by 23 days to 114 days in FY86 – twice that of the Air Force – and is projected to remain at about that level.



Note: Values shown for FY83, FY84, FY85, and FY86 are based on half-year actual and half-year projected data. FY87 and FY88 values are fully projected.

FIG. B-1. DEPOT REPAIR CYCLE

We now turn to a specific analysis of DRCT management in each Service. Our examination is based on visits to an Inventory Control Point (ICP) and a depot maintenance activity in each Service and an analysis of a sample of items selected by each ICP. Our analysis is constrained by two significant factors. First, the line-item sample on which we based many observations was limited. We believe, however,

that the results generated from this limited sample are, in most cases, relevant to the larger repairable inventory; nevertheless, care must be taken in such an extension. Second, we visited only a small number of Service ICPs, and depot maintenance activities. Where unique operating and support factors significantly affect ICP/depot repair activity procedures, the observations may be inappropriate for those organizations. These differences are likely to be particularly important in the Army (for the Aviation Systems Command) and in the Navy [for the Aviation Supply Office (ASO)].

THE ARMY

The Standard

The Army depot maintenance activity visited had standards for items in the current repair program. The Army used two different methodologies to develop the standards. Approximately 85 percent are engineering standards developed by a standards office independent from the depot maintenance function; the remaining standards are referred to as technical standards and are based on comparison with similar items and the expert knowledge of the production personnel. Technical standards are developed for new items entering the repair process and for items with very low repair frequency that do not justify the development of a formal engineering standard.

The standards are expressed in terms of standard man-hours, which reflect only the hands-on time required for each workstation and process; the standards do not include any queue time or time for movement between work stations. The comparison of actual man-hours and standard man-hours receives substantial management attention from the shop foremen/production controller up to the Director of Depot Maintenance. This attention is due, in part, to the fact that the repair price charged the customer for most items is based on the standard man-hours. While we did not make an in-depth study of the Army methodology for establishing man-hour standards it appears to be sound and the man-hour standards do not appear to be a primary target for potential reduction of Army DRCT.

In addition to the man-hour standards, the depot maintenance activity also develops elapsed workday standards referred to as "normal unit maintenance repair cycle time." These standards follow the critical repair path and, in addition to the standard man-hours for the workstations and processes on the critical path, provide

for non-man-hour events such as drying, operational testing, transportation among workstations, and queue time. The critical repair path elapsed time does not include any time in Condition "M" before the first man-hour event or after the last man-hour event nor any awaiting parts (AWP) time. It represents the normal throughput time required to repair an item once the item starts at the first work center. The critical path elapsed time is primarily used in depot production scheduling. Unlike the man-hour standards, the normal unit maintenance repair cycle time does not appear in any management reports nor are comparisons made to determine maintenance's actual performance compared to the elapsed time standards. We did not learn of any Army management reports that identified the amount of elapsed time that accrued in maintenance before the first and after the last critical path events. The exact methodology for determining the non-man-hour events and their elapsed time additives is not clear. While some reduction of the critical path elapsed time standard may be possible without major changes in maintenance operations or resource investment, such reductions do not appear to be an appropriate immediate target for DRCT reduction.

The History

Historical DRCT is collected at the Army ICPs by a standard system called the Automatic Repair Cycle Measurement Information System (ARCMIS). This system produces a report titled "Adjusted Repair Leadtime and Final Recovery Rate Computation Detail." As the name indicates, the report provides two products, a quantity-weighted DRCT based on a 2-year moving average and a Final Recovery Rate (FRR) for those Condition Code "F" items that are inducted into maintenance. The FRR is used to project the number of unserviceable items returned to the wholesale system that will be restored to an issuable condition through the repair process.

Inputs to the ARCMIS are those transactions that change the condition code of an item to "M" and from "M" to "A," "B," "C," or "G." The transactions contain the document number and date; they are grouped by document number, and the elapsed time is computed and weighted by the quantity of items in the transaction. At the beginning of the 2-year period, transactions change a number of items from Condition "M" to Condition "A," "B," "C," or "G" without the corresponding condition "M" document. Conversely, at the end of the period, a number of transactions change items to Condition "M" without the corresponding Condition "M" to

Condition "A," "B," "C," or "G" transactions. These missing transactions are not included in the Army DRCT computation. In the computation of the final recovery rate, because the quantity of Condition "A," "B," "C," and "G" assets is divided by the number of condition "M" assets, the resulting final recovery rates appear highly questionable based on the sample items we examined. For the 24 sample items provided by the ICP, the FRR ranged from 0.14 to 1.00 with an average of 0.76. The FRR for 42 percent of the 24 items was less than 0.80.

Coupled with the low Army recovery rate is a very low projected return rate. The return rate is used to project the number of unserviceable items that will be returned to the wholesale system based on the forecast of recurring demands, and for the 24 sample items, the Army return rates ranged from 0.11 to 0.92 and averaged 0.46. To the extent that the Army rates are substantially understated, several adverse conditions result: (1) the requirement for procurement appropriations is overstated and the requirement for maintenance appropriations is understated because both the FRR and depot recovery rates are too low, (2) the repair program requirement is understated for maintenance planning and workload forecasting because the FRR is understated, (3) the requirement for piece parts and subcomponents is also understated for the same reason, and (4) the total budget is overstated because the cost of a new asset from procurement typically exceeds the cost of repair.

Requirement Computations and Budgets

The Army Inventory Manager (IM) is responsible for the file maintenance of the DRCT used in the requirements computations for the supply control studies and the stratification reports. The ARCMIS system produces the historical report with the adjusted DRCT computation and detail. It also produces an input card with the new DRCT. If the IM agrees with the new DRCT, the card is forwarded for input into the system. If the IM does not agree with the new computation, the card is marked with the DRCT determined by the IM and forwarded to be input into the system (changes may be reviewed by the supervisor or control group). If no card is input, the previous DRCT is retained. IMs generally are not technically qualified to determine the validity of the DRCT, nor do they have the benefit of the depot maintenance standard as the basis for evaluating the historical data or determining the reasonableness of the DRCT.

In the Army system, the DRCT in the file is used for both the item supply control studies and the stratification reports. The supply control studies may be adjusted by the IM, and the quantities to be repaired or procured may be changed accordingly. The stratification reports are not adjusted. Any corrections or adjustments are made in the transition from the stratification to the budget documents.

Evaluation of the Army DRCTs

The comparison of the DRCT reflected in the Army workday standards with the historical DRCT and the DRCT recorded in the files for requirements computations and stratification reports provides a basis for evaluating the times currently used by the Army. Data from all three sources were available for only 15 Army sample items. Army critical path workday standards were converted to calendar days by multiplying by 1.45 (to account for nonworkdays), and 2 days was added to cover the return from maintenance and the time for recording the data on the records of the ICP. With these changes, the standard becomes comparable to the time period measured by the transaction history and the DRCT used in the requirements computation. Figure B-2 shows weighted times as computed in the stratification reports (weighted by the value of one day of RCL demand).

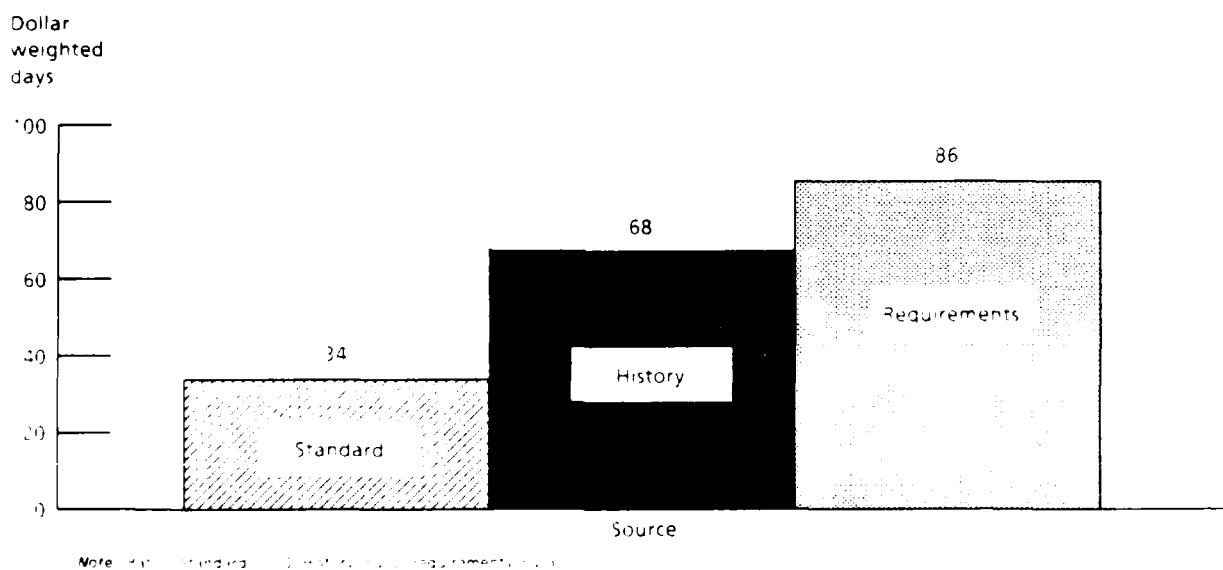


FIG. B-2. ARMY ORGANIC DEPOT REPAIR CYCLE TIME, FY86 SAMPLE

Figure B-3 reflects the three sets of DRCT times for each item. For all 15 sample items, the requirement computation DRCT exceeds the standard by 18 to 126 days. For Item B, the history is 1 day less than the standard but the IM uses a DRCT 12 times greater than the standard. For all other items, the history ranges from 12 to 82 days greater than the standard. In the aggregate, the actual (history) time required for the sample items is twice as long on average as the standard and the DRCT used in the requirements computation is 2.5 times the standard. If the sample is representative of the overall Army DRCT, reducing the DRCT used in the requirements computations to that determined on the basis of the actual history would result in a 20 percent reduction in time and investment in RCL assets. Initial provisioning requirements for new items and safety-level requirements could also be reduced.

The Army critical path elapsed time standards appear to be reasonable based on our cursory examination of the methodology used to develop them. Our field research did not disclose any factors that would justify the actual "did take" time being twice the "should take" time, nor did our discussion with IMs reveal a valid basis for IMs rejecting the historical data in 12 of the 15 samples in favor of DRCTs averaging 25 percent greater than historical data and 2.5 times greater than the standard. We believe that the greatest potential for reducing the asset investment and improving the responsiveness of the repair process is a combination of policies and programs that addresses the factors that contribute to the broad and substantial exceeding of the standards.

Factors Contributing to Long Army DRCTs

Induction Timing

Given a funded maintenance program and the availability of unserviceable assets, the Army inducts assets into the maintenance activity up to 30 days in advance of actual scheduled hands-on repair. Historical data were not available to determine the average backlog time awaiting the first work process. Whatever the historical average is, that many days were added to the DRCT without adding to the restoration of the item. The Army must strike a proper balance between inventory investment and maintenance line efficiency. The length of time that materiel is in backlog in maintenance awaiting induction at the first work station should be held to the minimum consistent with orderly flow. Currently, many personnel are

DRCT (dollar
weighted
days)

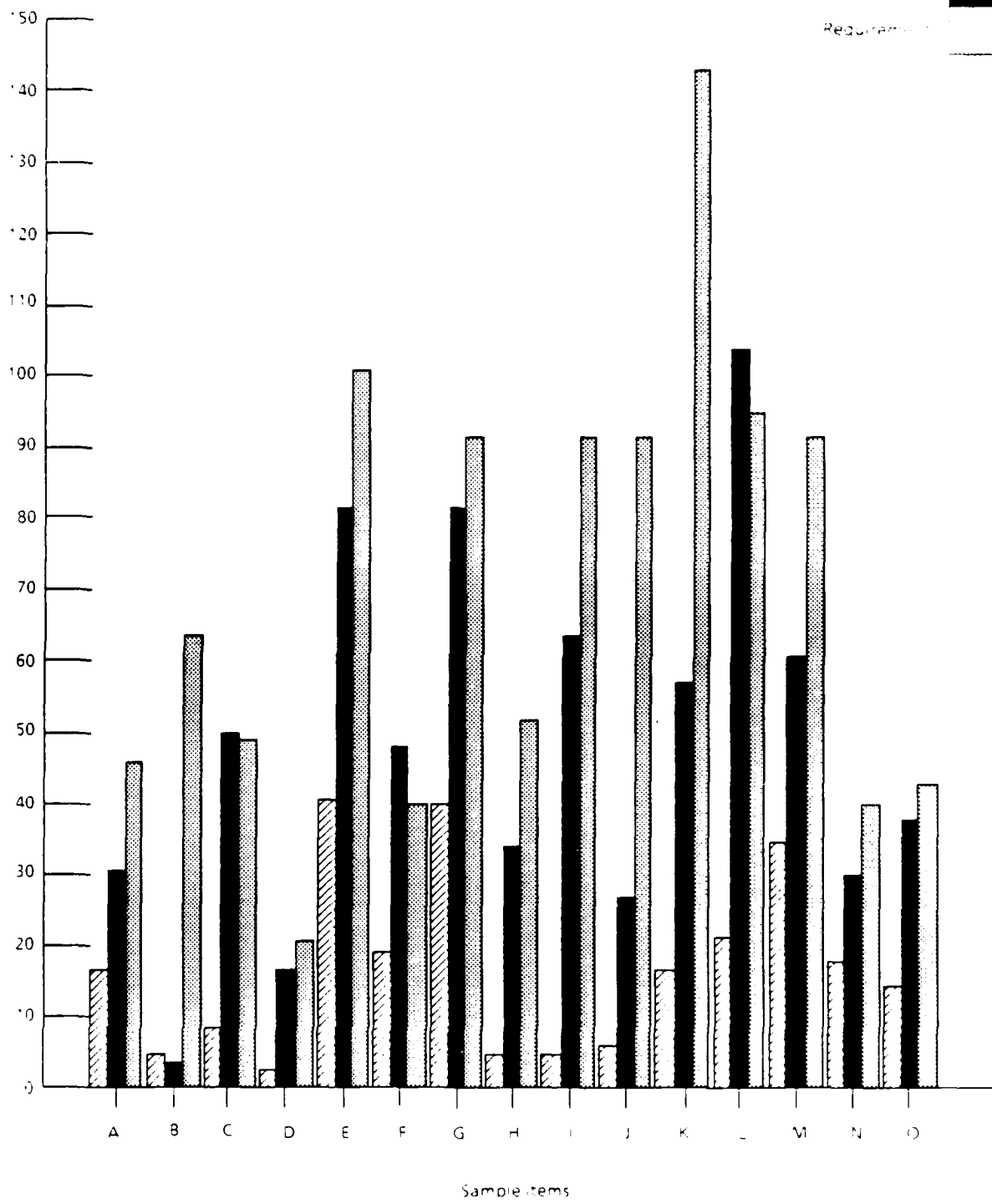
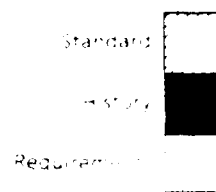


FIG. B-3. ARMY DEPOT REPAIR CYCLE TIME

Comparison by Item
Standard, History, and Requirements

inadequately aware of the effect of maintenance decisions and actions, including the effect of early induction on materiel management (responsiveness and investment).

