Design of Field-Based Crosstraining Programs and Implications for Readiness

William G. Wild, Jr., Bruce R. Orvis
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Design of Field-Based Crosstraining Programs and Implications for Readiness

William G. Wild, Jr., Bruce R. Orvis, with Rebecca M. Mazel, Iva S. Maclennan, Richard D. Bender

Prepared for the United States Army

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PREFACE

As part of a broad effort to reduce defense expenditures, the Army is exploring a number of new approaches to training individual soldiers. Prominent among these approaches is "field-based crosstraining (FBCT)," which involves combining two or more occupational specialties and shifting initial skill training from Army schools to on-the-job training in field units. (This type of program has also been labeled "generic" and "apprentice" in some quarters.)

This report describes a method for analyzing the features, advantages, and disadvantages of field-based crosstraining programs in the Army. Focusing on the specific case of helicopter maintenance, the report analyzes data from field units and recommends alternative field-based crosstraining strategies for the Army. An assessment of the Army's Apprentice Mechanic Initiative (AMI) for helicopter maintenance is included in the analysis. The results should be of interest to training developers, planners, and personnel specialists in the military services and Department of Defense.

This research was sponsored by the U.S. Army Training and Doctrine Command, Office of the Deputy Chief of Staff for Training. It was conducted under the Arroyo Center's Manpower and Training Program.

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SUMMARY

BACKGROUND
The Army training community faces a keen challenge: how to absorb significant reductions in funding without compromising mission effectiveness. As part of its response to this challenge, the Army Training and Doctrine Command (TRADOC) is exploring new approaches to training individual soldiers. Prominent among those approaches is “field-based crosstraining (FBCT),” which refers to programs that include:

- **Shift from school to on-the-job training.** Courses in Advanced Individual Training (AIT) are shortened and reoriented to focus on general “core” skills. Simultaneously, the shift usually involves a formal on-the-job training (OJT) program at the field unit to compensate for the reduction in schoolhouse training.1

- **Consolidation of two or more MOSs.** The numbers of distinct, related occupations are reduced by combining specialties.

Such programs also have been referred to as “generic” or “apprentice” programs. However, these terms have other connotations, so we avoid them here.

FBCT programs are intended to substantially reduce costs associated with the schoolhouse training and personnel management infrastructures. They also are expected to increase organizational flexibility in meeting the unit workload and increase personnel system flexibility in assigning personnel to field units. However, because the training obligation at the field unit also increases, FBCT poses risks to readiness. This report documents a methodology for exploring the trade-offs between organizational flexibility and training burden and applies it to the specific case of helicopter maintenance. Helicopter maintenance was selected for analysis because the Army was considering a major realignment and restructuring of that field, under an FBCT program called the “Apprentice Mechanic Initiative (AMI).” As proposed at the time of this study, the major features of AMI would include:

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1AIT courses immediately follow basic training and certify enlisted personnel in their Military Occupational Specialty (MOS) just before their first unit assignment.
• Consolidation of 13 MOSs taught at the Aviation Logistics School into a single MOS for first-term enlistees.

• Replacement of specialized AIT courses (which run 13 to 30 weeks in length) with a single 8- to 10-week course for these MOSs oriented toward introductory general maintenance skills, such as aircraft familiarization, basic hydraulics, engine characteristics, introduction to technical manuals, common/special tools, maintenance forms, and safety.

• Assignment of all AIT graduates to Aviation Intermediate Maintenance (AVIM) units for an 18-month OJT program, rather than dispersal to AVIM, Aviation Unit Maintenance (AVUM), and flying company units as is current practice. This would place the more experienced personnel “forward” nearer the aircraft.

• Use of additional training resources and time beyond that allocated to regular duties (“outside time”) to supplement workload-based OJT.

AMI has been considered as a model for similar programs in other MOS areas, and hence its relevance extends beyond helicopter maintenance.

OBJECTIVES AND APPROACH OF THE STUDY

Objectives

The field-based crosstraining concept involves several complex aspects that on balance could work either to the Army’s advantage or disadvantage. This report presents a method of analyzing and thinking about those aspects to help structure future discussions about FBCT. The case study of helicopter maintenance yields specific insights and recommendations.

Approach

This analysis focuses on the potential impact of FBCT programs on field unit operations and capability. To compare the current system with a FBCT system in helicopter maintenance, we built a baseline describing current helicopter maintenance operations. The baseline data collection was limited significantly by the intervention of Operations Desert Shield and Storm (ODS), which coincided with the information-gathering phase of this study. Nevertheless, it was possible to gather the following data:
• Interviews with subject matter experts including field maintainers, supervisors, and commanders, as well as schoolhouse training designers and instructors.

• Field surveys of maintainers and maintenance supervisors from all levels of maintenance.

• Helicopter field maintenance data from the Unscheduled Maintenance Sample Data Collection (UMSDC) database and the Standard Army Maintenance System’s (SAMS) Work Order Logistics File (WOLF).

• Enlisted Master File (EMF) data, which track individual enlisted soldier’s unit assignments and experience.

These data were used to support a variety of analyses modeling different aspects of helicopter maintenance training and operations. Results were then integrated from a systemwide perspective to examine how alternative maintenance training options might affect the operational readiness of aviation field units.

MAJOR FINDINGS AND CONCLUSIONS

Because of the wide range of possible implementations of the field-based crosstraining concept, the risks to field readiness vary substantially. We will first discuss findings regarding MOS consolidation, then the AIT to OJT shift.

MOS Consolidation

MOS consolidation aims to broaden enlistees’ skills through crosstraining. Broader skills can potentially result in more flexible work allocation at the maintenance unit (and hence higher weapon system availability) and more flexible assignment of personnel to field units. The payoffs do not increase proportionally with the scope of crosstraining. Rather, the benefits are likely to “tail off” as crosstraining broadens, for several reasons: (1) queuing models show that there are limits on how much a system can profit from flexibility in work allocation, (2) aviation maintenance unit structures limit the range of skills that can be used at any one unit, and (3) overly broad MOSs lead to ad hoc subspecialization that complicates skill tracking and the ability to provide units with the skills they need to maintain readiness.

On the down side, FBCT program trainees would have less depth of experience than do current enlistees. This is because: (1) MOS con-
solidation requires OJT time to be spread among a number of MOS areas, and (2) the FBCT trainee receives less specialized AIT instruction for these MOSs. In helicopter maintenance, this would likely result in a serious decrement in skill depth (relative to the current enlistee) because train-up times in these MOSs are fairly long (12 to 18 months). The effect on the unit depends on (1) how much depth is required of these individuals and (2) how many trainees are concentrated at a site. In helicopter maintenance, the negative effect on unit capability appears significant, particularly if trainees are centralized for OJT.

In total, then, large-scale consolidations in helicopter maintenance (i.e., to a single or two MOSs) appear undesirable. They offer little benefit over more conservative plans, but increase potential risks significantly. Consolidations to three to five MOSs fall into an uncertain area, presenting significant potential benefits but substantial risks as well. Additional data are required to resolve this uncertainty. Until broader consolidations can be justified, selective consolidations—to a number intermediate between five and the current 13—seem to offer the best plan for maintaining readiness while reducing training and personnel costs. To minimize risk, consolidations should encompass highly transferable skills and be augmented with policies that facilitate cross-utilization. Training packages to support flexible unit assignment of similar MOSs could be used to enhance cross-utilization without formal consolidation.

The AIT to OJT Shift

Reductions in the length of AIT courses have the potential for significant cost savings. However, the resulting increases in OJT requirements place additional burdens on field units that could decrease readiness. Graduates of shortened AIT courses would enter the unit with less MOS-relevant background, making their train-up period longer. During this time, they would require more supervision and perform less proficiently than today’s unit members. The problem is exacerbated when trainees are centralized at particular units and when duties do not permit “outside” training time.

First priority should therefore be given to understanding what cost savings can be realized with minimal increases in OJT requirements. This includes dropping unneeded materials from AIT courses and, more broadly, coordinating training of general skills and specific types of tasks with unit workload levels. One should not assume that a wide range of task training can easily be delegated to a field OJT program. Factors preventing this in helicopter maintenance include:
• Insufficient workload to ensure that trainees gain needed task exposures.

• Insufficient spare time to supplement workload-based training with other methods.

The data we examined for MOSs 67N, 67Y, and 68J suggest that whereas easy tasks (requiring one or two training exposures) might be learned in OJT, training difficult tasks through OJT may necessitate grouping the tasks into training blocks, and, in the extreme, concentrating exposures to the tasks within a block across a limited number of trainees. This approach recognizes that junior maintainers will develop experience in a general area of difficult tasks and that individuals will become experts on different tasks within that general area. In such cases, revised AIT programs should focus on general skills, with illustration of particularly difficult or important tasks as needed.

Prospects for reducing AIT without a large increase in OJT can be strengthened if unit operations can be accommodated to OJT of new graduates. For example, a “training bay” of work might be designed that is fairly predictable in content (hence easily prepared for in AIT) and of relatively low unit priority (hence appropriate for new trainees). Phase maintenance might provide such an opportunity.

OJT placement seems best suited for AVIM, if centralized, or dispersed to AVIM and AVUM, as currently. AVIM basing increases the dependability and variety of the workload, but it concentrates the training requirements at a much smaller number of units and adversely affects their experience base. AVUM-only basing appears ill-advised. It suffers from the same limitations as AVIM basing, and moreover offers less relevant workload and places inexperienced personnel forward.

With the data available, we cannot judge whether AVIM basing would be better than AVIM plus AVUM. However, some consolidations would be feasible only at AVIM, and the problems of centralization would be reduced with the types of limited consolidation and OJT proposed here.

The Reserve Components and the Future Army

FBCT programs pose special problems for the Reserves in helicopter maintenance. Over 50 percent of Reserve maintainers depend on AIT for training and would be directly affected by AIT reduction. At the same time, there is almost no ability to absorb a significant shift to
OJT, because the majority of personnel receive only 38–39 days per year of training (a portion of which is devoted to hands-on maintenance). Hence, a field-readiness-constrained program such as that described above appears much more tractable for the Reserves than an AMI-like model. Even so, special considerations will be needed for the Reserve Components.

Finally, any new training initiative must mesh with the Army's transition to its future structure. In helicopter maintenance, the following possible changes appear noteworthy:

- **New maintenance structures.** The "Operational Maintenance Battalion" would co-locate today's AVIM and AVUM operations. Such a structure could ameliorate some risks of FBCT: some MOS consolidations that current unit structures inhibit may be more attractive, and trainees might be co-located in some manner (e.g., on low-priority jobs) without the current degree of unit concentration and experience decrement.

- **Influx of sophisticated technology.** Problems in helicopter maintenance have been a high-profile topic for several years, concentrating on the sophisticated technology of the AH-64 Apache. The forthcoming Comanche helicopter is considered by some to represent an even greater technological leap over the Apache than the Apache represented over the AH-1 Cobra. Hence, if the Comanche fails to achieve design objectives of automated fault isolation and two-level maintainability, the potential complexity of maintenance problems could far exceed that of the Apache. Any significant revision in the aviation maintenance area such as FBCT will need to be compatible with the special strategies and plans developed to address this high technology challenge.
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1. INTRODUCTION

BACKGROUND: FIELD-BASED CROSSTRAINING PROGRAMS

The Army training community, like virtually every other element of the military forces, faces a keen challenge in the years ahead: how to absorb significant reductions in funding without compromising mission effectiveness. As part of its response to this challenge, the Army Training and Doctrine Command (TRADOC) is exploring a number of new approaches to the training of individual soldiers. These include taking advantage of established civilian training institutions; substitution of training aids, devices, simulators, and simulations (TADSS) for live equipment; and an approach we will call "field-based crosstraining (FBCT)," which is the subject of this report. (The approach also has been termed "generic" and "apprentice" training in some quarters. Because such terms have had other connotations, we avoid them here.)

The term FBCT refers to programs that include the following elements:

• **Shift from school to on-the-job training.** This strategy attempts to shorten initial school courses in Advanced Individual Training (AIT) and to reorient course content to focus on general "core" skills. Simultaneously, it usually involves a formal on-the-job training (OJT) program at the field unit, to compensate for the reduction in school training.¹

• **Consolidation of two or more MOSs.** This strategy aims to reduce specialization by combining occupational specialties, and hence to avoid various overhead and administrative costs associated with detailed MOS classifications while increasing personnel assignment flexibility.

Whereas TADSS, for instance, attempts to reduce costs associated with field training (as well as resident training), the FBCT approach attempts to reduce costs in TRADOC schools and in the personnel management system. A list of specific cost and operational payoffs often hypothesized for FBCT programs includes:

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¹AIT courses immediately follow basic training and certify enlisted personnel in their Military Occupational Specialty (MOS) just before their first unit assignment.
• **Cost savings from the reduction in AIT.** AIT courses are resource intensive. It is sometimes argued that school courses may overtrain individuals for tasks they are asked to perform early in their field assignments, and that trainees could learn many tasks during OJT.

• **Cost savings in course development and personnel management.** Army planners often anticipate these savings as a result of reducing the number of MOSs in a Career Management Field and absorbing low-density MOSs.

• **Increased flexibility of task allocation in the field unit.** It is sometimes argued that “broader” MOSs permit more efficient assignment of people to tasks at the field unit, thereby improving operational efficiency. Broader MOSs thus could help to overcome limitations of a specialized “union shop.”

• **Increased flexibility in the forcewide manning process.** By MOS consolidation, the Army could reduce the complexity of matching individuals with open MOS slots in field units.