Induction Quantities

We observed that the quantity inducted into maintenance frequently exceeded the immediately available capacity of maintenance. This practice has the same effect as bringing materiel in early – some portion of the quantity remains in backlog until production capacity becomes available and the DRCT is increased accordingly. Table B-1 shows the progressively increasing DRCT resulting from the induction of greater quantities than can be repaired by the immediately available capacity. In the first example, if we exclude the last delivery as an outlier, we have a spread of 129 days between the first ten completed items and the last two. This spread is greater than the total time to repair the first ten items, which may also include backlog time. The second example shows a similar spread of 123 days between the first four completed items and last item completed. The two examples are extreme in the total elapsed days between the first and last completions because of the long DRCT for these items. The relative increase between the first and last items as a percentage of the DRCT for the first item is a frequent occurrence for our sample items. Reducing the quantity inducted to the immediately available capacity could result in substantial reductions in the historical Army DRCT.

Materiel Support

The Army ICP personnel expressed the view that AWP was not a problem and not a significant contributor to the DRCT. Depot personnel, both in maintenance and depot supply, expressed the opposite view. In the Army system, most AWP time occurs while the items are in maintenance in Condition Code "M." Seldom are items returned to storage and placed in Condition Code "G" while awaiting parts. When prolonged parts shortages are experienced, unserviceable assets may be brought into the maintenance activity for the purpose of borrowing parts. This practice permits urgently required items to be repaired and precludes the closing down of the repair line. Under the current system, the condition code of the item being used for parts borrowing is changed to "M" and the historical DRCT clock is turned on. Consequently, most of the AWP time is included in the historical DRCT and, based on the sample, is included in the requirements computation. Depot personnel

TABLE B-1

IMPACT OF INDUCTION QUANTITIES ON DRCT

Example 1			Example 2		
Quantity induced	Quantity Completed	DRCT (Days)	Quantity induced	Quantity Completed	DRCT (Days)
59	-	-	21	-	-
	10	102		4	198
	12	134		2	205
	10	161		1	219
	3	185		1	240
	9	197		3	246
	1	200		2	273
	10	228		2	287
	2	231		2	289
	1	379		1	294
			1	296	
			1	321	

identified some of the sample items as those that had experienced parts shortages. Table B-2 shows the effect of including AWP time as an element of the Army DRCT.

TABLE B-2

IMPACT OF AWAITING PARTS ON DRCT

Description	Example 1	Example 2	Example 3
Standard (days)	19	6	22
Inventory Mngmnt File (days)	40	92	95
History (days)	48	27	104
History without AWP (days)	24	25	28
Reduction (days)	24	2	76
Reduction in RCL value (\$)	\$242,328	\$3,860	\$16,188
Percent AWP added to history	100	8	271

In Example 1, the historical DRCT was doubled as a result of the inclusion of AWP time. The shortage affected production through the end of Calendar Year 1985, and, therefore, the historical data will be influenced by the shortage until the beginning of 1988. The shortage did not recur during the first 6 months of 1986. If the AWP time were excluded, the RCL could be reduced \$242,328. In the second example, only one unit was affected by the shortage over the 13 months of historical data. That shortage increased the historical DRCT by 2 days (or 8 percent). In the third example, exclusion of the AWP time reduces the historical DRCT from 104 days to 28 days. AWP added 76 days or 271 percent to the DRCT. The shortage occurred during the period of January-March 1985 and did not occur again through June 1986.

The Army depot maintenance activity and depot supply are authorized 15-day and 60-day consumer levels of parts, respectively, based on outstanding funded work orders. Requirements are computed by multiplying the funded quantity times the depot overhaul factor. No provisions are made for a safety level or for requirements based on historical demand. Depot supply supports other customers as well as depot maintenance, and its assets are not reserved for depot maintenance. Three different sources are available for parts – the wholesale system, local purchase of designated items, and local fabrication of designated items. Some of the items designated as centrally managed (and therefore requisitioned from the wholesale system) are not stocked items, which means that the items are a procurement leadtime away at the time they are requisitioned. These items are one cause of part shortages because the depot does not have funded work orders in sufficient time to order the parts. We were unable to determine the essentiality assigned to these items by the Army. If the items are essential to weapons systems and so designated, they should be stocked at the wholesale level. One of the options available when centrally managed items are out of stock and will be so for an extended period, is local fabrication. Depot maintenance activities have extensive capability to make parts. We found the decision to "wait" or "make" being made from too narrow a perspective – namely the price if supplied by the wholesale system versus the cost to make. The equation should include the shortage cost for the difference in time between when the item would be available from the supply system and from local manufacture.

While the depot personnel clearly stated that part shortages were both frequent and extended enough to constitute a problem, they supported that position

primarily by citing examples. We did not find summary management reports that measured the frequency and duration of parts shortages or indicated the sources of supply that were the major contributors, nor did we find a local analysis of policies, systems, and procedures that contribute to the shortage.

Long Repair Time Processes

One or more processes or subassemblies may significantly increase the DRCT for a reparable component. As an example, a turbine engine is repaired at one maintenance activity but one or more components are repaired at a second activity. After the engine is disassembled, the components must be packed and shipped to the second activity. When the components are repaired they must be packed again and shipped to the original maintenance activity for assembly in the engine. In such cases, consideration should be given to a cost analysis to determine whether the cost of a rotatable pool of serviceable components or subassemblies would be more than offset by the savings in reduced the DRCT, thereby decreasing the investment in the RCL.

Scheduling Flexibility

Based on our discussions, the repair process is not very responsive to changing requirements; approximately 2 weeks is needed to input changes and receive updated schedules and output. As a result, few changes are made to the agreed-to schedule when wholesale inventory requirements change. The net impact of this scheduling inflexibility is the inability of the repair process to respond to the inventory requirements generated at the ICP. For example, we observed numerous instances in which items were scheduled for repair and inducted by the repair activity even though a wholesale inventory requirement for them no longer existed. Conversely, we noted many cases in which no repair was scheduled even though a wholesale inventory requirement existed and unserviceable assets were available. The process, therefore, results in an unnecessary investment in repair on the one hand or a support gap on the other hand.

THE NAVY

The Standard

The Naval Shipyard we visited had man-hour standards for items in the current repair program. Those standards provide the basis of establishing a price

list by National Stock Number (NSN) for the repair costs. Shipyard personnel recognize they are in a price-competitive situation with other shipyards and contractors. Comparison of actual man-hours with standards receives substantial management attention from shop foremen and production controllers primarily because the contract repair price (organic maintenance) for most items is based on the standard man-hours. The man-hour standards are developed by the major shops involved in the repair process and are expressed in terms of standard man-hours that reflect only the hands-on time required for each work station and process. Man-hour standards do not include any queue time or time for movement between work stations.

We did not examine the methodology used in establishing the standards, but one of the products of the system is a Repairable History that provides up to 4 years of line-item history, with the man-hour standard being one of the data elements. Table B-3 shows the number of line items by man-hour groups for the 162 items (every 10th item) for which we obtained data. Of the 162 items, 28 percent have standards of from 1 to 10 man-hours, 67 percent have standards of 1 work-week or less, and only 10 percent have standards exceeding 100 hours. We compared the standard man-hours with the actual man-hours for the first 20 items in our sample. The standards totaled 2,212 hours and the actual totaled 2,209.8 or a difference of 0.1 percent. One item exceeded the standard by 50 percent and one item was 38 percent less than the standard. The man-hour standards do not appear to be a primary target for potential reduction of Navy DRCT.

TABLE B-3
DISTRIBUTION OF MAN-HOUR STANDARDS

NSNs	Hours								
	1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 99	100 - 199	200 +	No std
Number	46	33	13	18	12	14	10	15	1
Percentage	28%	20%	8%	11%	8%	9%	6%	9%	1%
Cumulative percentage	28%	48%	56%	67%	75%	84%	90%	99%	100%

The shipyard did not have critical path elapsed time standards that included queue and movement time from one workstation to the next. To provide a basis for evaluating the historical DRCTs and those used in the requirement computations, we constructed those critical path elapsed time standards from data obtained from the Army. We grouped the Army items into three groups based on the standard man-hours — 1 to 199 man-hours, 101 to 200 man-hours, and over 200 man-hours. For each group, we computed the percentage of nonproductive time (queue and movement time) that the Army allowed. The computed add-ons were 1.55 percent, 0.42 percent, and -0.26 percent, respectively. For each of the Navy items, we then multiplied the standard man-hours by the appropriate percentage and added the product to the standard man-hours. The sum was divided by 8 to convert hours to workdays, and the workdays were then converted to calendar days by multiplying by 1.45. To this product, 14 days was added to cover the time from the input of the induction request (and change from Condition Code "F" to "M") until the materiel is received by maintenance and to cover the time from when the materiel is turned over by maintenance to storage, stowed, and reported as "ready for issue" (RFI) to the ICP.

While we did not find individual item standards, the Navy does have general goals for the total DRCT and for the segments that comprise the total. The goals are published in Naval Materiel Command (NAVMAT) Instruction 4400.14B, Navy Repairables Management Manual. That manual is currently being revised by the Naval Supply Systems Command (NAVSUP). The DRCT portions of these goals are shown in Table B-4. The first three segments are not included in our constructed standard (should take) time nor in the historical data used by the ICP to establish DRCT. In this evaluation of Navy DRCTs, we compare these NAVMAT goals with historical data and DRCT times used in requirement computations.

The History

Historical DRCT is collected at the Navy ICPs by the Uniform ICP (UICP) system. The system computes an exponentially smoothed (in contrast to the Army's 24-month average) DRCT. The more current the actual historical data, the more weight that is applied to this data. The number of events covered by the historical data varies between the two Navy ICPs [Ships Parts Control Center (SPCC) and ASO]. Both measure the "M" to "A" time. For SPCC-managed items, the measured DRCT starts with the input of the induction request, which generates a picking

TABLE B-4
DEPOT REPAIR CYCLE TIME

Segments	Performance Goal (days)	Remarks
Issue of repair directive to Designated Overhaul Point (DOP) receipt	1	Achievable only if advance funding provided
DOP receipt to DOP acceptance of funding document	0	
DOP acceptance of funding document to DOP initial request for induction of line item(s)	5	
DOP request for induction until DOP receipt of material	3	
DOP receipt of material to repair start date	5	
Repair start date to repair completion date	30	
Awaiting parts (AWP) time (depot)	5	
Repair completion to report (RFI Transaction Item Report)	1	

ticket and changes the asset Condition Code from "F" to "M," and includes the time to pick the materiel and move it to maintenance. The measured time ends with the change of the asset from Condition Code "M" to "A" or "B," which typically does not occur until materiel has been returned to storage, packaged, and stowed. For ASO-managed items, the condition code change from "M" to "A" or "B" is typically made when the materiel is returned to supply and before actual packaging and stowing.

Navy historical data include the time that a component is in Condition Code "G." That code is used much more extensively in the Navy than in the Army or Air Force. Condition "G" time is separately identified, and the process has parameters to exclude extreme times (more than 60 days) from the computation. In addition to the AWP time while in Condition Code "G," all of the AWP time while in maintenance is included in the Navy's computation of DRCT.

Requirements Computations and Budgets

The Navy IM is responsible for file maintenance of the DRCT used in the requirements computations for supply-and-demand studies and in the stratification reports. Each quarter, the UICP system generates a new exponentially smoothed DRCT, and the IM has the option of accepting the system-generated DRCT or entering a different value. The IM does not have readily available the detailed transactions used in the computations nor an insight into the segments of time reflected in the history, information critical for projecting a future DRCT. Furthermore, the IM does not have a critical path elapsed time standard to use in evaluating the historical data.

In the Navy system, the DRCT in the file is used for both the item supply-and-demand studies and the stratification report. The supply-and-demand studies may be adjusted by the IM, and quantities to be repaired or procured may be changed accordingly. Those changes are not necessarily reflected in the basic file data. In contrast to the Army and Air Force, the Navy makes two stratification runs. The reports from the first run are reviewed for major errors and updating of program data. Subsequently, a second stratification report is generated and used as the basis for preparing the budget. Additional adjustments for data not contained in the requirement computation files are reflected in the transition from the second stratification to the budget documents.

Evaluation of Navy DRCTs

The comparison of the DRCT as reflected in our constructed elapsed time standard, the Navy goal, the computed DRCT based on transaction history, and the DRCT recorded in the files for requirements computations provides the basis for evaluating the times currently used by the Navy. Data from all four sources were available for only 10 of the Navy sample items. Figure B 4 shows the number of days of DRCT from each of the sources. As discussed earlier, the Navy goal is reduced from 50 days to 44 days because the first three segments are not included in the historical data used by the ICP to compute the DRCT. The historical data are taken directly from the 2-year Transaction History File and have not been exponentially smoothed. Based on a comparison with our constructed standard ("should take") time, the Navy goal appears to be reasonable. Most of the difference (5 of 8 days) is due to the 5 days of AWP time included in the goal. The actual time for the items

sampled is 3.8 times the standard and 3.1 times the Navy goal. For the items in our sample, the managers reduced the DRCT used in the requirements computations by an average of 30 days. Nevertheless, the adjusted DRCTs remain 3 times and 2.4 times greater than the standard and the goal, respectively,

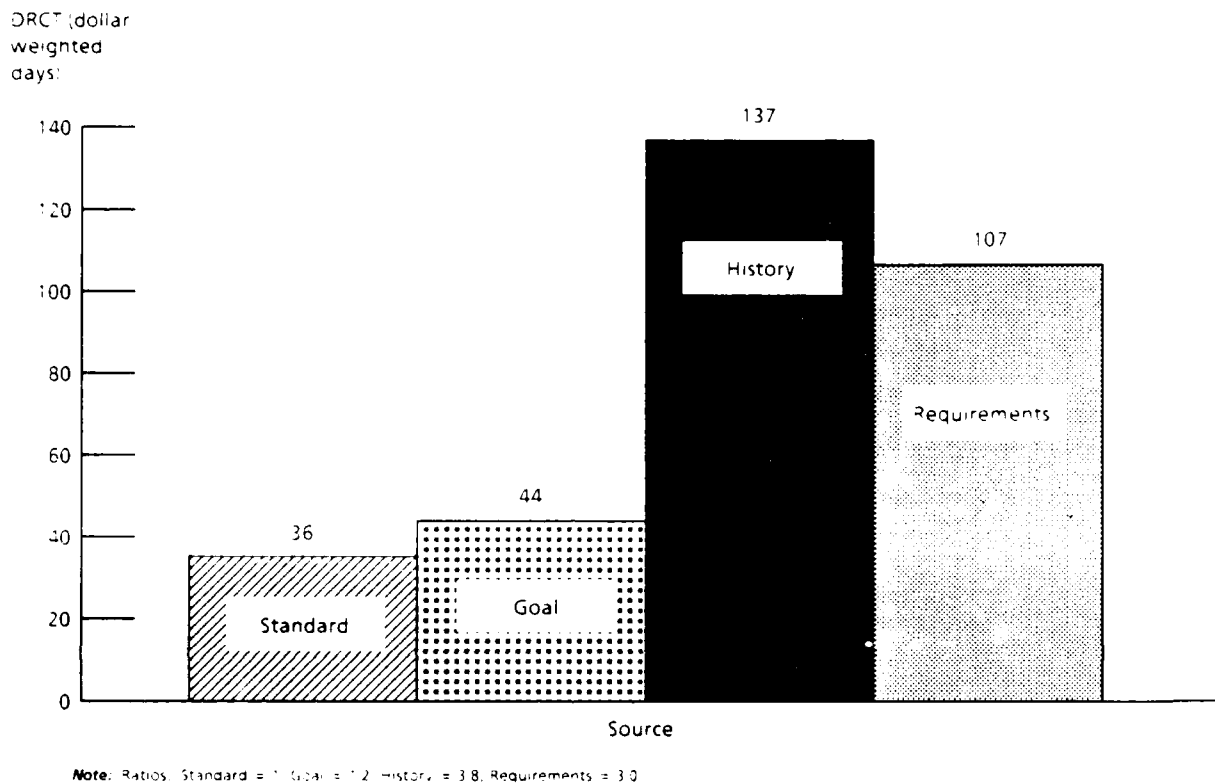


FIG. B-4. NAVY ORGANIC DEPOT REPAIR CYCLE TIME, FY86 SAMPLE

Figure B-5 shows the three sets of DRCT times for each of the 10 items. For all the sampled items, both the historical DRCT and the requirement computations DRCT exceed the constructed standard and the Navy goal. The history ranges from 54 to 225 days greater than the constructed standard, while the requirements DRCTs range from 40 to 253 days greater than the standard. For Item J, the manager increased the DRCT used in the requirements computation by 130 days over past history, thus increasing the value of the RCL by \$264,940. On the other hand, the managers of Items E and H reduced the DRCTs used in requirements computation by 150 days each, reducing the RCL by \$368,100.

We believe that our constructed standards represent a reasonable approximation of the "should take" time. Our field research did not disclose any

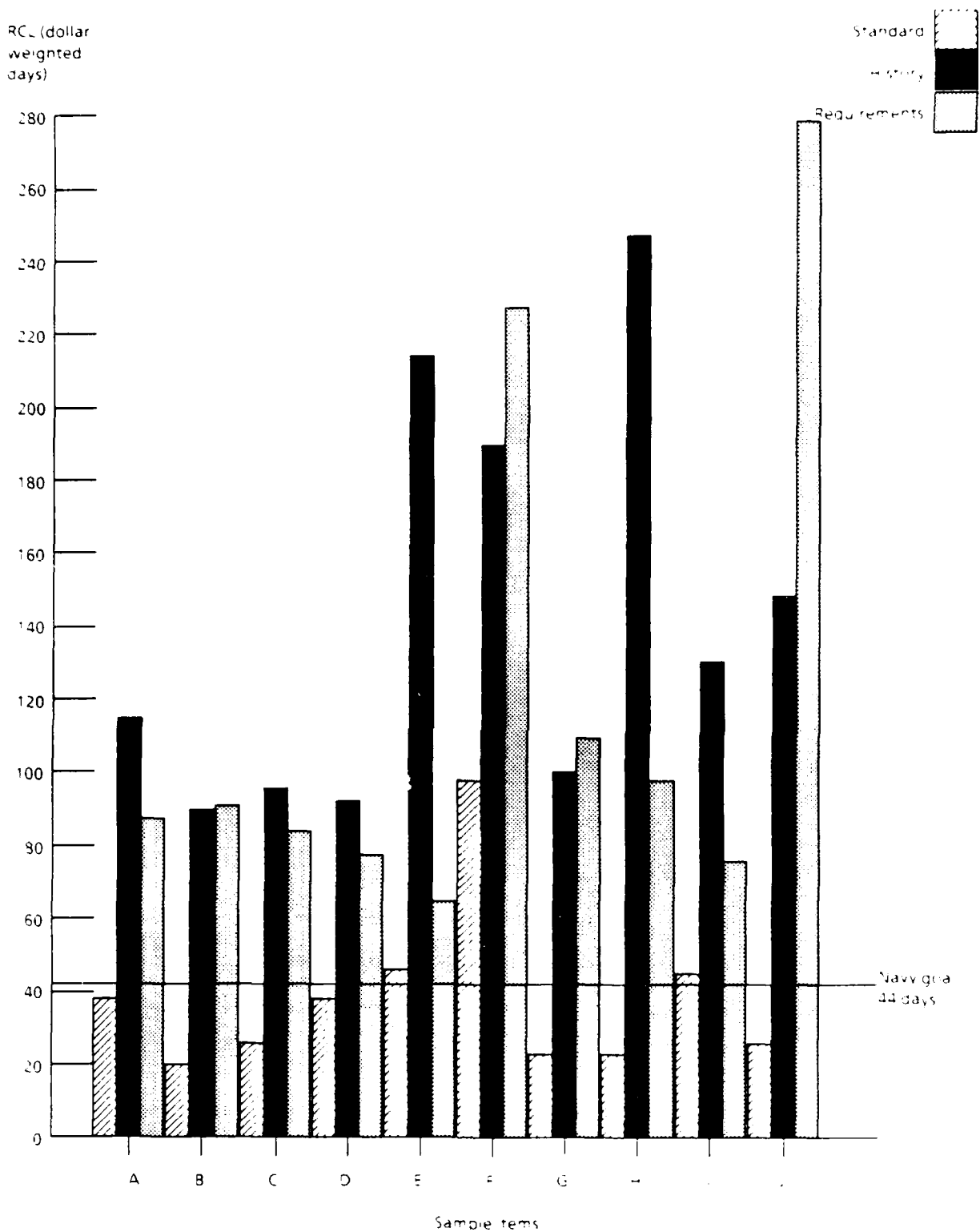


FIG. B-5. NAVY REPAIR CYCLE TIME
Comparison by Item
Standard, History, and Requirements

factors that justify the actual "did take" time (history) being more than three times the "should take" time. Furthermore, our discussions with Item Managers did not uncover a valid basis for the instances of substantially increasing the DRCT. NAVSUP is actively pursuing the reduction of DRCT. The DRCT in the BES has been reduced from 91 days in FY86 to a projected 65 days in FY88. The SPCC reduction is from 163 days to 121 days. While most of the current responsibility for achieving these reductions rests with the ICPs, our research indicates that many of the required actions are outside the authority and responsibility of the ICPs. Thus, while actual SPCC DRCT requirements have been reduced from 163 days to 121 days, we believe that the greatest potential for reducing the asset investment and improving the responsiveness of the repair process is a combination of policies and programs that addresses the factors that continue to contribute to the long Navy DRCTs and offer a clear potential for substantially reducing Navy DRCTs even further.

Factors Contributing to Long DRCTs

Induction Timing

As we noted earlier, the Navy induction process differs substantially between SPCC (largely workload-scheduled) and ASO (using a mix of workload scheduling and weekly induction probes). The discussion below focuses exclusively on our examination of the SPCC process at a Naval shipyard. The Navy maintenance activity is provided a workload schedule semiannually, and funds are provided quarterly. Work orders for items not previously scheduled may be sent biweekly. The ICP target is to have the funded repair schedule in the hands of maintenance at least 15 days before the beginning of the quarter. The Navy goals provide for maintenance to request asset induction within 5 days of accepting a funded order. That policy was interpreted by the maintenance activity that we visited to mean that, within 5 days of acceptance of a funded order, the entire quarterly workload must be inducted to the extent that unserviceable assets are available; those assets that are not immediately available, must be inducted as quickly as they become available. Maintenance personnel indicated that 50 to 60 percent of the quarterly requirement is inducted within the first 30 days of the quarter. Table B-5 shows the Navy goals and the actual performance against those goals based on the Repairable History report for the 162 line items selected. (The time covered in the report ends with the turnover of the materiel to storage and does not include the time to pack.

and stow it, and report to the ICP.) For the 162 line items reviewed, the average time in backlog before starting work is 37.1 days compared with the goal of 5 days. The average backlog time waiting to start for 39 items, or 24 percent of the items, was in excess of the 44-day goal for the total "M" to "A" processing time. The average for nine, or 6 percent, of the items exceeded 100 days and was as high as 434 days. Based on these data, average Navy DRCT for these items could be reduced by about 30 days by inducting in accordance with the shops' capacities to start work and by keeping the repair backlog to a minimum consistent with orderly flow.

TABLE B-5
NAVMAT ORGANIC DRCT GOAL VS. ACTUAL
 (Sample of 162 items)

Segment	Days		Over goal	
	Goal	Actual	Days	Percent
Request for induction until receipt of asset	3	9.3	+ 6.3	+ 210%
Receipt of asset until start work	5	37.1	+ 32.1	+ 642
Repair start until repair completion	30	80.9	+ 49.9	+ 161
Repair completion until report of ready-for-issue	1			
Awaiting parts (G)	5	38.0	+ 33.0	+ 660%
Total	44	165.3	121.3	+ 276%

Induction Quantities

The duration of time that materiel is in backlog before work begins is a function of the quantity inducted as well as the point in time that the induction takes place. Both factors contribute to the 37.1 days from receipt of the asset until start of work for the 162-item sample. We observed that the quantity inducted frequently exceeded the immediately available capacity of maintenance. This practice has the same effect as bringing materiel in early — some portion of the quantity will remain in backlog until production capacity becomes available either before the first work station and/or between work stations, and the DRCT is thereby increased. Table B 6 shows the progressively increasing DRCT resulting from the induction of quantities

TABLE B-6

IMPACT OF INDUCTION QUANTITIES ON DRCT

Example 1			Example 2			Example 3				
Quantity induced	Quantity completed	DRCT (days)	Quantity induced	Quantity completed	DRCT (days)	Quantity induced	Quantity completed	DRCT (days)		
31	3	18	14	3	49	11	1	58		
	1	28		1	56		1	65		
	1	36		5	70		1	72		
	1	42		5	75		1	74		
	1	56		2	64		1	78		
	10	59		1	66		1	85		
	1	70		3	71		1	88		
	4	109		5	79		1	99		
	5	122		2	36		2	106		
	2	182		3	42		1	110		
24	1	34	14	4	62	11	1	113		
	2	38		4	107		1	115		
	2	51		1	112		1	120		
	12	58		2	52		2	128		
	1	85		5	58		1	134		
	1	87		3	87		1	139		
	4	111		3	99		2	140		
				1	114		1	142		
									1	157

greater than the immediately available capacity. In the first example, we have spreads of 164 and 77 days between the first completed item and the last. This spread is greater than the total time to repair the first item, which may also include some backlog time. The man-hour standard for this item is 20 hours and our constructed elapsed time standard is 23 days. In Example 2, only 12 days elapsed between the first induction of 14 and the second induction of 13. The manhour standard is 20 hours and our constructed elapsed time standard is 23 days. In Example 3, only 10 days elapsed between the first induction of 11 and the second induction. The shortest DRCT for the second induction is longer than the longest DRCT for the first induction. The manhour standard is 20 hours and our constructed elapsed time standard is 23 days.

Materiel Support

The Navy parts support system and parts shortages are major contributors to the overall Navy DRCT. As shown in Table B-5, the average time in Condition Code "G" was 38 days for the 162 items in our sample. In addition, an unmeasured amount of AWP time occurs before items are placed in Condition "G" and for items that are never placed in that code. While inducting items for the purpose of determining what parts are needed is not strictly AWP time in the conventional use of the term, it does contribute to the total DRCT.

Unlike the Army and the Air Force, the SPCC generally does not have a system that provides data on parts application and depot maintenance parts consumption by component. Therefore, the ICP, the designated support point, and the designated overhaul point do not currently have the capability to translate a workload forecast or repair schedule into a parts requirement although the ASO has a pilot program underway.

The supporting stock point stocks items on the basis of the total demand for all supported customers; items not meeting the demand criteria are not stocked. In 1986, some Navy supporting stock points began using an industrial demand forecasting model in place of the previous Navy Economic Range Model. Preliminary indications are that the new model will provide better forecasts for maintenance. The stock points do not reserve specifically for maintenance — one of their many supported customers.

At the consumer level, the Navy Industrial Fund (NIF) is also authorized to support advanced acquisition of parts based on historical usage data. Apart from the NIF stockage, maintenance cannot generally order piece parts until the particular repair project is funded. The Navy workloading conference is not completed until approximately 30 days before the first induction, and the repair schedules are not in force until approximately 15 days before the first induction. This time period often is not adequate to acquire the required piece parts. By determining parts requirements and availability after induction, the Navy procedure is in marked contrast with the Air Force procedure of determining parts availability before the workloading conference and making parts availability a consideration in schedule negotiations.

Long Repair Time Processes

We did not observe a policy of selectively stocking long leadtime subassemblies for SPCC-managed reparable. Such a policy might prove economical for components requiring in excess of 100 or 200 man-hours by reducing the DRCT and thereby the RCL enough to more than offset the added cost of stocking the subassemblies.