However, such broad programs have not yet been implemented. Their potential benefits therefore remain unconfirmed, and there are operational risks to be considered. Prominent among the risks would be the following:

• **Less capability among junior personnel in units.** When training is shifted from AIT to field OJT, AIT graduates enter the unit with less background directly relevant to their MOS.

• **Longer train-up time in units.** Reaching the unit with less preparation, AIT graduates are likely to require a longer “train-up” period, during which they may need more supervision and perform less proficiently.

• **Loss of depth.** When MOSs are consolidated, breadth of training during OJT is emphasized at the expense of depth in particular work areas, which could adversely affect unit performance.

Recognizing both the potential benefits and risks, TRADOC asked RAND to develop and apply a methodology for examining these issues. This report documents that methodology and explores its application for the specific case of helicopter maintenance. Aviation maintenance was selected for the analysis because the Army was considering a major realignment and restructuring of that field, under an FBCT program called the “Apprentice Mechanic Initiative (AMI).”
AN FBCT PROGRAM FOR HELICOPTER MAINTENANCE

The Army's Aviation Logistics School at Fort Eustis is developing and experimenting with a plan that incorporates the objectives of FBCT training and that includes other elements tailored to the helicopter maintenance context. Versions of the proposed program were widely briefed as early as mid-1989, and the details of its design were still evolving in March 1991 when a field test of the concept began at a heavy division aviation brigade. However, the basic form of the program remained fairly consistent.

Figures 1 and 2 summarize the AMI plan and compare it with the current system. Principal features include the following:

- **Consolidation of 13 MOSs** taught at the Aviation Logistics School into a single MOS for first-term enlistees, designated 67A. Figure 1 illustrates how new AIT graduates would begin their careers as 67As at "skill level 10" (SL10, the basic level). After approximately 18 months in their first unit assignment, they would become 67Bs. They would progress to skill level 20 while remaining in that single MOS. At skill level 30, they would then

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**Figure 1—MOS Structure Under Apprentice Mechanic Initiative**
specialize in distinct MOSs that correspond to specific aircraft (Apache AH-64s, Huey UH-1s, Blackhawk UH-60s, etc.) or specific subsystems (engines, armament, etc.).

- **Corresponding consolidation of AIT courses** into a single program.

- **Revision of the content of AIT.** The 67A course would last 8–10 weeks. This represents a large reduction from the current 13- to 30-week courses, as illustrated in Figure 2. The revised course would focus on FBCT areas such as aircraft familiarization, reviews of basic hydraulics, engine characteristics, introduction to technical manuals, common/special tools, maintenance forms, and safety.

- **Assignments of all AIT graduates to Aviation Intermediate Maintenance (AVIM) units.** At AVIM units, trainees would receive an OJT program exposing them to all MOS areas. As Figure 2 shows, under the current MOS structure AIT graduates can be assigned to any level of maintenance. Under the proposed new program, all current AVIM slots for SL10 maintainers would be filled by AMI trainees.

- **Placement of “field training detachments (FTDs)” at AVIM.** These detachments, to be drawn from schoolhouse personnel, would help guide and verify training. Training is expected to be based on the existing workload of maintenance actions needed in the unit and on outside-workload instruction (for example, through the use of training devices). This program would take about 18 months at AVIM for an average trainee.

Figure 2 also illustrates the sequence of career steps after this initial training. Upon completion of the OJT program at AVIM, the 67As would become 67Bs, and most would proceed to Aviation Unit Maintenance (AVUM), although some may remain at AVIM as supervisors. Upon reenlistment, individuals would attend the Basic Non-Commissioned Officer’s Course and receive certification in one of the specializations of Figure 1. These senior SL30 personnel would be assigned to work at flying units and to supervise at other echelons, as is current practice.

Designers of the program expect it to yield a number of benefits. Consistent with the FBCT concept, the large reduction and course consolidation in AIT are expected to reduce costs at the schoolhouse. At the field units, particularly at AVIM, the conversion from 13 specialized MOSs to a single FBCT “apprentice” MOS could add more
flexibility in work allocation. Similar flexibility gains are intended for unit assignments, although this would affect primarily the 67B (that is, those who have completed the initial OJT but have not yet reenlisted and specialized into one of the current MOSs). It is not clear, however, how the consolidations would affect personnel system costs, because today’s MOSs still would exist after the first term of enlistment. That is, they are not removed from the Career Management Field entirely.

Some developers expect AMI not only to result in cost savings, but also to improve field readiness despite the large reductions in AIT. A special facet of the AMI plan is that the sequencing of echelon assignments shown in Figure 2 results in the more experienced personnel being placed “forward,” closer to the aircraft at the AVUM and in the flying units. In fact, under this program the flying units would be manned entirely by SL30 personnel. It should be noted, however, that increased SL30 manning at the flying units requires a forcewide increase in the number of SL30 personnel, because the number of such personnel elsewhere (at AVIM and AVUM) is intended to remain the same. Such a forcewide “plus up” would incur corresponding costs. In any event, the “experience forward” concept is aimed at im-
proving early stage troubleshooting and repair. If successful, it would enable a greater number of problems to be solved accurately at the aircraft, thereby lightening the workload being passed up to higher echelons.

NATURE OF THIS STUDY

Study Objectives

It can readily be seen that FBCT programs, including AMI, involve several complex aspects that on balance could work either to the Army's advantage or disadvantage. One purpose of this report is to present a method of analyzing and thinking about these advantages and disadvantages, to help structure future discussions about FBCT in the Army. Our other purpose is to derive specific insights and recommendations for helicopter maintenance. These should be of interest to aviation planners and training developers as design and evaluation of FBCT in that area continues.\(^2\)

Scope of Research

We focus primarily on the effects of an FBCT program on unit operations and capability. For the most part, we consider effects on current Active peacetime Army operations. This is the environment from which most of our empirical data were drawn, and we argue that any FBCT program must succeed in this environment, at a minimum. Where we can, we also attempt to identify implications for wartime operations. In the Conclusions section, we consider possible effects of FBCT programs in the Reserve Components, which face a markedly different environment for OJT, and in the "Army of the future," which is likely to contain significantly altered force structures, support structures, and equipment inventories.

Army policymakers, of course, will want to consider effects on the schoolhouse as well. They will need to balance risks to field capability against the potential cost savings that FBCT programs might of-

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Two major approaches to evaluation of FBCT programs might be envisioned. The first would be to test programs at field units and measure the outcomes. Such tests certainly can be highly beneficial. However, they may not be feasible in many cases, given the disruption to unit operations that can be entailed and the large number of MOS areas that might pursue FBCT strategies. Alternatively, a "front-end" analysis can be performed using other methods to highlight key issues, areas for attention, and benefits and risks to be weighed. This type of analysis can help inform a field test, or be used in lieu of field tests where it is not feasible to perform them. The charter of this study was to perform such a front-end analysis.
fer. Clearly, these potential savings should be reviewed with some rigor. However, we do not address cost issues directly, although we do attempt to keep them in view at appropriate points. Other recent Arroyo Center research presents costing methodologies for Army courses, which may be of use to Army planners in analyzing FBCT program costs.3

Because this analysis focuses on the helicopter maintenance case study, its results and conclusions may not generalize equally to all MOS areas. Obviously, other maintenance functions will be most similar to the environment we are considering. In this report, we attempt to maximize the relevance of the case study by identifying and emphasizing some of the more fundamental implications of the FBCT concept. The discussion therefore tries to strike a balance between general principles related to FBCT and specific implications related to helicopter maintenance.

DATA SOURCES

To assess the potential impact of FBCT programs in the field, we needed to compare anticipated operations under FBCT systems with those under the current system. For our case study this required building a baseline of information describing current helicopter maintenance operations, including:

- Types of work performed by personnel of varying experience levels, unit types, and MOSs.
- Volume and mix of the day-to-day maintenance workload.
- Unit manning patterns by MOS and pay grade.
- Unit organization and operational procedures.

Below we give the sources of this information. We caution that our data collection activities were limited significantly by Operations Desert Shield and Storm (ODS), which coincided with the information-gathering phase of this study. We note these limitations where appropriate in the text below.

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Visits to Field Units

Because FBCT programs directly affect field operations, we felt our assessments should pay special attention to them. Our information was drawn from numerous helicopter maintenance personnel whom we interviewed. At the Aviation Logistics School at Fort Eustis, these included schoolhouse personnel, instructors, and field NCOs assigned for advanced training. Despite the onset of ODS in August 1990, we were able to visit helicopter maintenance units at Fort Carson, Colorado; Fort Ord, California; Fort Polk, Louisiana; and Fort Hood, Texas; they were among the few units remaining in the United States after first-to-deploy units had moved to Saudi Arabia. We also visited civilian operations at the Army Aviation Center (Fort Rucker, Alabama) and a reserve maintenance facility.

Field Surveys

Although the visits helped to build a picture of field operations at the process level, we need a more detailed picture relating individuals to the jobs they perform in the current system. To assemble this picture we designed surveys both for helicopter maintainers and supervisors. (Many individuals play both of these roles.)

The maintainer surveys were designed to determine the frequency with which various types of tasks are performed by individuals with a given MOS, level of experience, and type of unit. The supervisor surveys were designed to yield ratings of task difficulty and to determine how long it takes individuals to train up in a given MOS area. From these sources, we wished to gather information to design AIT and OJT programs that are feasible and responsive to field needs, and to gain estimates of train-up times under various FBCT scenarios.

In all, we developed 14 maintainer surveys: one for each of the 13 MOSs taught at the Aviation Logistics School and one combining the four avionics MOSs (68N, 68L, 68Q, and 68R), which are taught elsewhere. Table 1 itemizes the helicopter maintenance MOSs.

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4The "Army Occupational Survey Program (AOSP)" has developed a number of surveys for the helicopter maintenance area. We did not make direct use of them, however, for two reasons. First, although some of the questions in these surveys—such as frequency of task performance—were relevant to the needs of this study, data were not available for most MOSs. Second, there were many types of information required for this study that the AOSP surveys were not intended to collect, such as ratings of the number of task exposures needed for train-up and train-up times in a particular MOS area.
Table 1

Helicopter Maintenance Specialties (MOS)

<table>
<thead>
<tr>
<th>67 series general helicopter mechanics</th>
<th>68 series subsystem repairers</th>
</tr>
</thead>
<tbody>
<tr>
<td>67N UH-1 utility helicopter</td>
<td>68B Powerplant repairer</td>
</tr>
<tr>
<td>67R AH-64 attack helicopter</td>
<td>68D Powertrain repairer</td>
</tr>
<tr>
<td>67S OH-58D scout helicopter</td>
<td>68F Aircraft electrician</td>
</tr>
<tr>
<td>67T UH-60 tactical transport helicopter</td>
<td>68G Sheet metal repairer</td>
</tr>
<tr>
<td>67U CH-47 medium helicopter</td>
<td>68H Pneumatics repairer</td>
</tr>
<tr>
<td>67V OH-58A/C scout helicopter</td>
<td>68J Armament repairer</td>
</tr>
<tr>
<td>67Y AH-1 attack helicopter</td>
<td>68N Avionics repairer, general</td>
</tr>
<tr>
<td></td>
<td>68L Avionics communication equipment repairer</td>
</tr>
<tr>
<td></td>
<td>68Q Avionics repairer, flight control</td>
</tr>
<tr>
<td></td>
<td>68R Radar navigation repairer</td>
</tr>
</tbody>
</table>

Similarly, we developed 14 companion supervisor surveys. Each survey presented a template of key tasks for the MOS—generally several hundred—and asked appropriate questions about them. The task lists were assembled from official Army sources, primarily Soldier's Manuals and Maintenance Allocation Charts (MACs), with additional review and input from subject matter experts (SMEs). Although the “task templates” tended to be rather large, only portions applied to any given respondent. The surveys are documented in detail in N-3600-A, Design of Field-Based Crosstraining Programs and Implications for Readiness: Survey Instrument and Database Documentation, RAND, 1992.

We administered approximately 100 supervisor surveys and over 100 maintainer surveys during our field visits. These provided data for the illustrative analyses in the following sections. The survey data could not be exploited to their full potential, however, because the sample size and character was necessarily limited by the movement of units to the ODS theater. For example, first-to-deploy units could not be surveyed. Also, the units we visited did not have the technologically advanced aircraft such as AH-64, CH-47D, or OH-58D (which were concentrated in the first-to-deploy units). Such aircraft are known to present unique and difficult challenges for maintainers. It
may be argued that first-to-deploy units should be part of the data collection process before a forcewide policy decision is made.

In addition, the samples at the units we visited were limited in size and representativeness. In part, this is because the field environment during ODS made it particularly difficult to give such surveys priority. But, in addition, there were 56 potential categories of respondents: 14 MOSs at two types of maintenance units, for both maintainers and supervisors. The limited number of available respondents and limited time they could give to the survey during ODS caused the number of cases for any given category to be small. Thus, we must regard our survey data as selective, and we treat them in that light in the analysis below.

**Maintenance Data**

Surveys can be of great value in providing information not otherwise available. However, we also wanted to have data collected during actual operations where possible. We expected that our surveys would accurately reflect the relative distribution of an individual's time across task types, but we also expected they might be less precise than valid hard data in pinpointing how often such tasks arise, particularly for the unit as a whole (at least in helicopter maintenance where the range of tasks is very broad). In this case study, therefore, we also acquired and analyzed field maintenance data from the Unscheduled Maintenance Sample Data Collection (UMSDC) database and the Standard Army Maintenance System's (SAMS) Work Order Logistics File (WOLF).