Scheduling Flexibility

As is true with the Army, the Navy repair process appears largely inflexible with respect to changing wholesale inventory requirements. Once workload schedules are established, the repair activity is reluctant to adjust them to meet emerging wholesale inventory requirements. We found that scheduling rigidities resulted in misallocations of repair resources as they did in the Army. Items without a wholesale requirement were being repaired, and those with an existing wholesale requirement were not scheduled for repair.

The size and complexity of a shipyard maintenance activity, with its large number of personnel and workstations engaged in repairing several thousand different items, compound this flexibility problem and point to the need for a state-of-the-art automated scheduling system to minimize the nonproductive waiting time and to manage queues.

THE AIR FORCE

The Standard

The Air Force uses standards far more extensively than the Army or Navy. For those segments pertaining to retrograde activities (base processing and in transit), the Air Force uses actual data for both organic and contractor repair whenever adequate history is available. When actual data do not exist or are insufficient, the Air Force has a series of default values (standards) that are used under such varying conditions as "not coded for airlift" or "operating base at the same location as the depot maintenance facility." After the asset is received at the depot, three segments of DRCT are completed. Each of these segments has a standard — two are constants for all items and one varies by line item. The constants are used for the segment beginning with the initiation of the induction request and ending when the asset is received in maintenance (10 days) and for the segment beginning with turn-in of serviceable asset by maintenance and ending when it is recorded as Condition Code A (2 days). The variable standard is the shop flow time. After the asset is received by the contractor, two segments of DRCT are completed. The first, shop flow time, is a standard as specified in the contract (frequently 30 days or multiples of 30 days), and the second is a constant that begins at turn-in of serviceable asset by the contractor (DD Form 250) to receipt by the depot and recording as Condition Code A (15 days).

The organic depot shop flow time is an engineering standard that encompasses the following factors for each resource control center: (1) labor standard hours, (2) number of workers, (3) a constant, 0.87, to convert to 7-hour productive days, (4) transportation between centers, (5) production delay in and out, (6) unique processing delays, (7) total flow hours, (8) hours per shift (shift hours per day to provide for multishift operations), (9) flow work days, (10) calendar days factor, and (11) total flow days. The labor standard work hours are divided by the number of workers to determine the number of elapsed work hours. The "production delay in out" covers the delay from completion of work at one work center and transportation to the next and the queue time at the subsequent work station before work actually begins. The unique processing delays cover operations requiring time but not man hours (e.g., item immersed in cleaning solvent, plating, or paint

drying). The total flow days for each work center are summed to establish the shop flow days for the asset.

The standard man-hours are scheduled for review at least every 2 years and are reviewed sooner if a significant change occurs. Any change in standard man hours triggers a review of the total shop flow days. In addition to the periodic reviews, reviews may be requested by the shop foreman, production planner, or the production management specialist in materiel management. Requests for revisions are infrequent. The standard man-hours are the primary focus of maintenance performance evaluation. We did not make an in-depth study of the methodology for establishing man-hour standards. The Air Force has a detailed standard methodology for determining the total shop flow days. The standard man-hours and shop flow days do not appear to be primary targets for potential reduction of DRCT. The "production delay in/out" factors, however, may present a potential for minor reductions. The Air Force DRCT standards do not include any AWP time.

History

Historical days for the purpose of computing DRCT are collected for those segments of the DRCT for which standard factors are not mandated – primarily base processing and in-transit time. Historical data for those segments covered by mandated standards is collected by the system but not usually generated in the form of management reports comparing the actual and the standard. Transaction histories are available to the item manager for research. For contractor repair, the GO72D system provides the flow days. In addition, the monthly report from the contractor shows the production flow days based on the contractor records.

The Air Force policies on the use of AWP time are distinctly different from those of the Army and the Navy. Neither the standards nor the historical maintenance data covering the Air Force DRCT include AWP or Condition Code "G" time; supply historical data, however, includes that time. Whenever a parts shortage occurs in maintenance and is serious enough to cause a work stoppage on the reparable item, that item is put in an AWP status in maintenance and removed from "on work order" status. The historical DRCT clock in maintenance is turned off. After 90 days in AWP status, the IM is notified, and he reviews parts availability to determine whether the item should be placed in Condition "G" and returned to storage. Components brought in for the purpose of borrowing parts are

usually brought in on a Temporary Work Order and are not included in the historical DRCT reporting.

Requirement Computations and Budgets

The IM is responsible for file maintenance of the DRCT used in the requirements computations and stratification reports. However, in the Air Force because of the extensive use of standards that are entered automatically by the system, the manager has much less latitude to make changes than do IMs in the Army and the Navy. The Air Force requirements computation system output documents show each segment of the DRCT and whether it is standard, estimated, or actual as well as the total.

Because the Condition "M" to "A" time portion of the DRCT used by the Air Force is based on standards that do not include AWP time or abnormal delays, the requirements and stratification reports that provide the basis for the procurement of new items and the repair of existing items and the budgets represent a "should take" time. The RCL, therefore, does not provide for investment in reparable components to cover inefficient operations or parts shortages. These problems are addressed by separate management actions with the objective of achieving the "should take" time. While individual computations may be adjusted by the IM and quantities to be repaired or procured changed accordingly, the stratification reports are not adjusted, and any corrections or adjustments are made in the transition from the stratification to the budget documents.

Evaluation of Air Force DRCTs

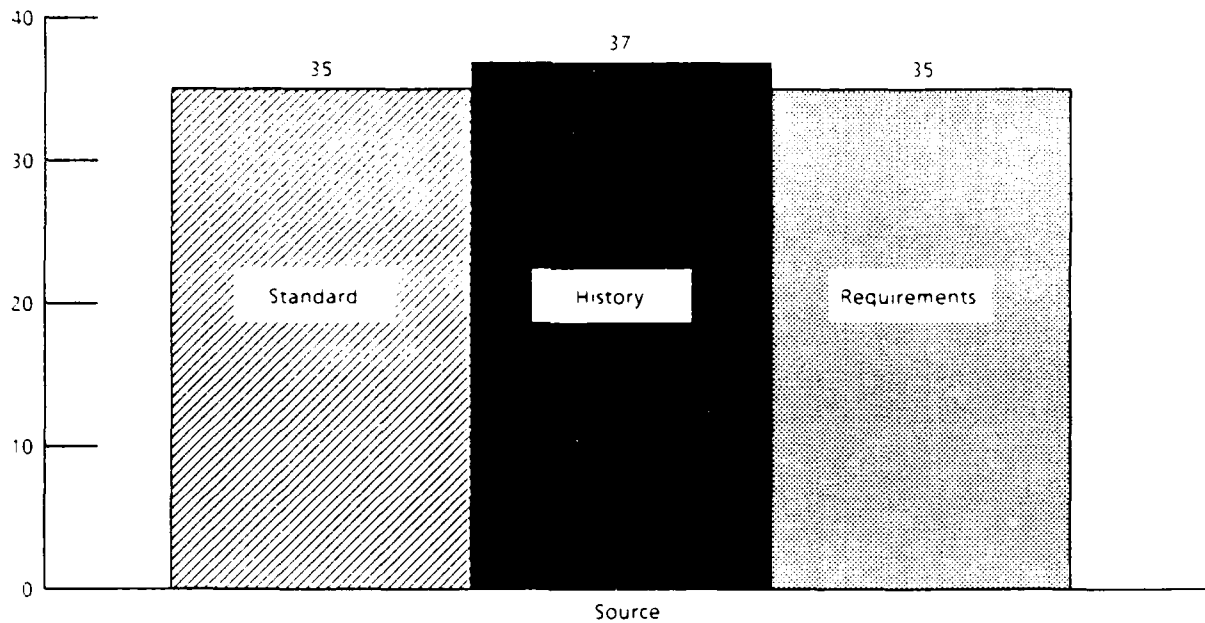
The comparison of the standard and historical shop flow days portion of the DRCT as reflected on the Air Force Logistics Command (AFLC) Forms 22, Workload Record, and 96, Production Control Asset Record, with the DRCT recorded in the files for requirements computations and stratification reports provides a basis for evaluating the times currently used by the Air Force. The history contained in the AFLC Forms 22 and 96 covers 3 months or less compared with the 2-year history we used for the Army and Navy. Data from all three sources were available for 23 of the Air Force sample items. The standard 10 days for supply to maintenance and 2 days for return from maintenance to supply were added to the standard shop flow days to generate a standard DRCT which covers all segments included in the requirements files. To develop actual DRCTs, we analyzed supply transaction history data for our

sample. Based on that analysis, 4 days for supply to maintenance and 4 days for turn-in were added to the historical shop flow days to represent an actual DRCT that covers comparable DRCT segments. These changes make the time periods covered comparable. Base processing and in-transit times were not included to maintain comparability with the Army and the Navy data. However, some of the base processing times for our sampled items appeared unexplainably long. Those base processing times represent actual history but may present an area for potential improvement of this segment of the DRCT.

Figure B-6 shows the DRCT times for the sample items (weighted by the value of one day of demand). The actual time required for the sampled items on an average is only 2 days longer than the maintenance standard and the requirements file time. Based on the sample, the weighted number of days of DRCT in the stratification reports that underlie the budget are only 2 days less than those actually experienced. However, an examination of the 23 sampled items show quite a different picture. Figure B-7 displays the three sets of DRCT times for each item. A comparison of the history with the requirements DRCT shows the history higher in 15 cases, lower in 7 cases and the same in 1. The history exceeds the requirement by from 1 to 48 days (Item W) and for nine of the items by more than 10 days. The history is less than the requirement by 3 to 28 days (Item L) and for four of the items by more than 10 days. These individual item differences indicate potential support problems and/or the need for closer surveillance of the induction and repair process.

The significant disparities observed between line-item histories and line-item standards used by the Air Force in developing RCL requirements and in managing the depot repair process clearly highlight the potential problems that arise when standards are employed without being continuously validated against history. The data indicate that either the standards are invalid (for all items sampled) or the management actions necessary to improve operational efficiency to comply with standards have not been successful (for those items for which actual DRCT exceeds a valid standard). We believe that the extent and magnitude of line-item differences between historical DRCT and the DRCT computed using standards reveals inattention and a failure to properly analyze line-item historical data. Where the current DRCT standard is too long, it should be revised downward. Where the standard is less than actual DRCT, actual DRCTs exceeding this standard should be specifically reviewed. In these instances, the standard should first be validated. If

DRCT (dollar weighted days)



Note: Ratios: Standard = 1.0, History = 1.1, Requirements = 1.0

FIG. B-6. AIR FORCE ORGANIC DEPOT REPAIR CYCLE TIME, FY86

valid, management action is required to reduce actual DRCTs. If invalid, the standard should be increased. In either case, because the Air Force approach assumes a valid standard, operational support may suffer until actual DRCTs approximate standard DRCTs.

Induction Timing

For the Air Force, we noted a more timely process of induction scheduling based on a monthly repair schedule, updated on a 2-week cycle. Thus, the repair effort at the maintenance activity is more consistent with current wholesale demand and asset data than it is in the Army and the Navy. Further, because the maintenance activity verifies both the availability of unserviceable assets and projected parts requirements prior to induction, actual repair typically begins much sooner.

TABLE B-7

IMPACT OF INDUCTION QUANTITIES ON DRCT

Example 1			Example 2			Example 3		
Inducted quantity	Completed quantity	DRCT (days)	Inducted quantity	Completed quantity	DRCT (days)	Inducted quantity	Completed quantity	DRCT (days)
30	3	27	30	4	3	20	1	7
	4	28		4	6		1	8
	4	29		7	7		3	15
	3	30		3	8		1	19
	3	34		6	10		2	20
	5	35		2	13		1	21
	2	36		3	14		6	24
	3	38		1	19		2	26
	3	40					1	28
							2	29

Induction Quantities

We observed that the quantity of assets inducted frequently exceeded the immediately available capacity of organic maintenance. Table B-7 illustrates the impact of induction quantities that exceed weekly throughput capacity. Examples 1 and 2 represent about two weeks production, and Example 3 represents about 3 weeks production. The quantity-weighted average shop flow time for Examples 1 and 3 exceeds the standard shop flow time for the items. Weekly induction quantities would reduce the actual flow time to or below the standard. The practice of inducting quantities that exceed capacity has the same effect as bringing materiel in early – some portion of the quantity will remain in backlog until production capacity becomes available, and the DRCT is increased accordingly. The large induction quantities, however, do not result in an increased asset investment as they do in the Army and Navy because the Air Force uses the shop flow standard rather than actual history in determining requirements.

Materiel Support

In the past, AWP has been the major contributor to failure to repair the quantity of items required by wholesale inventory manager. While AWP time is not included in the requirements computations of the Air Force (and therefore does not affect investment in components), AWP time has an adverse impact on supply support because it does in fact increase the time from induction until return of the serviceable item from maintenance to supply. The induction is scheduled on the assumption that repair will be completed within the standard DRCT. If parts are not available or are not expected to be available to meet the repair schedule, the item is not inducted. Again neither historical or standard DRCTs are affected but supply support is potentially degraded.