UMSDC data provide rich detail, but are concentrated primarily at unit-level maintenance (AVUM). Our sample included the units covered by UMSDC in the period from January 1988 through June 1990. Conversely, WOLF provides less detail, but covers all AVIM units. Our WOLF data sample was from January 1989 through June 1990. Both types of data, considered together, are needed to understand workload levels and job responsibilities.

Finally, we used a September 1989 version of the Enlisted Master File (EMF)—which tracks individual enlisted soldiers' unit assignments and backgrounds—to examine current personnel strengths and experience levels at helicopter maintenance units. (We wished to avoid any complications that may have arisen in the September 1990 version as a result of ODS.) This allowed us to consider how these factors might change under an FBCT program.
ORGANIZATION OF THIS REPORT

Section 2 develops the basic concepts of FBCT training in more detail. Sections 3 and 4 then analyze how various programs might affect unit capability, by looking at the two main features of FBCT: shifting training from AIT to OJT and consolidating occupational specialties. Section 5 synthesizes these results and recommends desirable features of an FBCT program for helicopter maintenance.
2. ANALYTIC FRAMEWORK: BASIC ELEMENTS OF FBCT PROGRAMS

We have distinguished two major components of FBCT programs: the "AIT to OJT shift" and MOS consolidation. However, we can further break down programs such as AMI into a small number of first-order "building blocks." Each block or element can be examined first in isolation, and then in combination as they are configured to form various alternative programs. This section identifies the key elements we focus on, and discusses the advantages and disadvantages associated with each. This lays the groundwork for more quantitative and integrated treatment in the subsequent sections.

THE "AIT TO OJT SHIFT"

In many (if not most) MOSs, OJT already takes place in the field either formally or informally. Personnel do not arrive fully trained from AIT, nor are they intended to, and much of their expertise is developed in the field. This is true even for areas such as maintenance, where "training" per se is not the peacetime mission (in contrast to, say, tank crews). The issue for FBCT programs, then, is not whether OJT should take place; rather, it is how much training should be relegated to OJT, and how OJT might be managed in a more formal manner.

A shift in training from AIT to OJT entails some inherent benefits and risks, as noted earlier. On the plus side, AIT costs may be reduced because of the reduction in course length. However, such savings must be weighed against the risk to unit effectiveness. Under FBCT, AIT graduates enter the unit with less MOS-relevant background. This prolongs their train-up time at the unit, during which period they may require more supervision and perform less proficiently (in terms of quality and speed of work). Hence, unit capability may be decremented and desired levels of training may not be achieved.

Although any shift from AIT to OJT carries these basic benefits and risks, the magnitude of these effects can vary widely depending on
the MOS area\textsuperscript{1} and the exact form of shift chosen. In this analysis we designate three key variables to define the form of the shift:\textsuperscript{2}

- OJT placement
- OJT source
- Size of the OJT shift.

\textbf{OJT Placement}

We consider two main options for \textit{where} the formalized OJT program will take place:

- \textbf{Dispersed OJT.} Under this plan FBCT trainees are dispersed in the same manner as current AIT graduates. In helicopter maintenance this would imply distributing FBCT AIT graduates throughout AVIMs and AVUMs (as is current practice), and providing OJT at both. Advantages and disadvantages of this approach are indicated in Table 2.

- \textbf{Centralized OJT.} Under this plan all trainees are concentrated at a particular type of site or unit. In helicopter maintenance this would imply concentrating trainees at either AVUMs or AVIMs. Centralization presents several advantages over the dispersed option but incurs additional risk as well, as shown in Table 3.

Clearly, the basic risk of a shift to OJT—infusion of less-trained personnel to the field—exists whether the trainees are dispersed or centralized (as does the risk that OJT at one type of unit may not train well for the work required of other types). The centralized alternative simply concentrates the less-trained personnel at the OJT unit. This

\textsuperscript{1}Some MOSs may be able to absorb more training responsibility because their peacetime mission is training (although a slower train-up might have implications for unit capability in wartime). In areas like maintenance, however, the peacetime mission is oriented toward support of peacetime operations and very little time is set aside for “training” per se. In such areas the peacetime mission—equipment readiness—may be impaired (as well as wartime capability).

\textsuperscript{2}The shift can be defined in greater detail by including additional elements such as the availability of training materials, ability to ensure standardization of training, and so forth. In an effort to keep the number of elements manageable, however, we have focused on the three above as “first-order” variables. When fixed, these variables will strongly, though not completely, define the nature of the shift. In addition, many other variables are accounted for implicitly as factors that influence decisions about these three.
Table 2

<table>
<thead>
<tr>
<th>Potential Benefits</th>
<th>Potential Risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Cost savings in AIT.</td>
<td>• All types of units incur basic risks associated with less-trained graduates.</td>
</tr>
<tr>
<td>• Increased experience levels at units where trainees are NOT concentrated, as these no longer receive fresh AIT graduates.</td>
<td>• One type of unit may not train well for another, due to differing missions, work mixes, etc.</td>
</tr>
<tr>
<td>• OJT resources can be centralized.</td>
<td>• OJT resources [Field Training Detachment (FTD) personnel, materials, etc.] must service a diversity of physical locations.</td>
</tr>
</tbody>
</table>

Table 3

<table>
<thead>
<tr>
<th>Potential Benefits</th>
<th>Potential Risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Cost savings in AIT.</td>
<td>• Decreased experience levels at the units where OJT is concentrated. These units receive a greater number of new graduates, because they are no longer dispersed throughout all types of units. Since these graduates are less trained than currently, a double impact is felt at the unit.</td>
</tr>
<tr>
<td>• Increased experience levels at units where trainees are NOT concentrated, as these no longer receive fresh AIT graduates.</td>
<td>• More trainees concentrated on the same workload may result in less training opportunity per trainee.</td>
</tr>
<tr>
<td>• OJT resources can be centralized.</td>
<td>• One unit may not train well for another, because of differing work mixes. The extent of this problem will depend on the type(s) of unit(s) at which trainees are concentrated.</td>
</tr>
</tbody>
</table>

unit now receives not only AIT graduates with less training than before, it also receives more new AIT graduates than before (and hence fewer experienced personnel)—a double impact. At the same time, non-OJT units receive fewer new graduates and so may benefit from an increase in experience levels.

Source of OJT

A second major variable defining the AIT to OJT shift is the source of the OJT. Two sources considered in this analysis are: (1) field work-
load only, and (2) field workload supplemented with activities outside duty time. We consider each of these in turn.

Field Workload Only. This option would rely on the “naturally occurring workload” at the field unit as a basis for OJT, including all tasks performed as part of day-to-day duties. For example, helicopter maintainers may receive hands-on training while performing the daily maintenance workload. Ideally, one might plan that each trainee would be exposed to an array of tasks that have been targeted for each MOS in which he is training. However, such ambitions might place a significant burden on field commanders, whose priorities are dictated by operational objectives. This would probably be the case in helicopter maintenance. Allocating work across many personnel—for example, 50 or more in helicopter maintenance—to accomplish both the workload and training goals for all individuals probably would be a difficult management task, and one for which commanders have little incentive. The alternative, which seems much more likely, is that trainees would simply “take it as it comes,” acquiring experience on whatever tasks fall to them during their training. Risks and benefits of this type of “workload-based” OJT program are outlined in Table 4.

Training During “Outside” Time. As noted in the table, reliance solely on the naturally occurring workload lacks standardization both of training content and supervision. This shortcoming can be addressed by including an “outside time” component, a supplement to workload-based training received during the course of daily duties. Under this option, resources are made available to train individuals in spare time or off hours. Resources might include instructors, written materials, video instruction devices, interactive training devices, real or simulated equipment, and so forth. Addition of the “outside time” component, however, brings with it additional complications, as shown in Table 5.

Size of Shift

An “AIT to OJT shift” increases the amount of training that must take place in OJT and thereby places an additional burden on the field unit. The degree of risk this burden presents to the field unit depends on OJT placement and source, as we have seen. It also depends on the magnitude of the increase in OJT—what we call the size of the shift. This is reflected in the number and types of tasks relegated to OJT that had previously been covered in AIT.
Table 4

**OJT Limited to Naturally Occurring Workload**

<table>
<thead>
<tr>
<th>Potential Benefits</th>
<th>Potential Risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Hands-on training, generally considered superior in quality to that gained from</td>
<td>• Quality of training varies with supervisors (who are not formally prepared to be trainers).</td>
</tr>
<tr>
<td>written materials, simulators, etc.</td>
<td>• Content of training varies with volume and mix of the workload/activities, which may vary over time and from unit to unit.</td>
</tr>
<tr>
<td>• OJT requires limited additional administration, since it is formed by “natural</td>
<td>• Young trainees may not be exposed to work designated for training.</td>
</tr>
<tr>
<td>unit operations.”</td>
<td></td>
</tr>
</tbody>
</table>

Table 5

**OJT Supplemented with “Outside Time” Training**

<table>
<thead>
<tr>
<th>Potential Benefits</th>
<th>Potential Risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Hands-on training, generally considered superior in quality to that gained from</td>
<td>• Quality of training still likely to vary with supervisors and volume/mix of workload.</td>
</tr>
<tr>
<td>written materials, simulators, etc.</td>
<td></td>
</tr>
<tr>
<td>• All trainees are exposed in some manner to the same set of subjects/tasks, by</td>
<td>• Presumes spare time exists or can be created.</td>
</tr>
<tr>
<td>“filling in” whatever the workload does not offer for a given individual.</td>
<td></td>
</tr>
<tr>
<td>• Can be used to “prep” the trainee for upcoming hands-on work, thus improving his</td>
<td>• Training resources, such as trainers, written materials, Electronic Information Delivery System (EIDS), etc. must be available in sufficient</td>
</tr>
<tr>
<td>performance and reducing training time requirements. (This would detract time</td>
<td>quantities to support the total OJT load at each site.</td>
</tr>
<tr>
<td>from the “filling in” use, however.)</td>
<td></td>
</tr>
</tbody>
</table>

An increase in OJT may be light enough to be accommodated easily or, if heavier, the trainers and trainees may be able to cope but at some personal cost. Alternatively, it may simply stretch units too far, at which point readiness decreases. Because any major shift incurs potential risk, the size of the shift should be minimized consistent with cost reduction objectives and unit workload levels. (It may be possible to reduce AIT significantly without a proportional increase in OJT, simply by revising AIT content to correspond more closely to
field needs, that is, cutting dead wood from AIT.) To calibrate the size of the shift, an explicit framework can help decide how to allocate tasks and skills between AIT and OJT.

Generally, one of the prime values of AIT is considered to be the production of graduates capable of contributing to the unit mission immediately upon arrival. This implies that tasks or skills to be included in AIT should be those most immediately relevant to the field’s needs:

- Skills that occur relatively frequently in the field and thus are important to the unit.
- Skills that are performed by junior personnel (such as recent AIT graduates). Otherwise, the individual is likely to have forgotten or lost the skill by the time he encounters it on the job.

A second major value of AIT is standardized training content and teaching quality, because personnel will be assigned to units having divergent workloads and training priorities. Tasks and skills that would require such careful instruction might be those that:

- Are difficult to learn, requiring special emphasis.
- Are particularly safety-sensitive.

Although many tasks might qualify for AIT according to the above attributes, from a cost savings viewpoint planners might like to move as many as possible to OJT. To protect readiness, however, the feasibility of training them in OJT must be weighed. We would expect the skills or tasks most feasibly learned in OJT to be those with the following attributes:

- Occur frequently in the field, implying there is opportunity to learn them during OJT.
- Can be learned quickly (after only one or two encounters).
- Do not incur pronounced safety risks (and so do not require highly structured instruction).

Interestingly, the foregoing implies that tasks and skills that arise frequently in the field are highly relevant and therefore are good candidates for AIT. It is not surprising that proposed AIT reductions often aim to preserve the most frequently occurring tasks in the Program of Instruction and delete the less frequent. However, such tasks may be exactly the ones that can be learned just as easily dur-
ing OJT, because their high frequency may provide repetitive training opportunity.

Figure 3 lends an explicit structure to the above reasoning. It is a simplified scheme in that it does not take into account all factors that might enter into the AIT/OJT decision. For example, some tasks yield high training leverage in that once learned, they yield widely transferable skills. The placement of other tasks might be influenced by the types of resources or aids available at the school or in the unit. Hence, more expansive allocation schemes may be valuable. As will be seen in Section 3, however, even the simple structure used here yields valuable insights into helicopter maintenance.

In Figure 3, we assume a rough screening process has yielded a set of tasks and general skills to be taught to junior personnel. The template distinguishes those tasks or skills for which formal AIT would appear most valuable from those for which OJT seems sufficient. The first two rows represent difficult or critical tasks or skills, for which AIT could help standardize the quality of instruction and prepare the trainee to be productive in the field. In the first row, training opportunity/task frequency is judged inadequate to permit full OJT. That is, not all junior trainees can be trained up properly. Row two concerns difficult jobs with adequate OJT possibilities. AIT remains the method of choice for general skills. It also may be desirable as a supplement to OJT at the task level.

The last two rows concern tasks or skills of low difficulty that can be learned in one or two exposures. In such cases, OJT would seem to be the method of choice, because such jobs can be learned as they are en-

<table>
<thead>
<tr>
<th>Relative Character of Task</th>
<th>Where to Train</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difficulty/Criticality</td>
<td>OJT Opportunity</td>
</tr>
<tr>
<td>High</td>
<td>Inadequate</td>
</tr>
<tr>
<td>High</td>
<td>Adequate</td>
</tr>
<tr>
<td>Low</td>
<td>Inadequate</td>
</tr>
<tr>
<td>Low</td>
<td>Adequate</td>
</tr>
</tbody>
</table>

Figure 3—Template for Allocating Training
countered. This choice would add little burden to the field, since a graduate's first one or two exposures to a job are likely to be closely supervised even if he has seen the task in AIT, and so AIT training would be redundant. An exception might be the case of low-frequency general skills that are needed by junior personnel (row three). Some of these might be included in AIT to ensure standardization and ability to perform the associated tasks soon after arrival in the unit.

Thus, AIT may be best oriented toward teaching high-value skills as a first priority and key illustrative tasks more selectively. This pattern supports the use of a "generic skill" AIT concept as a possible route to achieving course reductions, when budget constraints prohibit extensive coverage of both general skills and specific tasks.³

MOS CONSOLIDATION

We use the term "consolidation" to mean that two or more MOSs are replaced by a single one in the personnel system, and that enlistees in the new MOS are expected to perform tasks across the full range of its work areas (i.e., across the formerly distinct MOS areas composing it). The primary decision variable we define with regard to consolidation is the degree of consolidation, as defined by the number of current MOSs and the number to which they will be reduced. (In choosing the degree of consolidation, variables such as similarity of MOS areas, opportunity for cross-training, and so forth will be considered, as seen later in this report.)⁴

In this study, we consider the 13 MOSs in the AMI proposal whenever addressing AMI specifically. Elsewhere we broaden our focus to include the four avionics MOSs as well. Although these MOSs are not

³We recognize that training planners in particular specialties may not agree with specific judgments in this template. In such instances, we would argue that they should agree on a specific alternative, because the template forces the AIT/OJT choice to be subject to explicit and communicable criteria. Once this is accomplished, tasks or skills can be rated and sorted on these criteria to build a training program. We illustrate this process in Section 3.

⁴An additional variable may be mentioned. Cross-training of skills (and hence consolidation of MOSs) could take place not at the outset of enlistees' careers (during AIT) but later, after they have "gotten their footing" at the unit. If, for instance, cross-training of helicopter maintainers began after two years of field experience, the individual might be better equipped to learn. In addition, it would ensure that the trainee first developed significant depth in one area, before expanding his breadth into others. This scheme would still work toward the goal of more widely capable individuals who lend flexibility to the system. However, it diverges significantly from the goals of reducing initial training and personnel costs. Hence, we do not include it in the succeeding analysis because it would unnecessarily complicate much of the discussion. The Army might wish to investigate it as an alternative.
under the purview of the Aviation Logistics (AVLOG) School, they are an integral part of maintenance operations and are candidates for FBCT approaches. Whereas any degree of consolidation is possible, an illustrative set of alternatives could include:

- **Full**: Reduction to one specialty.
- **Large-scale**: Reduction to, say, three to five MOSs.
- **Selective**: Combining a few closely related MOSs.
- **None**: Keeping the current MOSs separate.

We want to examine how the major benefits and risks change with the degree of consolidation. Major benefits include:

- **Theoretical cost savings in courses and the personnel system.**
- **Flexible work allocation at the unit.** For productivity-oriented MOSs, this benefit can take a number of forms: greater effectiveness from current manpower, constant effectiveness with reduced manpower, or fewer hours per day at current manpower and effectiveness. For other MOSs, the primary benefit may be in greater redundancy of skills in case of attrition during battle.
- **Flexible assignment of personnel across units.** The complexity of matching supply and demand of personnel across units increases with the specialization of the MOS structure. Fewer MOSs should simplify this process.

Against these positive attributes, some of the major risks of consolidation under FBCT include the potential for:

- **Decreased depth of MOS-specific experience for individuals at the unit, because depth of training is traded for increased breadth.**
- **Corresponding decrease in the depth of MOS-specific capability for these individuals.**
- **Resulting decrement in unit capability.**

These benefits and risks will be weighed quantitatively in Section 4.

**RANGE OF PROGRAMS FOR FBCT**

We have presented a small number of “first-order” elements that can be used to define FBCT programs. Even these few elements, however, can be combined to form a wide range of possible programs. For
example, 48 alternative programs are possible if we consider four levels of consolidation; three levels of AIT to OJT shift (say, low/medium/high); two placement locations (centralized vs. dispersed); and two sources (workload vs. workload plus outside time). Hence, there is a great deal of flexibility inherent in the FBCT concept. We must consider the range of alternative forms available when assessing the potential for FBCT in a given MOS.

The wide range of potential programs has two implications for our analysis:

• Rather than compare full program alternatives at the outset, it is best to first analyze the building-block elements in isolation, so that their individual effects can be understood. Then, the more complex interactions and tradeoffs that result from combining them into full program packages can be examined more clearly.

• In the range of alternative programs for helicopter maintenance, AMI is at the extreme in its divergence from the current system: AMI proposes full consolidation of all 13 nonavionics junior MOSs into a single MOS; it proposes a dramatic reduction in AIT (from 13–30 weeks to about 10 weeks); it would centralize AIT graduates at AVIM for OJT, as opposed to the current dispersed (AVUM and AVIM) placement scheme for new graduates; and it proposes using part of the trainees' nonduty time for OJT instruction.

As we analyze program elements in the succeeding sections, we will find strong evidence that the aviation maintenance community may wish to consider less sweeping changes than the package represented by AMI.
3. FEASIBILITY AND EFFECTS OF SHIFTING TRAINING FROM AIT TO OJT

This section examines some of the principal effects of shifting training from AIT to OJT, independent of a simultaneous consolidation of MOSs. It yields some lessons for helicopter maintenance training, and lays a foundation for considering the combination of a shift to OJT with MOS consolidation in the next section. The discussion is structured around each of the basic elements of the shift described in the previous section: OJT placement, OJT source, and size of the shift to OJT.

OJT PLACEMENT

The final decision on OJT placement will depend in part on the consolidation scheme under consideration. Hence, in this section we will look at some basic factors contributing to this decision.

Comparability of Work at AVIM vs. AVUM

Wherever the OJT is done, an important consideration is whether the type of work performed at different maintenance units is comparable. If the work performed by a given MOS varies significantly among units, OJT trainees could not readily transfer among them. In helicopter maintenance we anticipate the possibility of such differences between levels of maintenance, because Maintenance Allocation Charts define what types of work are performed at AVUM and which will be passed up to AVIM. We used UMSDC data to examine this issue more closely, and examined comparability of work across the two maintenance levels, within a current MOS.1

AVIM-AVUM Comparability Within a 67 Series MOS. We would expect work for an aircraft mechanic to be fairly comparable at AVIM and AVUM. Both AVIM and AVUM mechanics perform unscheduled maintenance tasks at AVUM, because AVIM mechanics do some work there on "contact teams." Both also perform significant amounts of scheduled maintenance, which is uniform in content.

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1When MOSs are consolidated, comparability of work across maintenance levels may change significantly, as we describe in Section 4.
The similarity in job descriptions is borne out at a general level in the UMMSDC data. Table 6 shows the type of unscheduled tasks performed by junior (E1–E4) mechanics. Each row shows the percentage of an MOS's maintenance actions that fall into each work type. Data at AVIM are less rich than at AVUM, as the numbers of actions in the sample (N) indicate, but no striking differences in the pattern of work are visible for any given MOS. Similarly, Table 7 shows that the focus of work on the aircraft also is generally the same at AVIM and AVUM within an MOS. (In the interest of space, we show results for the two MOSs with the largest samples, but results for others are consistent.) It is possible that differences would be apparent at a more specific component level, although we do not expect they would be significant.

**AVIM-AVUM Comparability Within a 68 Series MOS.** We would expect the work of some subsystem repair MOSs to differ between AVIM and AVUM. At AVUM, components generally are removed and minor repairs made. If special tools are needed or the repair is expected to be relatively lengthy, components are sent up to AVIM. (For instance, the Cobra Heads-Up Display may require an oscilloscope and spare circuit cards.) Also, our perception from unit visits is

<table>
<thead>
<tr>
<th>Maintenance Level</th>
<th>MOS</th>
<th>Remove/Replace</th>
<th>Repair</th>
<th>Troubleshoot</th>
<th>Inspect</th>
<th>Other*</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVIM</td>
<td>67N</td>
<td>59</td>
<td>15</td>
<td>1</td>
<td>3</td>
<td>22</td>
<td>288</td>
</tr>
<tr>
<td></td>
<td>67R</td>
<td>61</td>
<td>11</td>
<td>0</td>
<td>7</td>
<td>21</td>
<td>846</td>
</tr>
<tr>
<td></td>
<td>67T</td>
<td>66</td>
<td>9</td>
<td>0</td>
<td>11</td>
<td>14</td>
<td>3686</td>
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<td></td>
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<td>65</td>
<td>13</td>
<td>1</td>
<td>4</td>
<td>17</td>
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</tr>
<tr>
<td></td>
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</tr>
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<td>67Y</td>
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<td>6</td>
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<td>1443</td>
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<td>7</td>
<td>21</td>
<td>10859</td>
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<td>67R</td>
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<td>67V</td>
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<td>67Y</td>
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<td>14</td>
<td>2</td>
<td>11</td>
<td>18</td>
<td>18746</td>
</tr>
</tbody>
</table>

*NOTE: Table entry (i,j) denotes the percentage of unscheduled maintenance actions in MOS i that fall into type j.*

*a*Other* includes such tasks as Maintenance Operational Checks (MOCs) and cleaning/washing.
Table 7
Subsystems Maintained at AVIM vs. AVUM in 67 Series MOSs
(% of repair actions)

| Subsystem      | MOS Level | Maintenance/
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Airframe</td>
<td>Landing Gear</td>
</tr>
<tr>
<td></td>
<td>Powerplant</td>
<td>Rotor System</td>
</tr>
<tr>
<td></td>
<td>Drive System</td>
<td>Instrumentation</td>
</tr>
<tr>
<td></td>
<td>Flight Control</td>
<td>Fuel System</td>
</tr>
<tr>
<td>67T AVIM</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>67T AVUM</td>
<td>18</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>67U AVIM</td>
<td>26</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>67U AVUM</td>
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<td></td>
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<tr>
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<td>9</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

NOTE: Table entry (i,j) denotes the percentage of unscheduled maintenance actions for MOS i that involve equipment in subsystem j. Percentages do not total to 100, because not all subsystems are included. Ns correspond to those in Table 6.

that 68 series MOSs work at AVUM (on “contact teams”) less frequently than for the 67 series (although there are exceptions, such as 68J).

Tables 8 and 9 give the type of information presented earlier, this time for the 68 series MOSs. Again, work within a given MOS appears roughly comparable. Some differences are evident. For example, Table 8 shows that a higher proportion of inspection tasks occur at AVIM, particularly in non-avionics MOSs, but less than we would have expected. In particular, we do not see a large shift toward more repair at AVIM in component repair MOSs such as 68B, 68D, or 68J. A possible explanation is that the data may not capture the differences at this aggregate level, so that a more component-specific approach may be required. It also is possible that the UMSDC data do not capture the work performed in the AVIM “shops” as extensively as the work that AVIM personnel do while at the AVUM location on contact teams. Since the UMSDC is unit-based, and its field monitor personnel are at AVUM, this might be the case. Alternatively, our initial perceptions may have been inaccurate and more closely applicable to high-technology portions of aircraft than to the workload in general.

In any event, it appears that the types of skills called upon at AVIM and AVUM may be similar, providing underpinning for OJT at one level to support work at the other within a given MOS. We believe
Table 8

AVIM vs. AVUM Maintenance Actions in 68 Series MOSs

<table>
<thead>
<tr>
<th>Maintenance Level</th>
<th>MOS</th>
<th>Remove/Replace</th>
<th>Repair</th>
<th>Troubleshoot</th>
<th>Inspect</th>
<th>Other*</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVIM</td>
<td>68B</td>
<td>61</td>
<td>7</td>
<td>5</td>
<td>20</td>
<td>7</td>
<td>1368</td>
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<td></td>
<td>68D</td>
<td>55</td>
<td>11</td>
<td>1</td>
<td>28</td>
<td>5</td>
<td>2871</td>
</tr>
<tr>
<td></td>
<td>68E</td>
<td>15</td>
<td>20</td>
<td>31</td>
<td>22</td>
<td></td>
<td>4151</td>
</tr>
<tr>
<td></td>
<td>68G</td>
<td>26</td>
<td>33</td>
<td>16</td>
<td>38</td>
<td>2</td>
<td>4120</td>
</tr>
<tr>
<td></td>
<td>68H</td>
<td>27</td>
<td>22</td>
<td>17</td>
<td>29</td>
<td>5</td>
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<td></td>
<td>68J</td>
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<td>6</td>
<td>1283</td>
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<tr>
<td></td>
<td>68M</td>
<td>47</td>
<td>14</td>
<td>15</td>
<td>12</td>
<td>12</td>
<td>553</td>
</tr>
<tr>
<td></td>
<td>68N</td>
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<td>21</td>
<td>22</td>
<td>20</td>
<td>8</td>
<td>1296</td>
</tr>
<tr>
<td></td>
<td>68L</td>
<td>18</td>
<td>14</td>
<td>30</td>
<td>35</td>
<td>2</td>
<td>1131</td>
</tr>
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<td></td>
<td>68Q</td>
<td>11</td>
<td>14</td>
<td>30</td>
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<td>1021</td>
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<td>945</td>
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<td>32</td>
<td>31</td>
<td>11</td>
<td>1136</td>
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</table>

NOTE: Table entry (i,j) denotes the percentage of maintenance actions in MOS i that fall into type j. 68M has been consolidated with 68J. Among the avionics MOSs, 68N is concentrated at AVUM, whereas 68L, 68Q, and 68R are concentrated at AVIM. As may be seen, there is some cross-utilization.