Long Repair Time Processes

The need to repair one or more subassemblies may significantly increase the DRCT for a reparable asset. A case-in-point in the Air Force is aircraft engines (an end item). An objective of the Air Force is to limit the DRCT for aircraft engines to 60 days to reduce the investment for spares while engines are being repaired. This objective is attained by examining the critical paths and substituting remove-and-replace processes for remove and repair. A pool of replaceable components is provided to implement this policy. The economic tradeoff is investment in a limited

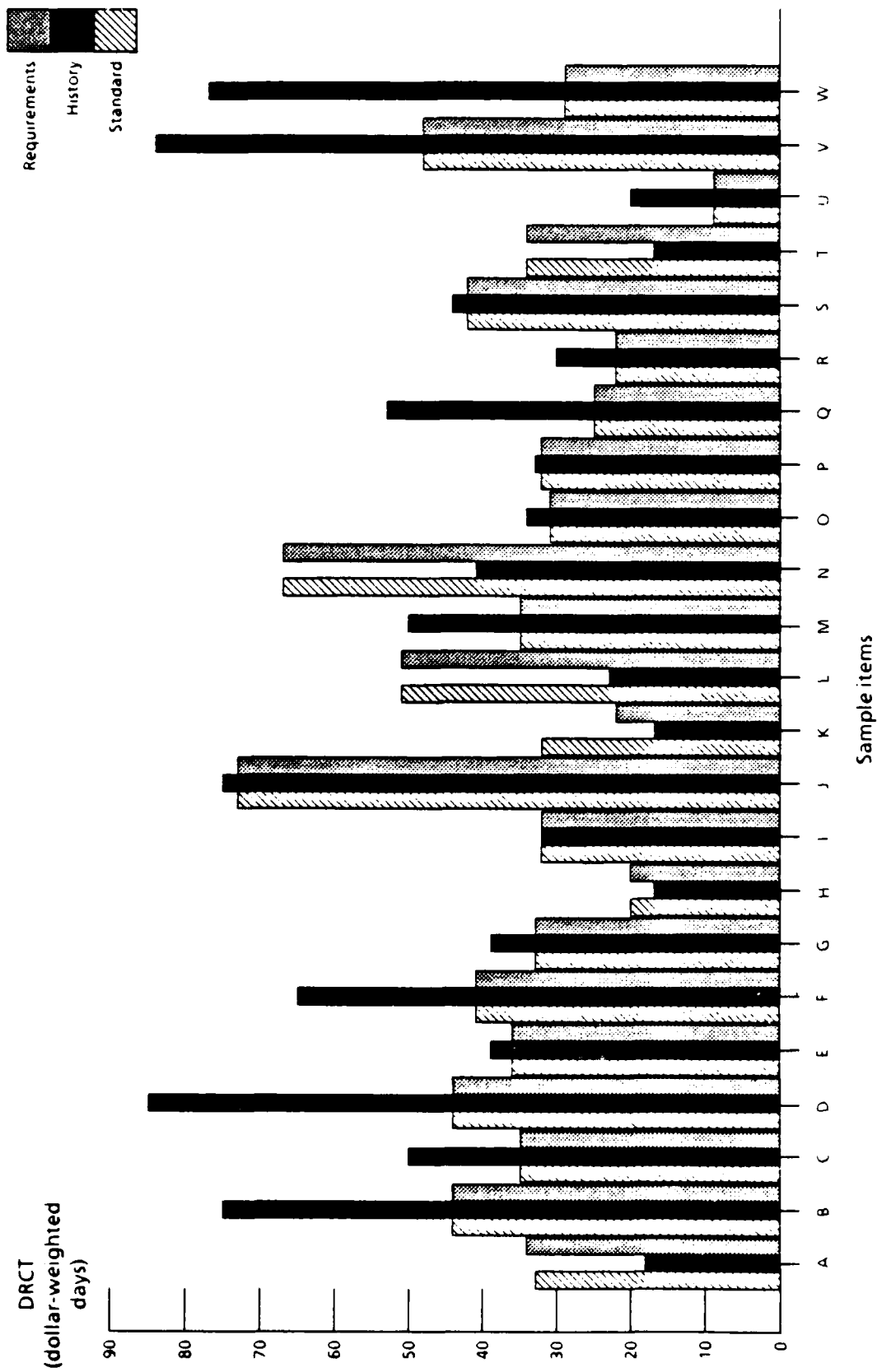


FIG. B-7. AIR FORCE REPAIR CYCLE TIME

number of lesser cost components in lieu of the cost of a complete engine. Aircraft engines were the only items to which this policy applied at the activity visited.

Scheduling Flexibility

While the Air Force depot repair process is generally based on smaller induction quantities and a more effective supply and maintenance interface, we noted problems with scheduling flexibility similar to those we observed in the Army and the Navy. The net result is either commitment of repair resources and inventory funding to items not required by the wholesale inventory or the failure to induct and repair items needed to fill wholesale inventory requirements.

APPENDIX C

CONTRACTOR REPAIR CYCLE ANALYSIS

INTRODUCTION

This appendix describes the objectives, methods, and results of our visits to DoD repair contractors. Contractor repair accounts for an increasing percentage of the asset repair volume, and our visits to contractors were used to study each step in the process of contracting for repair. While organic and contractor repair have many common problems/issues, contractor repair has some unique ones. This appendix addresses those problems and issues that are unique to contractor repair.

The sample data used in the review of contractor repair is extremely limited. We requested the Air Force and the Navy to provide the names of two major repair contractors and a representative sample of ten items that each contractor repairs; we did not request contractor data from the Army Inventory Control Point (ICP) since its contractor repair program is currently very small.

CONTRACTOR PROFILES

Of those selected by each Service's ICP for our sample, three contractors primarily repaired electronic components and one contractor repaired mechanical/hydraulic equipment. In each case the contractor operates from a repair facility used exclusively for repair; production work is done elsewhere. One contractor shares common test equipment with the production component and that is considered a capacity constraint and a scheduling problem since production priorities take precedence. The contracted workload consists of numerous stock numbers, forecast over a period of one quarter or longer. The repair quantities for these contractors seem generally smaller than the quantities that are scheduled for repair at organic depots.

Contractor #1

Contractor #1 is a subsidiary of a major defense contractor supplying missiles, fire control, and electromagnetic systems. This division, with locations on both

coasts, has been devoted exclusively to repair support of its end items for the past 10 years. A contractor to Ships Parts Control Center (SPCC), the firm reports a turn-around average of 37 days relative to the SPCC RTAT (Repair Turn-Around Time – the Navy term for Depot Repair Cycle Time (DRCT) goal of 60 days. This contractor exclusively repairs electronics items, and most repairs are completed at a single work station by one technician. Some parts may have either a preliminary clean-up step or a final inspection/test step as well.

Contractor #2

Contractor #2 is a manufacturer of radar units for both military and commercial applications. It also operates a repair facility dedicated to providing repair support for its equipment. The repair unit occupies separate facilities but shares test equipment with the manufacturing unit, a condition that is often a constraint to completing repair. Like Contractor #1, this contractor primarily repairs electronics equipment, with one technician at one workcenter completing an individual repair. While actual repair times can be measured in days, the contract times on the repair order are usually considerably longer. The contractor states this is necessary to allow sufficient time to purchase repair parts since few parts are stocked.

Contractor #3

Contractor #3 is a small family-owned electronics repair company whose entire business consists of item repair exclusively for the DoD, in particular the Air Force. Its annual revenues are in the \$1 million range. Again, most repair work can be completed at one workstation by one technician. The current Air Force contracts with this contractor specify a repair turn-around time of between 30 and 60 days. The company claims to meet this requirement consistently.

Contractor #4

Contractor #4 is a small overhaul and repair activity operating as a subsidiary of a large manufacturer who is a major defense supplier. Items are repaired in one location in a dedicated repair facility. About 65 percent of the repair work is performed for DoD (mainly the Air Force), with the remainder for commercial customers. The contractor repairs hydraulic and mechanical equipment associated with aircraft systems. It appeared that "should take" repair times were in the

2-to-3-week range, while elapsed times to complete repairs and ship to DoD were in the 2-to-3-month range.

EVALUATION OF CONTRACTOR DRCTs

Army Contractor Repair

Although we did not visit an Army repair contractor, we did discuss the Army contract repair system with supply personnel at the ICP. The Army normally retrogrades unserviceable components to the Area Oriented Depot (AOD) supporting the retail customer. Subsequent to classification, the unserviceable assets are reshipped to the contractor's repair facility. The shipping time from the AOD to the contractor is included in the DRCT. Under some existing repair contracts, the tasks are not priced until after the item is disassembled and inspected. Over certain dollar thresholds, the pricing must be reviewed by the Defense Contract Audit Agency before the repair order can be written and repair begun. This process can add up to 45 days to the DRCT.

Navy Contractor Repair

Contractor repair currently accounts for over 60 percent of the surface depot-level maintenance. SPCC uses unpriced Basic Ordering Agreements (BOAs) for approximately 90 percent of its contracted repair. Prices are established during or subsequent to completion of the repair. Upon receipt of the unserviceable assets (usually shipped directly from the customer to the contractor's facilities), the contractor reports the receipts to the Defense Contract Administration Services (DCAS), which then issues the funded order. The SPCC goal for issuing the order is 5 days, but actual times are measured in weeks and sometimes months. Upon receipt of the order, the contractor begins the repair process, and when the asset is repaired, the contractor prepares a DD Form 250 shipping document. We obtained the following data for seven items repaired by one contractor:

Requirements computation file at ICP	234 days
Contract order-to-shipping time (26 days)	
Add on for in transit and receipt (28 days)	
Total	<u>54 days</u>
Difference	180 days

Factors other than repair time subsequent to the order and reasonable in-transit times are contributing substantially to the DRCT used in the requirements computation process for these items.

Air Force Contractor Repair

The Air Force establishes standard or contract shop flow days in its repair contracts to the maximum extent feasible. These standards are usually stated in 30-day increments because that is the frequency of contractor reporting. The G072D program provides the basis for the DRCT in the requirements computation and reflects history. Figure C-1 displays the unweighted and dollar-weighted shop flow days for a sample of six contract repair items. The G072D and requirement DRCTs are the same, and both are based on actual repair history. The dollar-weighted G072D and requirement shop flow times exceed the contract standards by slightly over 50 percent. The weighted actual contractor's time exceeds the standard by 135 percent. The segments of contractor DRCT – date of receipt of the unserviceable asset, quality assurance representatives approval before starting repair, receipt of the contract order, delays for Government-furnished materiel, and actual repair completion date – are more difficult to track on a precise basis than are organic Air Force DRCT segments.

FACTORS CONTRIBUTING TO LONG CONTRACTOR DRCTs

Many of the problems that affect the performance of organic depot repair also affect contract repair, but those effects are compounded by the diminished control and visibility associated with a contractor repair facility. In addition, a series of unique problems is associated with contract repair. In this analysis we examine those unique problems in the areas of workload forecasting and scheduling, contracting procedures, and performance measurement and visibility.

Contractor Workload Forecasting and Scheduling

The contract repair process begins with the establishment of a workload forecast of items that will be contracted-out for repair. This workload forecast serves as the basis for the contracts written with the repair contractors and reflects the unserviceable asset generation forecasts made by each of the ICPs. The accuracy of the workload forecast is an issue with the contractors we visited. Contractors were reluctant to rely on the workload or contract quantities written in the repair

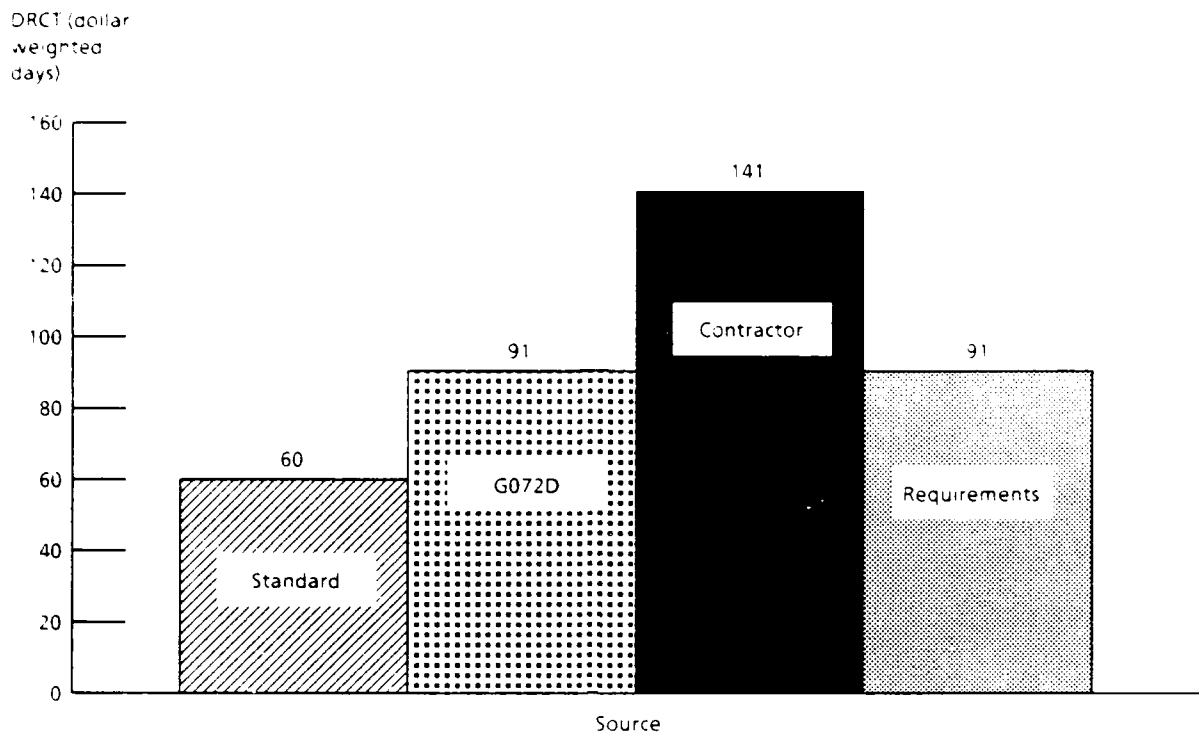


FIG. C-1. AIR FORCE DEPOT COMPARISON - CONTRACTOR

contract, and most other actions they planned were based on actual orders written subsequently against the contract. The Air Force contractors had not quantified the extent to which the actual repairs differed from the forecast, but they believed that the quantities received were always smaller than those projected. Both Navy contractors had maintained records. One reported that only 75 percent of the forecasted line items materialize and one-third of those received are in quantities that are less than those projected. The other contractor reported the workload accuracy to be at about 50 percent; only one-half of the forecasted line items were ever received for repair and of the items that did arrive for repair, the quantities were generally less than projected.

The contractors were less concerned about the exact mix of items they received to repair than they were about the total number of units. By far the more important consideration for their planning was the steady and predictable volume of units regardless of part number. The loading of specific work centers (in the case of electronics repair, groups of diagnostic/test equipment and the corresponding technical skills) is dependent not only on the receipt of individual line items but also

on having sufficient quantity of similar components, i.e., family groupings. Technicians are cross-trained for a variety of equipment repairs, and that cross training increases contractor flexibility in scheduling repair and decreases the probability of a worker being idle. However, if the number of units to be repaired is significantly less than that projected, workers will be idle. The investment in cross-training new workers and a lengthy "start up" when hiring a new employee make the contractor reluctant to release valuable employees.

The contractors also reported a wide variability in the number of units received from month to month. This variability in the rate of incoming assets further aggravates staffing problems that can indirectly affect repair cycle times. Workers experience slack periods where they are given "busy work" and heavy periods where they were pushed into overtime. To reduce exposure to the swings in workload, these contractors tend to staff on the low side of the workload variation and therefore limit their overall repair capacity. In addition, from the contractor's point of view, a backlog of unserviceable assets is desirable to smooth out the workload swings, and such backlogs existed in several instances. One contractor reported a backlog equivalent to 3 months of repair work; another indicated an 8-month backlog exclusive of assets awaiting parts.

Contracting Procedures

With few exceptions, contractor repair work is awarded on a sole-source basis. Some breakout of repair contracts has occurred, but it has been mostly to the original manufacturer where before it was to the prime contractor. Where that limited breakout occurs, it increases the number of contracts that must be written. The ICPs expressed concern that if such a trend continues, it would increase the workload of DCAS, which, especially in the Navy process, plays a large role in repair contracts, and would serve to further extend repair times.

As noted, SPCC uses BOAs for most of its repair contracts, particularly for workload forecasted items. After the contract is awarded, the contractor writes a proposal when assets are received at his facility and DCAS writes the order. The administrative time for SPCC contractors to prepare a proposal and DCAS to issue an order against the BOA is significant. For example, an analysis of BOAs for one contractor shows that the process exceeds 100 days. The process is further lengthened if the item is not covered by a BOA.

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IMPROVING DEPOT REPAIR CYCLE MANAGEMENT: A CHALLENGE
FOR SUPPLY AND MAINTENANCE(U) LOGISTICS MANAGEMENT INST
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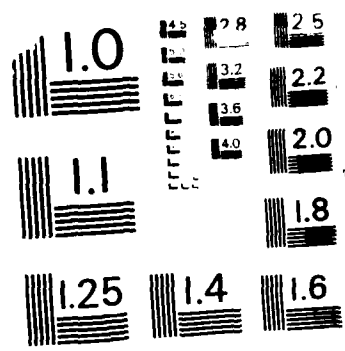
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The long order-writing process is of concern to Navy contractors we visited, and they are working with DCAS and SPCC to reduce it. One contractor has set a goal of 3 weeks after all unserviceable asset arrive for getting orders written against a BOA (1 week to complete contracting actions and 2 weeks to complete DCAS activities). Attainment of this goal would represent a significant improvement for this contractor. The Navy contractors would ultimately like to have pricing for all items on the BOAs. In one case, only 25 items on an 1,100-item BOA are priced; in 1988, the contractor hopes that about 650 items will be priced. That improvement would streamline the proposal writing associated with each individual order.

For the Air Force, Oklahoma City Air Logistics Center does not use BOAs to the extent that the Navy does. Instead it uses fixed-price, requirement-type contracts for workload forecast items. The contract is priced and has priced options for 2 to 5 additional years. Repair orders are written quarterly indicating the monthly shipping quantities. Once the contractor has this order and the assets in hand, work may proceed.

A trend noted by the contractors we visited is the movement to "tear down and inspect" type contracts under which the order-writing process is not completed until the unserviceable asset has been taken apart and inspected to determine the exact nature of the repair required in terms of both parts and labor. This type of contract is used to determine the exact costs so that the cost of the work can be closely approximated and offers some control benefits. However, the effect to date seems to have been to seriously slow the process and extend the overall repair time for these items. One contractor reported that tear-down-and-inspect has added 120 days to the turn-around times. While these contracts often contain a separate line item to cover the initial tear-down-and-inspect action, undue delays occur following this point because actual repair tasks required must be separately priced by the contractor and reviewed and approved by the DoD prior to beginning repair action.

Delays were also noted in the inspection and shipment process. Contractors maintained that the workload of assigned DCAS representatives is such that it precludes prompt inspection and shipment processing. One contractor noted that in the past he had shipped serviceable assets back to the depot two or three times per month, while he now ships only once a month. DCAS prefers to inspect during the first 2 weeks of the month and process shipments in the second 2 weeks.

Performance Measurement and Visibility

In the course of the repair process, the contractor collects usage history on repair parts for the components he repairs. In the case of the Navy, the contractor's history is the only record of the parts (and quantities) that is required to complete the repair. Since the Air Force maintains bills of materiel and usage factors, it uses the contractor's data to update internal records. The internal record is used to verify parts requests on subsequent repairs. One contractor reported that at times, however, the Air Force data were not as complete and up-to-date as the contractor's. The result is unnecessary challenges of the parts that the contractor requests to complete a repair.

For all the Services, production is reported by the repair contractor monthly to the ICP. In most cases, the production reports are manually generated and show only minimal data – the number of unserviceable assets on hand and the number of serviceable assets shipped. Since the reports do not tie events to the dates on which they occurred, the data are not sufficient to track a contractor's repair turn-around time nor to measure his actual performance against the time negotiated in the contract.

The present reporting method also does not provide the ICP with adequate visibility of the asset. In some systems, even the receipt date of the unserviceable asset at the contractor facility is not provided. No system makes the actual internal segments of contractor repair times visible to the ICP. Finally, the returned serviceable asset does not generally appear on the Inventory Manager's (IM's) inventory record until the repair has been completed and the serviceable asset has been received back into the wholesale system. In addition, the manual format precludes summarizing information for use as management data and makes it difficult to track an individual vendor's delivery performance.

The Navy has improved the production reporting process through the use of a computerized system called Contractor Asset Visibility System (CAVS). The CAVS has been implemented with a number of contractors for a portion of the repair items. It provides for the daily collection of receipt and shipment data, which is transmitted to the ICP on a weekly basis. In addition to providing more frequent updates on status, the system collects the processing times for the specific segments of DRCT that are needed to measure contractor's repair turn-around time accurately. While

some improvements are still needed and are currently underway, this system improves the measurement of contractor DRCT performance.

However, an aspect of reporting that CAVS did not address was for items not covered by a BOA. Where a contractor receives an unserviceable asset that requires an order for repair, that contractor reports it as received to SPCC through an in-house generated computer report referred to as an unfunded assets report. At the time of our visit to SPCC, this unfunded asset report was several inches thick and listed hundreds of items and millions of dollars in investment awaiting the issuance of orders. This report is usually the only means by which the contractor notifies SPCC that an unserviceable asset has arrived and an order needs to be written for its repair.

APPENDIX D

PRIVATE SECTOR REPAIR CYCLE ANALYSIS

INTRODUCTION

This appendix describes the objectives, methodology, and results of our analysis of component repair practices in the private sector for those companies using repair as a major source of supply to replenish inventories that support operations. Based on previous contact with firms in the private sector, we knew that repair turn-around times were shorter in the private sector than those generally found in DoD organic and commercial depot repair. Therefore, our research in the private sector was directed toward comparing operations to identify methods, techniques, and policies that DoD could incorporate to improve depot repair cycle time (DRCT) management.

Our analysis of DoD depot repair operations identified the major factors impacting DRCT. In our review of the private sector, we examined those same factors to determine the policy, procedures, or systems used to manage them, giving primary attention to the specific solutions to issues that in DoD contribute to the lengthy DRCTs. We also looked for ideas in the private sector – procedural enhancements or technical innovations – that could provide general improvements in the DoD repair process.

PRIVATE SECTOR ENVIRONMENT

We reviewed repair operations at six private sector companies selected because they represent different segments of industry and different operational styles and because we felt that the types of items they repair and the breadth of their repair are comparable to those of DoD. A further criterion was that the private company selected be generally regarded as excelling in repair management and considered a leader in their field. From an initial list of more than 20 possible firms, we selected six. The selected firms represent aircraft repair (Firms A and B), motor vehicle repair (Firms C and D), high-volume electronics repair (Firm E), and low-volume electrical, mechanical, and hydraulic repair (Firm F).

We visited each company and interviewed key managers responsible for basic repair management, including production control and materials management personnel. Where possible, we collected available performance data and reviewed performance measurement approaches. We placed emphasis on the policy and procedures that guide the method of scheduling and loading repair shops, setting and managing of inventory levels, and in-plant materiel movement. A brief description of each company is provided in Table D-1 and in the following subsections.

Firm A

Firm A is a major airline operating on domestic routes, and repair operations are geared towards keeping its fleet serviceable and in the air. This firm repairs virtually all of its components in-house at one depot-level repair facility located at the airline's operational hub airport. Unserviceable assets are returned on passenger aircraft, and the firm capitalizes on a hub system that routes all equipment through the one central location.

The maintenance facility employs 4,500 people and is the largest repair operation in our study both in terms of people employed and the number of assets repaired. A variety of types of items are repaired, requiring skill levels ranging in complexity from sheetmetal work to electronic repair and testing. The repair and inventory control operations rely on manual planning systems, and although some inventory control functions are computerized, they tend to be stand-alone systems.

Firm B

Firm B is also a major domestic air carrier. Like Firm A, its assets are repaired in one facility located at the operational hub; about 25 percent of its repair work is contracted out. The repair operation employs 2,500 people.

Repair and inventory control operations are highly computerized in an integrated, on-line, real-time computer system that is available throughout the company's transportation system. This firm, like Firm A, repairs a variety of item types.

The component repair operation is divided into 13 shops, each of which repairs a particular type of item, i.e., electrical, hydraulic, instrument, etc. Unique among the firms we visited, the shops are grouped according to four different sets of

TABLE D-1

PRIVATE SECTOR FIRMS REVIEWED

Firm	Scope of repair	Repair volume	Repair cycle time (days)	Repair lot sizes (# units)	Scheduling system	Inventory control system	Piece part availability (percent)
A	Electronic Mechanical Electrical	High	12.5	≤ 10	Manual	Automated	90
B	Electronic Mechanical Electrical	High	9.5	≤ 5	Automated	Automated	95
C	Electrical Mechanical	Medium	5.5	≤ 5	Manual	Manual	90
D	Electrical Mechanical	Medium	5.0	≤ 15	Manual	Manual	90
E	Electrical Hydraulic Mechanical	Low	21.0	1	Manual	Automated	98
F	Electronic	High	8.5	≤ 5	Automated	Automated	95

operating characteristics such as volume and cycle times. Production planning and control requirements are tailored to fit the different needs of the shops.

Firm C

Firm C is among the largest commercial trucking companies in the the United States, with operating revenues of \$1 billion annually. The company is organized into four repair regions that encompass 22 major operational hubs. Within the 22 hubs, some locations are also designated maintenance areas and house maintenance facilities for preventive maintenance and item repair. In addition, two central repair facilities are dedicated solely to major component repair and overhaul. The source of component repair is dependent on the value of the component, the difficulty of repair, and whether the component is used on long-haul or short-haul equipment. High-dollar value items, such as transmissions and engines for long-haul equipment, are repaired in one central location, while medium-value items are controlled regionally and repair work is generally done by contractors. Low-value, low-technology items are repaired in-house in maintenance shops in one of the four repair regions. The location we visited, an area repair facility, was responsible for rebuilding engines, transmissions, and differentials for short-haul equipment in the *region and for component maintenance of long-haul equipment*. With the exception of the long-haul equipment engines, transmissions, and differentials (which are managed centrally from headquarters), reparable inventory is managed and maintained locally.

Firm D

Firm D is a large truck-leasing company operating nationally and providing equipment for both commercial leasing and one-way rentals for the general public. The larger, heavy equipment used for commercial leasing represents the bulk of the fleet. The company is organized into 21 regions and 119 district offices that operate as independent profit centers. Vehicles operated by the district are maintained there for preventive maintenance and corrective maintenance as needed. Components are repaired either centrally (in one of three rebuilding centers) or are repaired by local contractors. The central rebuilding program is recent and now handles only a limited number of different components. The rebuilding centers operate on a pool of *serviceable and unserviceable* assets. Districts ship unserviceable assets and receive in return an equal number of serviceable. The volume of repair in the rebuilding

centers represents requirements in the entire system and is fairly stable and repetitive in the thousands of units per month range. Approximately 50 mechanics are dedicated to component repair at each of the three centers.

Component repair is scheduled uniformly at the district level. A parts manager usually ships components for local repair or to the rebuilding center based mostly on judgment and with a minimum of recordkeeping. Most stock replenishment decisions for consumable maintenance items are also made that way. Computerization of district parts inventories is planned in the next few years. The corporate purchasing department is responsible for managing repair and setting inventory levels at the central rebuilding facilities. The district manager is responsible for inventory levels at the district although he is given financial targets from the corporate maintenance organization.

Firm E

Firm E is a nuclear power plant associated with a major utility company. In addition to executing a rigorous preventative maintenance program, it performs low-volume component repair on a variety of its replacement parts for in-plant use. The type of equipment repaired is generally electrical, mechanical, or hydraulic, with electronic repair normally being contracted. The plant operates on a strict preventive maintenance schedule and performs corrective maintenance as needed. Preventive maintenance schedules are maintained in a computer data base, and workorder printouts indicate when a maintenance task is due. The components are repaired on an as-needed basis, and their repair not scheduled in advance. The entire maintenance workforce comprises approximately 200 technical and supervisory personnel. A materials department manages the inventory on the plant site; however, that department does not report through plant management but is a part of the corporate headquarters team.

Firm F

Firm F is major producer of electronic data processing equipment with worldwide sales. In addition to numerous manufacturing plants, it also operates three repair facilities for electronic components. The components to be repaired are, in most cases, turned-in by the customer at local service centers in exchange for serviceable components. While there are cases in which the customer wishes to have a specific component repaired rather than exchanged, most of the components being

repaired are the property of the firm and upon repair are returned to a central inventory for future issue. While the range of items varies in volume of repair performed, overall the repair environment can be characterized as high volume and repetitive, with a monthly average of 18,000 component repairs. In addition, about 10 percent of the repairs are done under contract. Each of the three facilities employs about 100 people. The repair process is controlled by a computerized tracking system that uses bar coding. Item status is maintained from the local service center at which it is turned in to receipt into the repair facility and repair completion. The scheduling system is semiautomated and relies on some manual interfaces to collect repair priority data. Parts support inventory is managed at the repair locations but under financial guidelines established at the division headquarters.

ANALYSIS

In our analysis of private sector component repair practices, we present data comparing private sector repair cycle times to those of the Service Components we visited and a discussion of the major factors contributing to the differences in repair leadtimes. The major factors are divided into three elements of repair operations that coincide with the problem areas identified in DoD operations during our on-site visits, areas that we feel benefit from the application of private sector approaches.

Table D-2 compares the average repair cycle times of each company we visited with the averages for each of the Services. Clearly, overall times for the items repaired by these private sector companies were shorter than the overall average DRCTs of the three Services in our study. Some of this disparity reflects differences in measurement and in the segments included in the overall definition of repair cycle time. Nevertheless, the order of magnitude of difference raises questions of management policy and processing efficiency.

Table D-3 is a comparison of DoD and private sector scheduling, induction, and piece-part support performance. We examine the methods and policies used to schedule, induct, and support repair operations in more detail in the following sections.