*Other* includes such tasks as MOCs and cleaning/washing.

that further examination at the component/part level is needed for individual task comparisons.

Centralized OJT at the AVIM

When OJT is centralized at a particular type of unit, all AIT graduates are concentrated there. As noted in Section 2, these new trainees displace more senior SL10 personnel, who in turn fill slots at the non-OJT units (those slots that would otherwise be manned by the trainees if OJT were not centralized). Clearly, this leads to a de-
Table 9

Subsystems Maintained at AVIM vs. AVUM in 68 Series MOSs

(percent of repair actions)

<table>
<thead>
<tr>
<th>Maintenance MOS Level</th>
<th>Subsystem</th>
<th>Airframe</th>
<th>Landing Gear</th>
<th>Powerplant</th>
<th>Rotor System</th>
<th>Drive System</th>
<th>Instrumentation</th>
<th>Flight Control</th>
<th>Fuel System</th>
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<tr>
<td>68D AVIM</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>64</td>
<td>17</td>
<td>0</td>
<td>5</td>
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<td>2</td>
<td>64</td>
<td>19</td>
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<td>0</td>
<td>1</td>
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<td>6</td>
<td>53</td>
<td>5</td>
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</tr>
</tbody>
</table>

NOTE: Table entry (i,j) denotes the percentage of unscheduled maintenance actions for MOS i that involve equipment in subsystem j. Percentages do not total to 100, because not all subsystems are included. Ns correspond to those in Table 8.

cline of experience levels at the OJT unit. But how significant might this be?

As a baseline, Figure 4 shows typical current experience levels for 68B SL10 personnel in an AVIM engine repair shop. Each vertical bar represents one maintainer, and its height indicates the number of months of career work experience that maintainer has in the 68B MOS area. Figure 5 similarly displays experience levels for SL10 AVIM personnel in other 67/68 series MOSs. In each MOS the pattern is roughly similar to the 68B pattern, and hence we will continue with the 68B example for simplicity.

Now suppose that, as proposed under AMI, 18 months are allowed for training and that trainees replace all current SL10s at AVIM. Those positions now filled by SL10s with a range of experience under the current system would be filled by recent AIT graduates. Even assum-

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2Data for Figures 4 and 5 are drawn from the EMF database, depicting manning levels in late 1989. (1990 data were affected by ODS and hence not used.) The figures are representative of a typical AVIM, although manning levels can vary significantly by unit. For example, there may be junior personnel with less than 12 months experience in such a shop, although in this composite a 12-month minimum is used. The data are based on a sample of 14 selected AVIMs, which included four corps and ten divisional units, based in both CONUS and Europe, and drawn from units expected to remain after the force drawdown.
Figure 4—68B Shop: Experience Levels of Typical SL10 Personnel at AVIM

Figure 5—Experience Levels of Typical SL10 AVIM Personnel by MOS
ing no consolidation takes place, the maximum experience these trainees can develop in a given MOS area (e.g., engine shop) before moving to AVUM would be 18 months (the full OJT program). Generally, trainees will be at different points of progress in the AVIM OJT program—some just beginning, others finishing—averaging about nine months experience overall. Comparing the nine-month average with the experience levels illustrated in Figure 4 shows that this represents a considerable decrement in unit experience relative to the current system. Moreover, because maximum experience is limited to 18 months, formation of self-supervised senior-junior work teams becomes problematic.

Consequently, although AVIM may be capable of training personnel for AVUM work, centralizing OJT there would result in a substantial loss of experience at AVIM units. As we will see in Section 4, adding consolidation of MOSs to the plan would cause even greater decrements in experience. In theory, this decrement at the AVIM could be partially offset by the greater experience concentrated at the AVUM, which might reduce AVIM workload. However, it is not clear that relevant experience at AVUM would actually increase. We will return to this point in Section 5, after discussing consolidation.

Centralized OJT at the AVUM

Under the AMI proposal, helicopter maintenance may move toward a centralized plan at AVUM. Another option would be centralization at AVUM. However, this seems less desirable than the AVIM-based option just examined. If experience levels were to be reduced at AVUM, it would result in exactly the opposite of the “experience forward” objective that AMI is designed to achieve. It would remove experience from the place it is widely deemed to be most necessary—near the aircraft. In addition, the urgency of work is reportedly higher at AVUM, because of time constraints on maintenance actions and the fact that these units are evaluated based on their Operational Readiness (OR) rate. Once again, the effect of many new trainees would likely be felt more keenly at AVUM than at AVIM.

Finally, as will be seen in detail later (Figure 7), the presence of only one or two predominant aircraft types at AVUM units limits the crosstraining possible during OJT.³

³The implications of centralized vs. dispersed OJT for unit performance and workload training opportunity are closely intertwined with MOS consolidation (Section 4), so this topic arises again in that discussion.
THE OJT SOURCE

The decision to be made is whether to include an "outside time" component of OJT as a supplement to the OJT gained with the naturally occurring workload. In helicopter maintenance, the availability of outside time appears to be a severe constraint. There is a widely held perception that the current Table of Organization and Equipment (TOE) is understrength and that many if not all MOSs are overworked. Time is diverted to other work details and unit duties such as physical training, facility clean-up, motor pool, guard duty, and common task training. This time diversion has been supported by a number of sources. A 1987 study estimated that only 50 percent of assigned maintenance manhours are applied to MOS-related tasks. More recent Army briefings have placed that figure at 25 percent, and a widely quoted figure of "2.5 hours/day" was roughly consistent with information gleaned during our field visits. At least twice in the recent past, the Forces Command (FORSCOM) commander issued directives stating that commanders must ensure that helicopter maintainers get at least 4.0 hours per day of productive maintenance time. As further evidence, we found a marked increase in the number of maintainers actually assigned per unit (from EMF data) as compared with those authorized [from Modified TOE (MTOE) data]. This also suggests possible difficulty in meeting the workload.

Hence, it appears maintainers have difficulty finding time to do their jobs, let alone get additional training. It also appears that there is less flexibility for unit commanders to influence this problem than one might imagine. Duty allocations flow down from higher level units to lower, generally distributed in proportion to the manpower of the subordinate units. Hence, AVIM receives a portion of duties based on its size, allocated to it by the Division Support Command (DISCOM) or the Aviation Brigade. Similarly, AVUM has duties allocated to it from the battalion, which in turn receives them from the brigade, and so forth. In either case, the first sergeant then distributes duties among the platoons. For all helicopter maintainers Armywide to experience a significant increase in productive hours, other than by further lengthening the duty day, it would seem that helicopter maintenance units would have to be allocated fewer additional duties than their manning size would dictate—in essence, granting special treatment to these units. This would represent a fundamental cultural change in the Army. The Aviation Logistics

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School has recognized this difficulty and has been a leading proponent in efforts to make changes. In the meantime, though, it seems unrealistic to expect that additional time can be found to support "outside" training to any great extent. Moreover, the problem may be worse for (untrained) junior personnel, who seem more likely to be affected by additional duties than highly valued senior unit members.

Thus, OJT will depend almost solely on the naturally occurring workload as a training source. A basic condition that must be satisfied for this to be feasible is that there must be continuity in the types of work performed by junior and senior personnel. If, as junior personnel became senior, we observed a sudden shift in the functions they performed (e.g., from removing and replacing to troubleshooting) or in the subsystems they worked on (e.g., certain components of power plant or weapons delivery vs. fire control/target acquisition subsystems), formal preparation might be needed to transition to the new responsibilities. A more detailed review of the data shown in Tables 6–9 revealed that, although there is some evidence of these types of shifts, for the most part the picture is one of gradual transition rather than sharp discontinuity. This suggests that the type of workload assigned to junior personnel is suitable for training them gradually for their more senior responsibilities.5

DETERMINING THE SIZE OF THE AIT TO OJT SHIFT

Since OJT will need to depend largely on the naturally occurring helicopter maintenance workload, the size of the OJT shift will be determined by the training opportunity the workload is able to offer. Using our best available data, we outline below a procedure for assessing training opportunity in a given MOS. Our data concentrate on MOSs 67Y (Cobra mechanic), 68J (armament repairer, Cobra portion), and 67N (Huey mechanic).6 In each case, we draw on the logic of the task allocation template in Section 2. Specifically, if a task is "easy" (i.e., capable of being trained in just one or two exposures on the job), we presume it can be trained in OJT. On the other hand, if a task is "hard," it may be trainable in OJT, but only if the unit’s workload presents sufficient training opportunity. For example, to train

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5 This is consistent with the fact that the first formal training after AIT, currently BNCOC, does not occur until considerably after the period in question. It also suggests that junior personnel have important responsibilities and are not just "tool box carriers," a point we will return to later.

6 These MOSs were chosen based on availability of data from our surveys, administered to units remaining in CONUS in late 1990 and early 1991 during Operations Desert Shield and Storm.
difficult troubleshooting tasks on complex assemblies, the field unit must have enough maintenance work on those assemblies to provide every trainee sufficient exposures to learn those tasks.

This analysis relies on our maintainer and supervisor surveys (see N-3600-A), as well as on an analysis of UMSDC and WOLF maintenance data. For clarity, we will concentrate on the survey data, because they provide the most straightforward information and require fewer technical assumptions. We will then discuss how the detailed analyses of UMSDC and WOLF data provide direct confirmation of the survey-based results.

Methods for Estimating Parameters

The analysis examines maintenance actions ("tasks") on particular components, such as a gear box, "heads-up" display, or engine oil cooler. In the surveys, each supervisor and each maintainer was given a list of such components for his MOS, and was asked to describe certain features of maintenance actions on each component, as follows.

Difficulty. Supervisors were asked to rate the number of exposures that a SL10 soldier would need to become proficient in three primary tasks for that component: (a) remove and replace, (b) repair, and (c) troubleshoot. Number of exposures was defined as the number of times an average graduate of today's AIT program would need to encounter a given task before being able to perform it independently (i.e., without "over the shoulder supervision"). We classified a task as difficult ("hard") if at least three supervisors rated the task and both the mean and median rating indicated that three or more exposures were required. We then aggregated these ratings to the component level, by classifying a component as "hard" if at least one task was hard.

Frequency/exposure. SL10 maintainers in each MOS were asked to report the frequency with which they had undertaken maintenance actions on each component within the past six months. We also obtained similar frequency ratings for specific tasks on the components, but in this analysis we consider only the overall component-level frequencies.7

7A task-level analysis yielded similar findings.
Results for 67Y, 67N, and 68J

Table 10 displays illustrative results from these data. The top panel of the table shows the number of components considered in the surveys for each of the three MOSs, based on the tasks prescribed for SL10 personnel in the Soldier's Manuals and MACs. For example, these sources prescribed 192 such components for 67Y personnel.

The middle panel of Table 10 shows the number of components that were classified as being "hard" (according to the three-exposure criterion for training). For 67Ys, that number was 95—about half of the components. Finally, the bottom panel shows the number of components for which the median exposure was zero (i.e., no exposure in the past six months). Among 67Ys, this represents 74 components, or about four-fifths of all "hard" components.

The MOSs in this analysis vary in the number and average difficulty of components and tasks, but they all share a common problem for OJT-based training: many hard tasks apparently had few or no exposures during a six-month period for SL10 maintainers. The proportion of hard components with no exposures reported by the typical respondent was over 50 percent for 68Js and about 80 percent for 67Ns and 67Ys (as described above). This is particularly troubling for MOSs 67Y and 68J, which are characterized by high proportions of difficult tasks.

As noted, we also analyzed the UMSDC and WOLF databases to provide information on training exposure opportunities. The UMSDC

Table 10

Component Difficulty and Exposures by MOS

<table>
<thead>
<tr>
<th>Item</th>
<th>MOS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>67Y</td>
</tr>
<tr>
<td>Number of components covered in survey</td>
<td>192</td>
</tr>
<tr>
<td>Number of components rated &quot;hard&quot;a</td>
<td>95</td>
</tr>
<tr>
<td>Percentage of components rated &quot;hard&quot;</td>
<td>49</td>
</tr>
<tr>
<td>Number of hard components with no exposuresb</td>
<td>74</td>
</tr>
<tr>
<td>Percentage of hard components with no exposures</td>
<td>78</td>
</tr>
</tbody>
</table>

a Based on supervisor ratings of components requiring three or more exposures to train important maintenance tasks.

b Based on median number of exposures during the past six months reported in the maintainer survey.
analysis covered four Cobra units. The WOLF analysis covered 11 of
the 14 units used to examine AVIM SL10 manning levels, as de-
scribed earlier. These analyses provided information for MOSs 67Y
and 68J.

In conducting the analyses, we adjusted the overall frequency of
maintenance actions on a given component for several factors: (1)
standardization of the number of months included in the observation
period, (2) multiple training opportunities arising from each reported
maintenance action, (3) restriction to the subset of actions performed
by junior personnel (E1–E4) in the MOS of interest, and (4) conver-
sion of the resulting frequencies to average numbers of exposures per
person. We further allocated actions according to specific tasks (e.g.,
troubleshooting) to estimate task-specific exposures (as compared
with component exposures).

Because of these complexities in the UMSDC and WOLF analyses, we
have used the survey data to illustrate the analysis and its implica-
tions. We would expect UMSDC and WOLF to provide more accurate
estimates of maintenance action frequencies than the surveys. Thus,
we note that our analyses of those data showed even fewer potential
training exposures.8

Although each of the three data sources has limitations, when consid-
ered together the analyses are clear and convergent in their impli-
cations:

• All three data sources suggest that many difficult tasks arise infre-
quently in units’ naturally occurring workload. There are not
enough exposures for adequate training on the job.

• Training opportunity probably is even less than is reported here,
for two reasons. First, our illustration gives training exposures at
the component level rather than further allocating them to compo-
nent-task pairs (e.g., troubleshooting vs. component repair).
Second, the level of workload varies across units and over time; as
a result, some trainees will experience even lower frequencies than
those reported for the average person.

• To provide adequate OJT opportunity for all trainees, program de-
signers would have to perform substantial “clustering” (combi-
nation of related tasks into larger groups). In some cases, this

8Underreporting of maintenance actions arising from problems detected during
scheduled maintenance may account for the lower frequencies found in the UMSDC
and WOLF data.
clustering would need to aggregate tasks to form only a few clusters within a subsystem, or even to the subsystem level itself.

Finally, we note that MOS consolidation would increase the number of trainees requiring exposure, reducing average training opportunity and increasing clustering requirements.

**Interpretation of Results**

These are striking results that should be reviewed closely by aviation SMEs. There are limitations in these calculations, so we expected them to yield only “ballpark” results to classify workload as too low, possibly sufficient, or clearly sufficient to provide OJT. Our ingoing hypothesis was that frequencies would be low, and therefore that OJT might be a problem for some hard tasks, particularly when consolidating across dissimilar MOSs (which would encompass different tasks). Even so, the frequencies are well below what we expected.

We wondered if the tasks that had been selected as “hard” also happened to be those with lower frequencies. We tested this hypothesis by generating a ranked listing of all components identifiable on the Cobra (not just those components with hard tasks), using the WOLF and UMSDC data. We found that low frequencies characterized the vast majority of components. The survey data also bear out the preponderance of low frequencies for most components, not just hard ones.

**Implications for Training Helicopter Maintainers**

These findings suggest that MOSs can vary greatly in difficulty. For example, 10 percent of components in MOS 67N were rated as being difficult, whereas 70 percent of the components worked on by MOS 68J were so rated. The figure for MOS 67Y was intermediate, at about 50 percent. Thus, OJT may be much more feasible for some MOSs (like 67N) than others (like 68J), because most training for simple tasks can be done in the field. (We assume the maintainer will be trained when he encounters the task.) We cannot be sure where the remaining helicopter maintenance MOSs fall: closer to 67N or to 68J. In addition, some aircraft (e.g., the Apache) could generate much more workload than others. If so, training exposures for related MOSs (e.g., 67R) might be substantially higher than those reported for MOSs 67N, 67Y, and 68J.

If validated for other MOSs and aircraft, the findings imply two major conclusions. First, generically oriented AIT training, concentrating
on general skills such as use of tools, manuals, and understanding of aircraft subsystems and major components, is well suited to helicopter maintenance. The wide range of relatively infrequent tasks means that it probably is not cost-effective to prepare all trainees for such tasks in advance. Representative tasks or task types should be covered to illustrate methods and to facilitate training and contribution to productivity after arrival in the unit. This is particularly true of MOSs with many hard tasks, but coverage of general skills and illustrative tasks seems desirable for all MOSs.

Second, formal OJT programs that are heavily oriented toward task-specific training of hard tasks are not desirable. The low frequency of such tasks makes it problematic that all trainees could gain adequate exposure to become "trained up." OJT problems will be exacerbated by consolidation, particularly when the MOSs combined involve large numbers of dissimilar difficult tasks. Attempts to require more OJT should concentrate on training clusters of related tasks, with the understanding that individual trainees will acquire expertise on different tasks within the clusters. Where expertise on especially difficult or important tasks is required, OJT might deliberately concentrate exposures across a smaller number of selected trainees. This would ensure that at least some individuals learn the task. They could then perform the task and supervise others in their current and next unit assignments.

AIT TO OJT SHIFT: SUMMARY

Placement of OJT

Centralized placement of OJT appears feasible for helicopter maintenance because of the similarity of the types of work and functions performed at AVIM and AVUM within an existing MOS. Hence, skills OJT trainees develop at one maintenance level may be broadly transferable to the other, although important differences could exist at the task-specific level for some 68 series MOSs. Of the two centralized options, AVIM appears better than AVUM with respect to the variability, variety, and urgency of work.

However, decentralized OJT across both unit types—the current practice—might be desirable, because centralizing OJT at AVIM could impose unacceptable losses in experience levels in AVIM units. Our data suggest that for most MOSs, a centralized 18-month OJT program limited to AVIM would reduce average experience levels from about 25 to 9 months. The experience decrement worsens under MOS consolidation.
Source of OJT

Helicopter maintenance OJT probably will need to rely on the naturally occurring workload. It appears that expectations of using "outside time" for OJT would founder because of labor shortages in units, which arise from the combination of their maintenance and nonmaintenance duties. We doubt that junior maintainers' schedules would allow "outside time" for training after performing their duties or that they would be released from performing those duties to make time for training activities.

Size of the AIT to OJT Shift

It does not appear that task training can be delegated readily to a field OJT program in helicopter maintenance. Our analysis of three MOSs found insufficient workload to ensure that trainees would gain needed exposures to difficult tasks to learn them in OJT. Although easy tasks—requiring only one or two training exposures—might be learned in OJT, the data suggest that training difficult tasks through OJT would require grouping them into training blocks, or, in the extreme, concentrating exposures to the tasks within a block across a limited number of trainees. This approach recognizes that junior maintainers will develop experience in a general area of difficult tasks, and that individuals will become experts on different tasks within that general area. Revised AIT programs would then focus on general skills, with illustration of particularly difficult or important tasks as needed. The extent to which tasks arise infrequently in other helicopter maintenance MOSs requires further investigation.
4. MOS CONSOLIDATION AND IMPLICATIONS FOR FIELD READINESS

We consider next the implications for unit capability when an AIT to OJT shift is combined with MOS consolidation. We also suggest consolidation options among helicopter maintenance MOSs.

We first consider two of the major potential operational benefits of MOS consolidation under FBCT, as described in Section 2: (1) flexible work allocation at the unit and (2) flexible assignment of personnel among units. Against these benefits we then weigh some of the major risks, including the potential for: (1) decreased depth of MOS-specific experience in individuals as a result of broadened training, (2) a corresponding decrease in the depth of individual capability, and (3) a resulting decrement in unit capability.

The analysis will reveal two basic trends. We find that as the degree of consolidation broadens:

• The risks of consolidation grow more pronounced. (They are particularly acute when OJT trainees are concentrated at one type of unit.)

• Potential operational benefits may tail off because of the inherent dynamics of flexible work allocation and the nature of Army unit structures. Put another way, very broad consolidation may produce much more potential flexibility than the system can generally use.

We now turn to the analysis supporting these findings.

MODELING AND METHODOLOGY

The key tradeoff for unit capability is whether the benefits of greater breadth in individuals offset the risks associated with less depth. In theory, for an MOS area such as helicopter maintenance, this tradeoff could be explored directly using computer modeling. Individuals would be granted greater breadth, but less depth, and the overall impact on productivity and weapon system availability could be examined under a range of scenarios and assumptions.

Such a model, however, would require detailed information on workload, work allocation across MOSs and experience levels, team tasks,
task sequencing among different MOSs, and most troubling, individual capability under the current system and under contemplated consolidation scenarios. We did not feel that enough data relevant to the future system could be extracted from the existing one to make a "full system" modeling effort worthwhile, even in an exploratory mode. Instead, we modeled various elements of the problem individually, as a route to drawing lessons for the system as a whole. Because of its transparency, this general approach should lend itself easily to application in other areas.

**POTENTIAL OPERATIONAL BENEFITS FROM MOS CONSOLIDATION**

**Flexible Work Allocation and Unit Effectiveness**

**How Flexible Work Allocation Can Help.** This type of benefit is most pertinent to MOS areas that are geared toward "productivity" in the sense of accomplishing a workload that contributes to the functioning of a larger system. Certainly, maintenance MOSs fall into this category. In such areas, the system gains flexibility in meeting the workload as its personnel become more widely capable across specialty areas. When personnel are specialized into MOS A and MOS B, workers of MOS A may stand idle due to temporary lack of "type A" work, while "type B" jobs queue up (or vice versa). Similarly, one type of worker may be working on a relatively low priority job, while higher priority jobs queue up at the other work center. (Higher priority maintenance jobs are those that contribute more directly to weapon system availability.) Clearly, when personnel are capable of both types of work, such instances can be remedied.

Added flexibility generally offers two types of improvement: (1) constant effectiveness with less manpower (or fewer hours per day from personnel), or (2) gains in effectiveness from the same number of personnel/manhours. AMI is intended to yield the latter form of improvement and would help alleviate a manpower shortfall that is widely perceived within the aviation community. It would also help compensate for the decrement in formal schoolhouse training under AMI (particularly at the AVIM units where trainees are concentrated). We therefore look at the increased effectiveness that might be gained with constant manpower/manhour levels.

Specifically, crosstraining of personnel can result in:
• Decrease in the number of jobs waiting for service. In a
maintenance system, this reduction is a measure of "good" in that
it translates into greater weapon system availability. (The degree
to which queue reduction translates to weapon system availability
will vary depending on work management and ability to identify
high-priority jobs.)

• Potential for greater average unit productivity, should cir-
cumstances require it. If some MOSs are underutilized because of
lack of workload, broadening their capabilities may allow them to
convert idle time to productive work in other areas. This new po-
tential might increase the unit's overall productivity. If the system
is meeting its targeted performance (e.g., flying-hour program or
Operational Readiness rate for aircraft), then greater utilization of
such personnel simply relieves some of the load from other MOSs;
on average, however, the system accomplishes the same workload
(although queues decrease as noted above). This might be expected
to be the case in peacetime. In some situations, however, the sys-
tem may need to use crosstrained and underutilized personnel to
accomplish more work than it could otherwise. This might be neces-
sary if the current performance targets are not being met, or it
might occur in wartime if average workloads cannot be met by
staffed personnel in particular MOS areas. Whether this payoff is
realized, then, depends both on the existence of low-utilization
MOSs and on the situational workload.

We look at the first, primary benefit, and briefly discuss the second,
more situational one.

Insights From a Basic Queuing Model. Queuing systems—in
which customers or jobs arrive, form queues as they await service, ob-
tain service, and leave—are well understood in mathematics and op-
erations research. There is a long history of experience with such
queuing systems in areas ranging from manufacturing to telephone
and airline systems, and, more to the point, past studies of Air Force
maintenance. Picturing AVIM as a queuing system, each MOS is
thought of as a "service center" to which jobs arrive and queue up for
processing.

We used a basic queuing model to explore potential benefits of flexible
work allocation. We formulated the model to resemble an AVIM-like
situation, because the AVIM unit is the only location supporting the
full range of MOSs, and so it allows the greatest range for broad
training and flexible work allocation. (This is documented in greater
detail later in this section.) The base case was composed of 16 MOSs,
corresponding roughly to the 17 helicopter maintenance MOSs. Individuals in this 16-MOS case were assumed to be specialized, with no cross-utilization taking place. The performance of this system was compared with alternatives wherein individuals were assumed fully capable of work across two, four, eight, and 16 MOS areas (corresponding to consolidation from 16 to eight to four to two to one MOS). Note that this comparison represents the maximum possible improvement through consolidation. In helicopter maintenance, the improvement would be less pronounced because: (1) some cross-utilization already takes place in the current base case system, (2) under the FBC concept personnel will not arrive at the unit with their broader skills already developed, and (3) when their skills are developed, it will not be at a full level of capability across MOSs, but at some apprentice level of capability.

Figure 6 shows consistent results over a range of assumptions. The uppermost band summarizes cases in which the system is very busy (workers occupied 90 percent of the time) and shop sizes range from one to six to ten personnel. The lower band represents cases in which the system is less busy (occupied 75 percent of the time), for the same range of shop sizes. As expected, in all cases the total number of jobs waiting for service declines as consolidations take place. However, approximately 50 percent of the total improvement is realized when workers are cross trained into just one other MOS. More generally, a fundamental trend is apparent: when cross training across service centers (MOSs), the bulk of the queue reduction is achieved with the first few combinations. As the scope of cross training increases beyond these, the payoffs diminish rapidly. Intuitively, this can be translated to mean that “not everyone needs to be able to do everything,” because the system can rarely if ever make use of that much flexibility.

The pattern relative to the second type of potential benefit—increases in average productivity that might occur if the system is overloaded during wartime—is less clear, because it is highly situational. First,

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1 We chose 16 instead of 17 simply for analytic convenience, allowing us to reduce MOSs by powers of two.