TABLE D-2

COMPARISON OF PRIVATE SECTOR FIRMS
AND DoD REPAIR CYCLE TIMES

Component	Repair Cycle Time (days)
Army	68
Navy	137
Air Force	37
Vendor# A	12.5
Vendor# B	9.5
Vendor# C	5.5
Vendor# D	5
Vendor# E	21
Vendor# F	8.5

TABLE D-3

GENERAL COMPARISON OF DoD AND PRIVATE SECTOR

Characteristic	DoD	Nominal Private Sector
Induction Quantities	> 5	≤ 5
Schedule Timeframes	Quarterly	Weekly
% AWP	10-20	Under 1
Parts Support Available to Maintenance (%)	65-70	90-95
Inventory Levels (expendables) (months)	1-5	2-3

PLANNING, SCHEDULING, AND CONTROL

The private sector approach to repair is characterized by small induction quantities (usually a quantity of one), frequent scheduling (often on a daily basis), and flexibility in changing schedules (just as requirements change).

An induction quantity of one unit is typical; in most cases, unserviceable assets are shipped directly to the repair depot when they require repair and are inducted into repair soon thereafter. Generally, unserviceable assets are not permitted to accumulate at any intermediate storage location or at any collection point for shipment to a depot at a later date. At the repair location, items are generally inducted into repair as received. Any accumulation of unserviceable assets is permitted only for specific and documented reasons, such as to minimize transportation costs to the repair location or to optimize the number of set ups for automatic test equipment as in the case of some electronic repair.

The private sector repair facilities that we visited are characterized by small storage areas allocated to unserviceable assets. Measured data show short retrograde times and short receipt-to-induction time segments. The scheduling process is straightforward in terms of selecting work to be performed. Some type of priority system is used as a guideline to determine the order in which unserviceable assets are repaired. For example, current inventory position is a common method for establishing repair priorities.

The striking difference between the private sector and the DoD operations is the overall frequency with which the schedules are planned, replanned and updated. In the private firms, on the average, schedules are replanned weekly looking at requirements for a period of a week. The schedule is refined daily, often taking into account immediate capacity constraints, and a dispatch list is prepared detailing the exact items to be repaired that day. These schedules are not simply maintenance schedules, that is, schedules that maintenance uses to determine how to organize a backlog of requirements; rather, they are based on real day-to-day requirements, generated by the inventory managers through the supporting requirements systems. The single unit lot sizes of work moving into the shop further enhance flexibility in changing from one job to another.

In addition to frequent replanning periods, the private sector repair process is able to respond to emergent requirements with little disruption and a minimum of procedural delay. An emergency requirement, tied to an immediate operational need, is handled in leadtimes even shorter than the normal. These requirements seem to cause no dislocation of the process and minimum disruption in the shop.

MATERIEL SUPPORT

The responsiveness we observed in the private sector repair process is not possible without effective materiel support. The materiel availability rate (fill rates) to support repair requirements in the companies we visited are reported to be in the 90 to 95 percent range, in one case exceeding 98 percent. This high assurance of parts availability fosters an environment in which repair priorities can change from day to day and parts to implement the new schedule are routinely available in stock. Confidence in materiel support is such that parts availability is not checked prior to induction and components set aside awaiting parts are not considered a problem.

The inventory control systems that support these firms range in level of sophistication from manual, perpetual inventory records (at one company inventory records are not maintained in the preventative maintenance shops) to well-integrated, fully computerized systems. In all cases, the inventory management approach is some form of order-point methodology based on historical usage. Program demand is generally not used in component repair planning, nor are planning bills of any sort used to forecast component repair parts requirements.

The high level of materiel support enjoyed by private sector firms suggests that, relative to requirements, inventory levels of piece parts at these private sector firms are much deeper than those in DoD. Shorter replenishment pipelines in the private sector also contribute to the responsiveness of the parts support inventory.

Another important factor in supply responsiveness in the companies we visited relates to materiel movement within the repair facility. The time needed to move items from shop stores to the maintenance shops is considerably shorter than that experienced in the DoD repair facilities. Materiel movement time from stores is generally measured in hours or minutes. One company has a standard of 30 minutes for parts delivery to maintenance; in all cases parts delivery can be expected within the same day. Again, this responsiveness is required to support the more flexible repair scheduling systems common to the private sector firms surveyed.

MANAGEMENT ISSUES

In our evaluation of approaches to managing the repair process in the private sector, we were impressed by the focused management attention the repair process receives. This focus is the result of an what we feel are common objectives among the

key participants resulting in an integrated approach to carrying out the repair mission. The common objective serves to define the performance of each department contributing to the repair process. This common objective is often operationally defined. For example, operational objectives driving repair cycle management are related to aircraft downtime for the airlines and out-of-service times for trucks for the trucking firms. These objectives guide the tradeoffs between competing departmental (supply and maintenance) objectives. Departmental moves to efficient operations are tempered by considerations of overall company performance. Supply and maintenance operations are jointly accountable for satisfying operational requirements.

Further, evaluation and resolution of the tradeoffs is easier in the private sector because, in general, the key departments such as supply and maintenance are usually operating at the same geographic location and physical plant. In addition, the key local managers often report to the same superior in the chain of command, thus enhancing the ability to weigh cost and performance options.

In comparing the private sector firms we visited to DoD repair operations, general organizational differences are also evident. Of course, no firm's repair operations are comparable in size to those of the DoD; the largest firm we visited only approximated the volume of a single large DoD repair facility. Organizationally, the private sector firms are more compact both in the number of people employed and the reporting structures through which repair decisions are operationally integrated. In part because of these factors, the private sector organizations are more responsive to changing requirements and more closely attuned to operational performance. Yet some of the contrasts we have made between DoD and private sector repair procedures are very useful in highlighting operational philosophies that are independent of the size of the organization or their respective missions.

SUMMARY

In summary, private sector repair cycle times are shorter than those of DoD for three major reasons. First, in the private sector, the importance of repair as the primary means of replenishment for reparable items is well recognized by both supply and maintenance personnel. Second, because a limited volume of unserviceable assets is available, those assets can be inducted directly into repair

and returned into operating inventories. The private sector inventory systems we saw were highly dependent on short repair throughput times. Third, the companies we visited make a conscious commitment to minimize repair cycle times (and the related investment in assets) at the expense of repair efficiency. Tradeoffs in capacity and piece-part support versus short repair cycle times tend to be resolved in favor of short repair cycle times.

APPENDIX E

RECOMMENDED DEPOT REPAIR CYCLE SEGMENTS AND TIMES

DEPOT REPAIR CYCLE SEGMENTS

The depot repair cycle is a discontinuous time beginning not earlier than the placement of a demand on the wholesale system and ending when the unserviceable item has been returned to a ready-for-issue (RFI) condition on the records of the wholesale inventory manager. Depot Repair Cycle Time (DRCT) should encompass those time-sensitive tasks that must be performed consecutively.

The current DoD policy specifies those segments of the depot repair process that are authorized for inclusion in the DRCT. To those segments, we added Batch Accumulation, Transfer to Maintenance, Production Buffer (organic only), Order Administration Time (contractor only), and Transfer to Storage as essential time-sensitive segments. The Batch Accumulation and Production Buffer segments provide a funded level of assets that permits induction in batches (up to one-fourth of the scheduled monthly requirement) as infrequently as weekly and provide maintenance with an in-hand supply of unserviceable components for production input flexibility. The time standards are based on the average time to accumulate a batch and to input a batch on a steady-state basis. The first units of the batch would be in the accumulation queue for 7 days and the last units 1 day. Conversely, the first units would be in the production buffer 1 day and the last units 7 days. Actual operations may vary. The Transfer-to-Maintenance segment permits maintenance to ascertain the on-hand availability of unserviceable assets, initiate the induction request, and firm up the production schedule while the induction request is being processed, with a required delivery date the day before the first planned input into the repair process.

The DRCT should not be extended to cover those tasks that can be performed concurrently with one or more of the time-sensitive tasks. The tasks should be grouped into logical segments that permit performance evaluation of the various functional elements involved. The time allowances for each segment should attempt to strike a balance between minimizing inventory investment in the repair cycle

level (RCL) assets and maximizing operational efficiency of depot maintenance operations. In this appendix we recommend DRCT segments for organic depot and contractor repair, respectively, and discuss each segment of the recommended DRCT.

Some tasks and processes that are critical to a timely and successful depot repair process can be performed before or concurrently with the DRCT segments without adding to the total DRCT. Those tasks have a "required by" date beyond which the repair process will be delayed. The following five types of tasks are illustrative of those that are *not* included in a specific DRCT segment but that require timely completion:

- Funding work orders
- Executing schedules
- Ordering parts
- Ensuring asset availability
- Scheduling shop production.

SHOULD TAKE TIME VERSUS DID TAKE TIME

The Army and the Navy use historical moving averages and exponentially smoothed averages, respectively, to measure the DRCT and compute the RCL. In both Services, the computer-generated DRCT based on historical "did take" time is frequently overridden by the Inventory Manager (IM). The Air Force uses a "should take" time that is a combination of actual data, default values when insufficient data are available, constants, and standards. Only the retrograde segments (the base processing and in-transit segments) that are based on actual or default values are subject to change by the IM. The use of the "should take" time establishes an objective toward which the several functional areas involved in depot repair can work.

Figure E-1 shows the standard ("should take") DRCT, the historic ("did take") DRCT, and the requirements (IM-adjusted) times for the Army, Navy, and Air Force for items that we sampled. The Army historical data [which reflect both awaiting parts (AWP) time and nonproductive time] is twice the established elapsed time standard for the sampled items, and the IM adjustments further increase the time used in the requirements computation to 2.5 times the standard. The "did take" time

for Navy sampled items (also includes AWP time and other nonproductive time) is 3.8 times greater than the "should take" time, but for requirements computation, the IM decreased the time to about 3 times the standard. In the Air Force, neither the "should take" nor the "did take" maintenance times include AWP time although "did take" supply history includes some AWP time. The Air Force sample "did take" times, on an average, exceeded the "should take" time by only 5 percent.

Air Force line item requirement computations are based on the "should take" time; therefore, investment in reparable assets is not increased to compensate for parts shortages or unnecessary nonproductive time. However, as we illustrate in Appendix B, the disparity between "did take" and "should take" times on a line-item basis is substantial.

Using "should take" times to validate and monitor "did take" times has a great potential for ultimately reducing the DRCT and the repair cycle level (RCL) inventory investment and increasing the responsiveness of the repair process as actual processing times decrease through management improvement action.

ORGANIC DEPOT REPAIR CYCLES

Proposed Organic Repair Cycle Segments

Figure E-2 displays the proposed segments for the organic depot repair cycle and identifies those segments authorized for inclusion in the "should take" and "did take" DRCT. The explanatory comments identify the events that begin and end each segment and the processes to be accomplished within each segment.

Explanation of Organic Depot Repair Cycle Time Segments

- A Date organizational/intermediate maintenance determines that the unserviceable asset is Not Repairable This Station (NRTS) or Beyond the Capability of Maintenance (BCM); unserviceable asset is turned in to supply. The DRCT clock is turned on.

- A - B Supply determines whether the item is on the automatic return list; if not, it queries the Inventory Control Point (ICP) for disposition instructions, prepares documentation, packs materiel, and turns the item over to transportation and transportation ships it.