2 In practice, operational factors will probably inhibit the payoffs of broad consolidations. For example, for shorter queues to translate to greater weapon system availability, commanders must be able to identify and focus on the highest priority tasks. The determination of priorities becomes more difficult as the pool of work broadens (requiring, for instance, decisions to be made between a phase maintenance task and a component repair in the engine shop).
it presumes that in wartime some MOS areas are overloaded on average, whereas others are underutilized. There are many possible combinations across 16 MOS areas. The magnitude of over/underutilization adds another significant variable. In general, the payoffs realized will depend on whether the consolidations made in peacetime happen to coincide with MOSs that can profit from pairing in a given wartime scenario, that is, whether shops that turn out to be underutilized in wartime happen to have been consolidated with those that turn out to be overloaded. To be certain of capturing in peacetime the "right" consolidations for an unknown wartime scenario, full consolidation would be required. Rudimentary analysis reveals that for many types of scenarios—for example, eight overloaded MOSs and eight underutilized, or four overloaded and 12 underutilized—most (about two thirds) of the potential gain would be captured with crosstraining to four MOS areas. This is similar to the result of Figure 6. However, one can devise scenarios for which this is not true. In view of the uncertainties of this type of situation, it seems best simply to recognize that there are wartime scenarios for which broad crosstraining might carry an additional payoff not represented in Figure 6, whereas there also are many in which it would not.

**Interpretation of Queuing Model Results.** The trend of diminishing returns seen in Figure 6 is a fundamental characteristic of a
queuing system, not an artifact of the input parameters chosen here. The same trend was found to hold true over a range of assumptions, some of which are not depicted explicitly in Figure 6 but which included:

- Shop sizes of one, six, and ten servers, with servers both very busy (.90) and not so busy (.75, .50, .25),
- Combining shops of unequal size (one and ten people),
- Combining shops of unequal utilization (.3 and .9), and
- Fast-paced systems (many short jobs arrive and are serviced per day by each server) and slow-paced systems (the opposite).

At the same time, the limitations of this finding should be noted. It was generated using a classical multiple-server queuing model with the following characteristics:

- Independent and identically distributed exponential job processing and interarrival times,
- Infinite population of potential jobs,
- Potentially unlimited queue length, and
- System is in “steady state.”

This model reflects the essential dynamics of flexible work allocation, which are relevant to AVIMs and to other types of queuing systems. It does not simulate AVIM operations in detail, and thus is too simplified to estimate the magnitude of payoffs that might be expected at AVIM units. (For that reason, we do not emphasize magnitudes on the Figure 6 axis.) The model is appropriate, however, for demonstrating the relative trend of potential payoffs as the scope of crosstraining broadens, which is our focus here.

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4Those with logistics modeling background will note immediately that weapon system maintenance is more precisely defined by a finite population model. However, the AVIM unit supports a large number of aircraft (typically over 100 in a heavy division), each composed of hundreds if not thousands of major repairable components. Hence, unlike unit-level maintenance, the infinite population is likely a good approximation for AVIM and requires considerably less data.
How Unit Structures Can Affect Consolidation Benefits

The potential benefits of cross-training can be achieved only if there is opportunity to exercise those broad skills at a given site. In some areas, the Army unit structure may preclude this. That is, even if individuals can be broadly trained they may be able to use only a portion of that training at a given unit assignment.

In helicopter maintenance, AVIMs are well suited to train for broadly consolidated MOSs because they perform a significant amount of work across the spectrum of specialties. As Figure 7 shows, most AVIMs support nearly all types of aircraft and, therefore, could offer training on nearly all 67 series MOSs. However, under an AVIM-based OJT system, most trainees would “graduate” and move to AVUM where, as Figure 7 also shows, they would support (predominantly) only one or two types of aircraft.\(^5\) Hence, AVIM can train a wide range of 67 series MOSs, but only one or two can be brought to bear at any given AVUM. A similar story appears to apply

<table>
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<tr>
<th>AVIMs can provide broad scope of training across aircraft types:</th>
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<tr>
<td>Heavy Div (10)</td>
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<tr>
<td>AH-64</td>
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<td>AH-1</td>
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<td>OH-58</td>
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<th>AVUMs offer limited opportunity to use it:</th>
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<tr>
<td>Attack Bn</td>
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<td>AH-64</td>
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| Or: |
| AH-1 |
| OH-58 |

| Or: |
| UH-1 |

Figure 7—Aircraft Supported at AVIMs vs. AVUMs (shaded entries)

\(^5\)This information is drawn from Army Field Manual FM-111, Aviation Brigades. Numbers in parentheses in Figure 7 indicate the number of each division type in the force. Each battalion command typically will also have three lift aircraft (UH-60), which we do not depict at AVUM because of the very small number.
for 68 series MOSs. The AVIM unit has a full range of these specialties, each in sizable quantity, consistent with its mission of major component repair. (According to the EMF, units might typically have six to eight 68F personnel, ten to 14 persons for other 68 MOSs such as 68B and 68D, and from 20 to 30 68Js. These counts include all skill levels in the MOS.) AVIMs hence have the potential to train a wide variety of 68 series specialties. Once again, however, trainees would proceed to AVUM which, excluding avionics, is dominated by 67 series MOS and 68J work. AVUMs carry very limited (one- or two-man) representation in 68 series MOSs B through F. This is reflected in the distribution of manhours at AVUM. Figure 8 shows estimates of the distribution of manhours for unscheduled maintenance at AVUM (excluding avionics) and for scheduled maintenance in total (a large portion of which is performed at AVUM).6

Hence, although AVIMs might provide broad-based training in both 67 and 68 series MOSs, under an AVIM-based system trainees would proceed to AVUM where they would have an opportunity to use only selected skills. This implies that for broad consolidations:

- Much of the initial AVIM training might be superfluous at any given AVUM. Though a maintainer might later be transferred to another unit that would draw on a different set of skills, his training in that area may be well behind him and of limited use.
- The maintainer would probably be more effective at AVUM if his training was less broad and his training time was spent instead on the type of duties he might perform at a given type of AVUM.
- A system giving broad initial training but then using only a portion of it for long periods results in subspecialization. Maintainers' actual experience and skills could vary widely, but they would carry the same MOS. For example, mechanics with primarily Apache experience would carry the same MOS as mechanics with primarily

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6The upper portion of Figure 8 is based on UMSDC data at units in our sample. We excluded the flying units. (Under an AMI-like plan, OJT graduates would not be placed there.) These, however, are manned almost exclusively by 67 series MOS and, hence, if included would only increase their proportion of all work shown here. To produce the data represented in the lower portion of the figure, we took estimates associated with each aircraft type from the Sample Data Collection (SDC) scheduled maintenance summary reports, and then averaged them with weights assigned proportionally to the number of each aircraft type in the active inventory. We did not weight further by flying hours. The "other" category in this figure includes technical inspectors, pilots, and the like.
Figure 8—Distribution of Maintenance Manhours at AVUM by MOS
Huey experience. Therefore, although such personnel appear easily interchangeable to the personnel system when making unit assignments, they might not be. The personnel management task could be made more difficult, rather than simplified, and units might not be able to receive the skills they require.\footnote{At this point we reach a definitional issue. Some label or “tag” would need to be devised to describe the individual’s area of work experience and capability. Although this seems to resemble an MOS, it might be possible to develop a simple tag with fewer systemwide implications. All personnel might be of one “MOS” in terms of promotion structure, etc., but be tagged by their different capabilities. Such scenarios would need to be considered carefully by Army personnel experts.}

For these reasons, AVUM unit structures appear to seriously limit the operational payoffs of broad consolidations. Some of these restrictions may be ameliorated if the Army implements certain future support structure concepts now under consideration. We discuss this in more detail in Section 5.

\section*{RISKS OF COMBINING MOS CONSOLIDATION WITH A SHIFT TO OJT TRAINING}

Generally, when considering MOS consolidation in a context other than FBCT, program designers contemplate longer formal training times to accommodate the wider range of material to be learned. For instance, two 15-week courses might be combined into one 30-week course, or, if there is commonality between the courses, something between 15 and 30 weeks might result. FBCT, by contrast, undertakes to combine MOS responsibilities while reducing or holding constant the total length of formal training per individual, shifting instead toward OJT at the unit. (AMI is an example in which courses of 13–30 weeks in length are combined into a course of 10 weeks or less in length.) Coupling of consolidation with reduced (or even constant) AIT poses special risk.

To assess this risk, we analyzed three key effects of such a training program:

- How consolidation causes the depth of an individual’s experience to decline as depth is traded off for greater breadth during OJT.
- Whether the decline in experience is likely to cause a corresponding decline in depth of individual capability. This will depend on the difficulty of train-up in a given area.
• Whether estimated reductions in individual capability have major consequences for the unit. This will depend on how much capability the unit requires of the individuals.

Before beginning, we define more specifically the FBCT program under which the consolidation is assumed to take place.

**Defining a Helicopter Maintenance Illustration**

An illustration of interest would be an AVIM-based program with an 18-month OJT program for the average trainee. This would allow insights into an AMI-like program and is the most natural formulation because (1) unrestricted cross-training is possible only at the AVIM unit, and (2) an 18-month initial unit assignment appears to coincide with the current unit rotation times for junior personnel. Consistent with AMI, this illustration will assume that FBCT trainees concentrated at AVIM replace the current SL10 personnel there, and that only the 13 nonavionics MOSs are included in the consolidation plan.

**Issue 1: Effect of MOS Consolidation on Experience Levels**

The primary effect of MOS consolidation on the individual under an FBCT program is to spread out his work experience over a broader area than before. This is true during the initial, formal OJT period, and also thereafter as he continues to work in his new, broader MOS area. For example, under the current system the first $t$ months after AIT are spent developing expertise in a single MOS area, whereas under an FBCT program those $t$ months might be spread across $n$ MOS areas. The individual is gaining greater breadth of experience, but sacrificing some depth. We have already discussed the benefits of increased breadth in terms of flexible work allocation. We did so, however, ignoring the effect of the loss of depth that we must now add to the equation.

The time spent in any one MOS area ($t/n$) will decline as the scope of consolidation increases. During the 18-month OJT period, the number of months experience in any one of the current MOS areas drops off quickly as we increase the number of areas being trained. (See the top portion of Figure 12, where we assume for simplicity that OJT time is spread equally among the MOS areas being trained.) As the individual loses depth, so does his unit. This is particularly true when all trainees are concentrated at one type of unit. Figure 9 depicts the levels of experience among SL10 maintainers in a "typical"
68B shop at AVIM, as described in Section 3. The white bars indicate the experience loss (relative to the current system) that would be caused by centralizing trainees there, without consolidation. (See discussion in Section 3.) Now suppose that in addition the 13 nonavionics MOSs are consolidated into three MOSs, each composed of four or five of the current ones. During an 18-month OJT, each maintainer would receive only 4.5 months experience (at best) in each of the old specialties. At any given time, SL10 personnel would have completed half the training on average, thus gaining only 2.25 months experience on average in each of the four current MOSs. This additional decrement in experience due to consolidation is shown by the diagonally hatched bars, with each individual at slightly different points of progress.

Such a decrement appears daunting. However, by itself it does not necessarily imply significant damage to the unit’s capability, because it is not clear how much experience is necessary to develop capability in the area. Continuing with the three-MOS example (each of which includes four of the current MOS areas): if we believe that each of the four current MOS areas can be learned in about four months, then an individual in the current system would be fully trained in his MOS by the 18-month mark. However, an individual in the new system would
be fully trained in all four areas. On the other hand, if about 18 months are needed to master the areas, then under the current system an individual at the 18-month mark would be fully trained, whereas under the new system he would not, being only partially trained in each of the four areas. We must translate “experience” to “capability” before drawing conclusions.8

**Issue 2: Effect of Experience Decrement on Individual Capability**

An Aggregate Measure of Individual Capability: the FTE. We defined a rough measure of capability for helicopter maintenance: the ability to perform a task independently, without “over the shoulder” supervision. (Final quality control inspections are of course necessary.) This ability marks a critical level of accomplishment in terms of the maintainer’s potential to contribute to unit effectiveness. It does not imply that to be productive an individual must be able to perform a given task independently, since many tasks can be done in teams. It does, however, mark the individual as ready to supervise others on the task, to lead a team. In wartime we would expect the ability to function independently to be at a premium; under high volumes of work, personnel who can work alone are particularly valuable. Also, because independent work implies a level of technical capability—an individual can be expected to perform the task adequately—we would expect such individuals to be better able to adapt to new and rapidly changing situations that can characterize wartime operations.

Therefore, we consider the percentage of tasks that an individual is able to perform independently to be a useful first-order measure of the degree of his train-up. For convenience, we refer to a maintainer who is capable of independent work on the full range of typically occurring tasks in his MOS as 100 percent of a “full-time equivalent (FTE).” Similarly, a maintainer who is capable of independent work on only 50 percent of tasks is 50 percent of an FTE.

More detailed measures would include the amount of time and supervision a maintainer requires to perform various tasks, as well as the quality of the maintenance action (accuracy of fault diagnosis; ex-

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8Of course, the expertise developed depends not only on the amount of time spent but on how that time is spent: what workload has been available, the supervisor’s availability and talent for training, the initiative and aptitude of the individual, etc. However, most of these factors are outside the control of the planner, whereas experience level (in terms of time spent) is a planning factor.
ecution of removals, installations, and repairs without damage to parts or weapon systems; etc.). Although detailed information concerning performance and supervision times was not obtainable in this study because of ODS-related events, we did obtain some approximations of how these measures change with experience levels. The results are discussed below.

**Estimating Train-up.** We surveyed five to ten supervisors from each of the helicopter maintenance MOSs and had them estimate the percentage of day-to-day maintenance tasks they felt a current AIT graduate could perform independently as his experience at the unit increased. Responses were elicited based on MOS and considering “average” graduates, “fast burners,” and “slow learners.” Although we would expect train-up times at the unit to depend on MOS, we found that such differences could not be meaningfully distinguished in our data. We believe this is attributable to (1) the small sample size, (2) lack of respondents for “high-tech” (e.g., AH-64) MOSs, which we might expect to exhibit more pronounced differences, and (3) the special treatment trainees receive in more difficult MOSs. (Under the current system, more difficult MOSs can have AIT lengths more than twice as long as simpler MOSs, and they admit more highly selected personnel.)