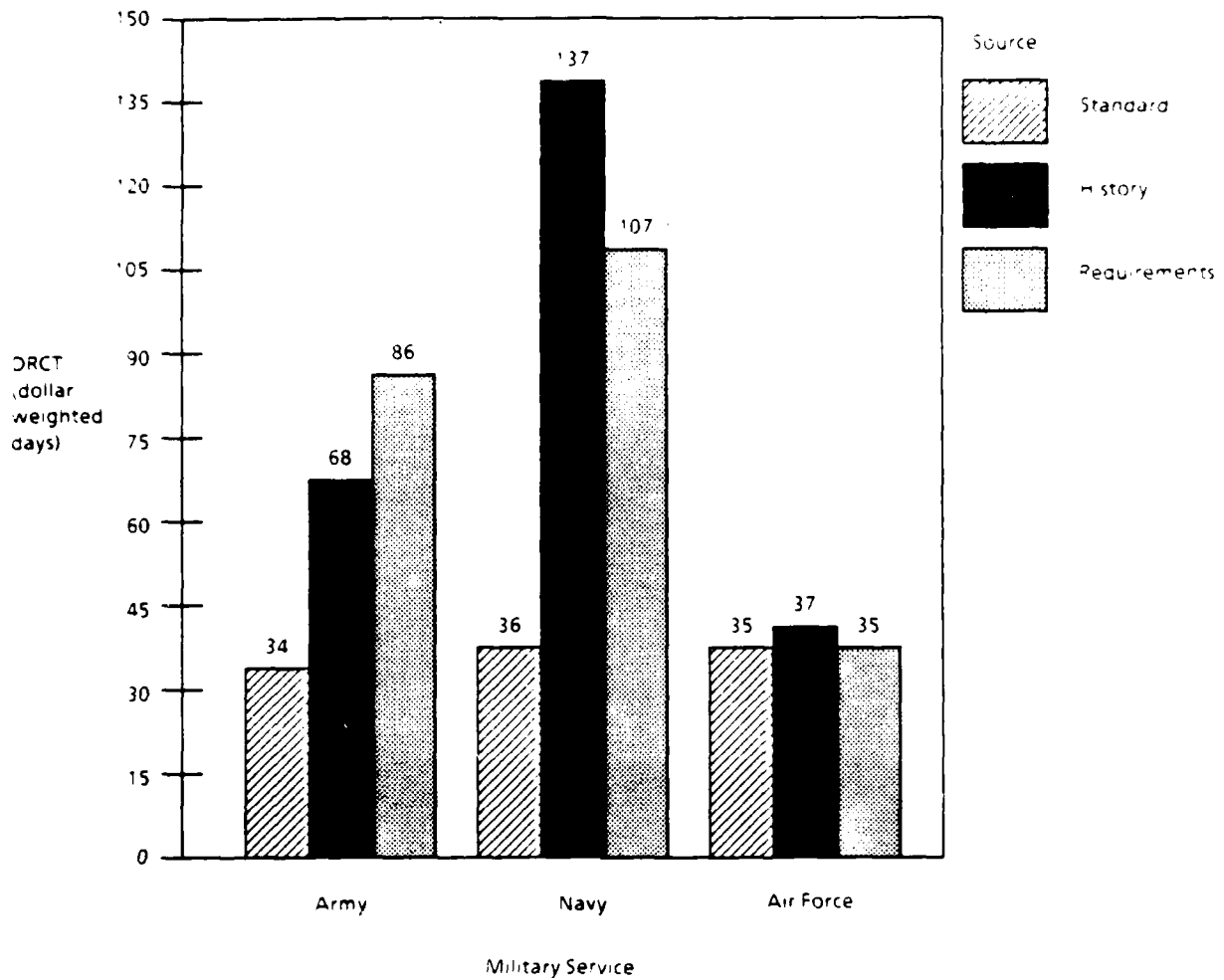


FIG. E-1. ORGANIC DEPOT REPAIR TIME, FY86

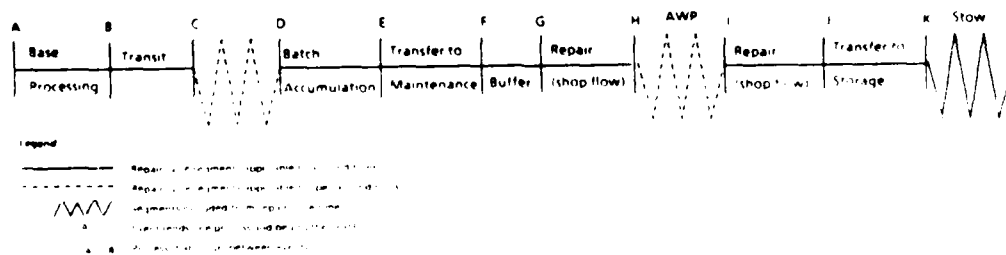


FIG. E-2. PROPOSED ORGANIC DEPOT REPAIR CYCLE SEGMENTS

- B Date unserviceable asset is shipped.
- B-C In-transit time from base to depot; delivered to depot; received, classified, stowed, and reported to ICP as on-hand in Condition Code F.
- C Date item is recorded as on-hand in Condition Code F. The DRCT clock is turned off if there is no immediate requirement to accumulate unserviceable assets.
- C-D The accumulation of a backlog of unserviceable assets for which there is no immediate requirement. This segment is bypassed if an immediate requirement exists.
- D Date on which the accumulation of the maximum authorized batch size (expressed in days of requirements) begins. The DRCT clock is on.
- D-E Storage accumulates unserviceable assets in Condition Code F not to exceed maximum authorized batch.
- E Date of the induction request from maintenance or ICP.
- E-F Maintenance (or ICP) forwards induction request to storage; supply processes induction request by processing condition code change from F to T, reflecting the induction request date¹ and generating picking ticket; storage picks assets, moves asset to maintenance, and maintenance signs receipt.
- F Date of receipt in maintenance. In-maintenance time begins.
- F-G Maintenance changes condition from T to M reflecting the date received by maintenance. Maintenance draws on buffer stock to start repair process.
- G Date work is put in process. (This is the point in time that hours and charges against the work order are normally started.) Begins shop-flow time.

¹The transfer process is currently recorded under Condition Code M in the Navy and Condition Code F in the Army and Air Force. To provide a uniform method for recording the transfer time and to provide visibility and evaluation of this segment, we propose the establishment of Condition Code T (transfer to and from maintenance)

- G-H Maintenance performs tasks and processes required to restore the item to serviceable condition until the repair process must be stopped for lack of parts.
- H Date maintenance is stopped because of lack of parts (AWP). DRCT clock is turned off.
- H-I Period during which AWP precludes further processing until parts are received, work rescheduled, and work-in process begins. Maintenance generates a document indicating date, item, and quantity of items on which work must be stopped. The condition code is changed from M to G even if the component is retained in maintenance. Segment H-I occurs only if work is stopped because of a parts shortage.
- I Date that in-process work is resumed. DRCT clock is turned on.
- I-J Maintenance generates a document indicating the date, item, and quantity of items on which work has resumed. The condition code is changed from G to M. Maintenance continues the hands-on repair process until the item is restored to RFI condition. Maintenance prepares turn-in document and notifies storage.
- J Date the asset is restored to RFI as reflected on the turn-in document. Ends shop-flow and in-maintenance time. Begins transfer time.
- J-K Condition Code is changed from M to T by maintenance reflecting the turn-in document date. RFI asset is returned to storage; supply processes condition code change from T to A, B, or C and reports change to ICP.
- K Date the change from Condition Code T to an RFI condition code (A, B, or C) is processed to the ICP. DRCT clock is turned off.
- K-L Storage packs, packages, preserves, and stows materiel and updates locator file. This segment is not included in the DRCT.

Proposed Organic Repair Cycle "Should-Take" Time Allowances

The authorized time allowances or the method of establishing them for each segment of the DRCT are set forth below. All times are expressed in calendar days. The sum of these allowances comprise the standard DRCT to be used as a goal for

evaluating RCLs in budget submissions and execution. An RCL quantity greater than 0 but less than 1 should be raised to a quantity of 1.

Base Processing Time²

Actual time with the following constraints:

- Items on the automatic return list: maximum of 7 calendar days.
- Items requiring reporting to ICP for return instructions: maximum of 21 calendar days
- In the absence of at least five observations, use a maximum of 14 days as a default value.

In-Transit Time³

Actual time: Services will establish maximum and default values that take into account eligibility for shipment by air and Uniform Materiel Movement Issue Priority (UMMIPs) geographic time standards.

Accumulation Time

A standard of 4 days. (The average number of days that items are in queue to accumulate a batch equal to one fourth the monthly repair requirement.)

Transfer from Storage to Maintenance (Induction Time)

Actual time, with a maximum constraint of 5 calendar days.

Production Buffer

A standard of 4 days. (Permits weekly induction of batches equal to one fourth the monthly repair requirement and represents the average number of days from "induction" to "in-process" for the batch.)

²The retrograde process, consisting of the base processing and in-transit time segments, applies only when the IM computes wholesale RCLs on a worldwide basis and applies retail level assets and in-transit unserviceable returns

³Ibid

Maintenance-In-Process (Shop Flow) Time

Standards expressed in calendar days (Engineering standards covering the critical path elapsed time from the first to the last "in-work" process except for new items and very-low-frequency items for which technical estimates may be used).

Awaiting Parts Time

Awaiting parts time will be accumulated as a separate element of information but is not authorized for inclusion in the DRCT.

Transfer to Storage

Standard of 2 calendar days except when the storage site is more than 50 miles from the depot maintenance activity; then a standard of 5 calendar days is authorized.

Storage Processing Time

Not authorized for inclusion in the DRCT.

CONTRACTOR REPAIR CYCLES

Proposed Contractor Repair Cycle Segments

For contractor repair, the schematic in Figure E-3 represents the possible segments required to cover four different repair scenarios: unserviceable assets may be shipped to the contractor direct from retail locations as they are generated; they may be accumulated in a wholesale supply depot and shipped to the contractor in a batch; the contractor may be authorized to start repair upon receipt of the materiel; or the contractor may have to request an order to authorize the repair after tear-down, inspection, and testing. In addition the contractor may accumulate some assets to preclude the necessity of induction of small quantities or requesting order authorization on a daily basis. The DRCT segments and time allowances are predicated on the policy that a repair contract will be in place before unserviceable assets are shipped to the contractor.

The proposed contractor DRCT segments, time standards, and their measurement are predicated on revisions to the monthly contractor reporting requirements similar to those currently used by the Navy. The dates that items

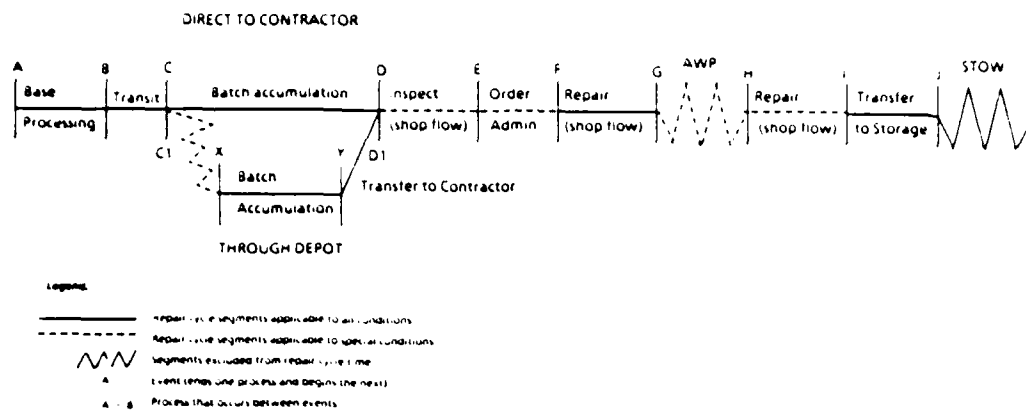


FIG. E-3. PROPOSED CONTRACTOR DEPOT REPAIR CYCLE SEGMENTS

enter and exit each DRCT segment while in the hands of the contractor are required. As a minimum, the date received and date shipped by the contractor and documented AWP time for government-furnished parts are required. More frequent reporting as under the Navy Contractor Asset Visibility System could provide management with more timely information on the status of contractor repair – a major source of serviceable assets.

Explanation of Contractor Depot Repair Cycle Segments

All Transactions

- A Date the organizational/intermediate maintenance determines that the unserviceable component is NRTS or BCM; unserviceable carcass is turned in to base supply. The DRCT clock is turned on.
- A – B Supply determines whether the item is on the automatic return list; if not, it queries the ICP for disposition instructions, prepares documentation, packs materiel, and turns the item over to transportation and transportation ships it.
- B Date unserviceable asset shipped.

Direct Shipments To Contractors

- B – C Intransit from base to contractor, received, and reported to ICP as on hand.
- C Date asset is received by contractor.

- C-D Accumulation of batch.
- D Date batch accumulation is completed (receipt date plus standard accumulation time). Begin shop flow (in process).

Shipments Through Depots To Contractors

- B-C1 In transit from base to depot, received, and reported to ICP as on hand in Condition Code F.
- C1 Date depot reports item on-hand in Condition Code F. DRCT clock turned off if there is no immediate requirement to accumulate unserviceable assets.
- C1-X The accumulation of a backlog of unserviceable assets at the depot for which there is no immediate requirement. This segment is bypassed if an immediate requirement exists.
- X Date on which the accumulation of the maximum authorized batch size (expressed in days of requirements) begins. The DRCT clock is on.
- X-Y Depot storage accumulates unserviceable assets in Condition Code F not to exceed maximum authorized batch.
- Y Date of ICP request to ship materiel to contractor.
- Y-D1 ICP forwards shipment request to depot; supply processes shipping request and generates picking ticket; materiel picked, prepared for shipment, shipped, and received by contractor.
- D1 Date the contractor receives unserviceable assets from depot.

Contracts Requiring Inspection Before Repair Order

- D,D1-E Contractor tears-down, inspects, and tests asset to determine the extent of the repair required before the repair order is issued, and requests order.
- E Date of contractor's request for order.

E-F Contractor requests authorization order from Defense Contract Administration Service (DCAS) or ICP; request processed and order issued.

F Date of order.

All Transactions

F Date in-process time for repair begins:

1. Date of maximum batch accumulation (D) or date batch received from depot (D1) when inspection is not required before repair order.
2. Date of order (F) authorizing repair when inspection is required before issuing repair order.

F-G Contractor performs tasks and processes required to restore the item to serviceable condition and inspection is completed unless work must be stopped for lack of government-furnished parts.

Work Stoppage Because of Lack Of Government Furnished Parts

G Date work stopped because government furnished parts are not available. DRCT clock turned off.

G-H Period that AWP precludes further processing until parts are received, and work rescheduled. This segment is not included in the DRCT.

H Date government-furnished parts are available for work to resume. DRCT clock is turned on.

All Transactions

H-I Contractor continues repair process until item is restored to serviceable condition, requests government inspection, and ships materiel to designated storage depot.

I Date item shipped to depot as reflected on the DD250 form.

I-J In transit from contractor to depot, received, and reported to the ICP as on hand in serviceable condition.

- J Date depot reports item as being on hand in serviceable condition. DRCT clock is turned off.
- J-K Materiel is packaged as required and stowed. This segment is not included in the DRCT.
- K Materiel is available for issue.

Proposed Contractor Repair Cycle Should Take Time Allowances

The authorized time allowances or the method of establishing them for each segment of the DRCT are set forth below. All times are expressed in calendar days. The sum of these allowances comprise the DRCT to be used in computing or evaluating RCLs for budget submissions and execution by multiplying by the anticipated daily net recoverable return (regeneration) rate. If an item is to be repaired at both organic and contractor facilities, a weighted DRCT is computed. An RCL quantity greater than 0 but less than 1 should be raised to a quantity of 1.

Base Processing Time⁴

Actual time with the following constraints:

- Items on the automatic return list: maximum of 7 calendar days.
- Items requiring reporting to ICP for return instructions: maximum of 21 calendar days.
- In the absence of at least five observations, use maximum of 14 days as a default value.

In-Transit Time⁵

Actual time: Services will establish maximum and default values that take into account eligibility for shipment by air and UMMIPs geographic time standards.

⁴The retrograde process, consisting of the base processing and in-transit time segments, applies only when the IM computes wholesale RCLs on a worldwide basis and applies retail level assets and in-transit unserviceable returns

⁵Ibid

Accumulation Time

A standard of 4 days. (The average number of days required to accumulate a batch equal to one fourth the monthly repair requirement.)

Transfer to Contractor

Actual time with a maximum constraint of 12 days. Services must justify bringing unserviceable assets into the depot for transshipment to contractors rather than shipping directly.

Inspection Time

This is the time stated in the contract for tearing down, inspecting, testing, and generating the contractor request for an order when these processes must be performed before repair can be authorized.

Order Administration Time

A standard of 10 days is authorized from the date inspection is completed to cover contractor request/proposal preparation until completion and forwarding of the contract order/amendment.

Repair Shop Flow Time

This is the time stated in the contract for the contractor to complete the entire repair process (excluding tearing down and inspecting when that is a separate contractual element as discussed above) and prepare the materiel and documentation (DD250 form) for shipment.

Awaiting Parts Time

Awaiting parts time for government furnished-materiel will be accumulated as a separate element of information and shall not be included in the DRCT. Delays in obtaining contractor-furnished materiel will not increase the authorized time repair time. Documented delays in the government furnishing materiel will not be charged to the contractor.

Transfer to Storage

This time is the actual time from the date of the DD250 Form until the asset is recorded as RFI on the records of the ICP but not to exceed 15 days.

Storage Processing Time

Not authorized for inclusion in the DRCT.

END
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