We have chosen, therefore, to use the curve shown in Figure 10, which broadly characterizes the train-up estimates for helicopter maintenance MOSs. This composite curve is quite rough, and more accurate versions might be elicited by drawing more rigorously on a larger set of respondents. The curve is sufficient, however, for the first-order assessments we wish to make. It indicates, for instance, that to become capable of independent work on a majority of tasks (65 to 70 percent), maintainers are consistently estimated to require on the order of 1.0 to 1.5 years, rather than, say, three to six months.

These estimates are generally consistent with the results of other more detailed survey questions concerning supervision and performance times. In one question, supervisors were asked to provide the performance times required by maintainers in their MOS to correctly perform the same amount of work that a maintainer with two years’ experience would accomplish in one hour. Answers were provided for maintainers with 3, 6, 12, and 18 months’ experience. In a related question, respondents estimated the amount of supervision (in minutes) required for maintainers at each of those levels of experience for the given amount of work. The information was provided for each major subsystem in the questionnaire (e.g., powerplants, instrumen-
Figure 10—Rough Train-Up Rate for Helicopter Maintenance MOSs

tation) and for each type of work (i.e., remove/replace, repair, troubleshoot). Figure 11 summarizes the overall results for supervision time by MOS, for those MOSs in which we had a sufficient number of respondents. It shows supervision requirements tapering off at about 1.0 to 1.5 years of experience, which is roughly consistent with Figure 10. Results for time to complete tasks, though not shown here, were similar. By about the 12- to 18-month level of experience, maintainers were judged able to correctly perform work in roughly the same time frame (within 25 percent) as maintainers with 24 months of experience.9

Comparing Capability Under the Current and FBCT Systems.
Some interpretation is required to apply the train-up curve of Figure 10 to anticipated graduates under our “AMI-like” example, because the estimates are based on the current AIT graduates with whom supervisors were familiar. In one respect, FBCT graduates might be

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9The questions had to be tailored to the smaller sample sizes created by the deployments for ODS. This may have encouraged some stereotyping and raised the estimates for junior personnel. Future assessments should use standard versions of the questions. In any case, we do not believe this change affected the overall pattern of results.
Figure 11—Reduction in Supervision Requirements Over Time
expected to train up more slowly: they will have far less AIT training specific to any given area. On the other hand, the FBCT trainee might be expected to train up more quickly in the additional MOS areas he encounters later in OJT. Part of train-up is becoming oriented to unit and Army life, which will be required once, not in each new MOS area. More important, as the apprentice progresses in OJT, he will build up transferable experiences in maintenance procedures, tools, technical manuals, etc., and in more specific skills where MOSs are similar. Hard data on “transferability” will not be available until a pilot training program is implemented, but we expect transferability will be variable across the MOSs. We would expect little transferability between the “high-tech” 68J armament specialist and the less sophisticated 67V OH-58 aircraft mechanic, but a great deal of transferability between the 67N Huey mechanic and the 67Y Cobra mechanic (because the aircraft share the same engine, rotor, and drive systems). In this analysis, we assume that the negative effects of a decrease in formal training and skill decay during OJT across multiple MOSs are roughly balanced by the positive effect of transferability. Hence, the train-up estimates for current graduates and FBCT trainees are assumed similar. (As will be seen shortly, assumptions granting greater transferability do not notably alter the findings.)

Using the train-up information in Figure 10, we can equate each point of the individual experience curve to a corresponding capability, yielding the result shown in Figure 12. Clearly, the amount of capability the trainee could be expected to develop in each MOS area falls off rapidly as the number of MOSs he takes covers increases. The pattern remains similar even when higher “transferability” is assumed across all MOSs. The dashed line assumes that train-ups are reduced in every area by an average of 30 percent (despite decreased formal training and skill decay as maintainers move across areas). Nonetheless, the trend remains about the same, with the amount of capability declining significantly as crosstraining broadens.

Basically, it appears that helicopter maintenance MOSs are sufficiently challenging that an individual cannot become trained in a few months. Although his breadth across MOSs is increasing, there appears to be a significant decrement in the depth of his capability in any given area. This can be measured in terms of decreased ability to work on a variety of tasks (Figure 10) and of increased performance time and supervision time requirements for specific tasks (Figure 11 and discussion).
Figure 12—Decline in Capability with Decline in Experience
Issue 3: Effect of Decline in Individual Depth on Unit Capability

The decrement in the depth of an individual's capability need not be a liability, if, as under an apprentice concept, less is to be asked of the individual at the unit. The question then becomes: Can the unit afford to ask less of these individuals? Or, put another way, can the AVIM unit in our illustration still accomplish the same mission it does today, particularly were it to deploy to a combat situation? To answer this question we must assess unit-level capability.

Figure 13 uses the train-up information shown in Figure 10 to translate unit experience profiles at AVIM to profiles of FTE capability. Once again, 68B is used for illustration, but results are similar in other MOSs.

The results imply that today's AVIM units have a number of highly capable SL10 individuals (60 to 100 percent FTEs) in the current MOSs, whereas under the FBCT model FTEs would fall dramatically. Is this acceptable to the unit? Our observations indicate that:

- A great deal of potential capability under the current system could be lost under a program like the one examined here (i.e., AVIM-based, large-scale consolidation). We would expect this potential to be particularly critical in wartime.

- Even in peacetime, SL20 and SL30 personnel would be faced with a significant rise in both supervision and maintenance requirements. Figure 13 suggests that current SL10s can often work independently or supervise each other. Under the new program, however, the figure indicates trainees would be capable of very little on their own. At the same time as the supervision burden rises, more of the difficult work presumably would fall to the senior personnel, since the apprentices would be unable to perform it in a timely manner or be unable to perform it at all.

The consequences of this loss in SL10 capability are emphasized by the data in Figure 14, which depicts the percentage of total man-hours accounted for by pay grades E1–E6 on various kinds of unscheduled maintenance jobs at units in the UMSDC sample. For example, E4s account for 40–50 percent of all repair, remove/replace, and troubleshooting manhours. This reflects the high numbers of E4s in the force, as well as how they spend their time. (Note, for example, that despite their high density in the force E4s account for less than
Figure 13—68B Shop: Decline in SL10 Capability at AVIM

Figure 14—Percentage of Unscheduled Maintenance Manhours by Pay Grade
20 percent of inspections.) These curves suggest that SL10s are not merely "tool box carriers" in the current peacetime system. Hence, although we are not able to quantify the full impact of these maintainers on overall production—that would require data not currently available regarding reject and rework rates, repair flow times, etc.—one conclusion seems clear: units rely on SL10 maintainers for a significant portion of all types of maintenance, and would suffer from a significant decline in their capability.

SUGGESTIONS FOR SELECTIVE MOS CONSOLIDATIONS

Findings in this section clearly discourage broad consolidations in the context of an AVIM-oriented OJT program. More selective consolidations might be feasible, particularly if they are chosen so that:

1. Transferability of skills between the MOSs is high, decreasing train-up time in the new MOS.
2. Opportunity for cross-utilization of skills at the unit is high, allowing payoffs from flexible work allocation to be realized.

During our visits to field units, we interviewed or surveyed 52 supervisors and some 20 quality control personnel to elicit their suggestions for MOS consolidations. We asked them to create new combinations from the current MOSs according to the two criteria above. We also stipulated that the new combinations should not exceed a person's training capacity during the first term. Uniformly, the combinations suggested were quite limited, and in no cases did they approach consolidation to one or even a few MOSs.10 Based on these interviews and surveys, reviews of current course content, and a supporting analysis of UMSDC data, we offer the following suggestions.

Combinations Within the 67 Series

Personnel in the 67 series are trained to perform basic tasks across subsystems (e.g., engine, pneumatics, electrical) on a particular type of helicopter. Consequently, there is similarity across these MOSs in terms of functions and basic subsystem familiarity. Tables 6 and 7 reflect some aspects of this similarity, showing that 50 to 60 percent

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10 Some of the limits might result from field personnel thinking less boldly than would planners searching for broad consolidation possibilities. Field personnel were told, however, that MOS consolidation was being considered for first-term enlistees, and that one option was reduction to a single "apprentice" MOS that would receive AVIM-based OJT training.
of the actions performed by these maintainers consist of removals, installations, and replacements across such subsystems. Much smaller percentages of the actions are scattered across the remaining functions.

These are broad similarities, however. Important differences apparently exist among aircraft from the maintainer’s point of view. Most of our respondents felt the small OH-58 A/C observation helicopter was the easiest aircraft to learn, and for that reason MOS 67V could be consolidated most easily with other 67 series MOSs. At the other end of the spectrum, the large, twin main-rotored CH-47D troop carrier was considered to be “a world unto itself,” and it was felt that MOS 67U should not be consolidated with any other MOS.

67Y-67N, 67R-67T. The respondents noted that a particularly apt pairing would combine 67Y Cobra and 67N Huey mechanics. Though the Cobra has significant technological advances over the Huey related to its capabilities as an attack helicopter, it developed from the Huey and the two retain many structural similarities, including essentially the same engine, rotor, and drive systems. To a lesser degree, the Apache and the Blackhawk aircraft also share some similarities. Both have twin T-700 turboshaft engines and share sophisticated technologies. Although the Apache is far more sophisticated than the Blackhawk, our respondents felt that at the level of the 67 series (67R and 67T, respectively) the jobs may be somewhat comparable.

Unfortunately, similar aircraft tend to be located at different units. (Section 5 considers future unit organization concepts that may have different structures.) Cobras and Hueys generally are not colocated in significant numbers. Cobras are assigned to cavalry and attack battalions, whereas Hueys are assigned to air assault units (although found in small numbers elsewhere). A similar situation exists for Apaches and Blackhawks. Hence, pursuing consolidations based solely on similarity might yield AIT cost savings, but at the unit level there would be little payoff in flexible work allocation and limited opportunity for one person to grow concurrently in both areas. Instead, subspecialization would take place.

67R-67V/S, 67Y-67V. Alternatively, planners could let unit structures guide consolidation, and make similarity a secondary criterion. Advantageous pairings from this point of view would involve “attack unit mechanics” such as 67R with 67V/S (OH-58D) at Apache units, and 67Y with 67V at Cobra units. Lift aircraft mechanics 67N, 67U, and 67T would remain separate since each is located in separate types of units.
Combinations Within the 68 Series

MOSs in the 68 series are subsystem-specific, each capable of complex tasks within one (or more) subsystem(s) across a range of aircraft. This specialization pattern is readily visible in the UMSDC data in Table 9. There is thus less direct equipment similarity across MOSs than in the 67 series. At a more specific level, however, there appears to be similarity in the skills that these specialists rely on, and in some cases they are specialized on closely related types of equipment. We found the following possibilities:

68B–68D. The powerplant-powertrain combination was suggested frequently. There is, of course, direct mechanical continuity on the aircraft between these two subsystems, and many respondents saw significant transferability between the skills. The UMSDC data in Table 8 also indicate similarity in types of tasks. Some 50 to 60 percent of the actions in each MOS consist of removals, installations, or replacements, and remaining actions are scattered across the other functions. An additional appeal is that this combination exists under the civilian commercial license. This also suggests transferability, and combining the specialties would help the Army maintainer obtain the license should he wish to do so. Many maintainers seem to value this opportunity, and hence it may be an incentive for enlistments.

68G–68H. MOS 68H is a low-density MOS, with only about 200 in the active force, and respondents reported that pneumatics work was often performed by other MOSs such as 67 series, 68D, and 68G, all of which were suggested as consolidation options. MOS 68G was considered the most natural choice because it shares metalworking skills with 68H and, as Table 8 shows, 68Gs and 68Hs both carry out higher percentages of repair work than the other 68 series MOSs. Should it be decided that a specialist is not necessary, another option is simply to absorb pneumatics work into each 67 series MOS.

High-Tech MOSs: 68J, 68F, Avionics. We consider these MOSs different in kind from those above. They draw heavily on logical deduction (troubleshooting), understanding of electronics and electrical theory, ability to read wiring diagrams, use of special test equipment, and use of demanding technical manuals. This basic similarity across high-tech MOSs implies that consolidations among them might be promising; MOSs 68J and 68F, for instance, already share a common five-week core in AIT. However, caution is warranted because many electronics tasks are regarded as especially demanding. Even with the current carefully selected and highly trained personnel, mainte-
nance in these MOS areas has proven to be problematic. Consolidations should therefore be selective, and train-up times must be examined in some depth.

Although many consolidations were proposed by the SMEs we interviewed, we are not in a position to make strong recommendations because our data are limited. Avionics MOSs were not part of the AMI initiative and were incorporated into our analysis only in later phases. During our data collection period, Apache-qualified 68J and 68F personnel were scarce as a result of ODS. More important, this MOS area is sufficiently challenging to warrant consideration of non-FBCT options. Although we do not recommend specific combinations, we offer the following ideas.

The Army could benefit from a wider dispersion of 68F skills in the force. MOS 68F has low density—about 530 in the active force—and consistently was reported as one of the most keenly felt shortages at maintenance units. We suspect this is because the 68F plays a key role in a wide range of tasks involving other MOSs, and hence can easily become a bottleneck in the system. Absorption of 68F into other MOSs, such as 68J and/or 68N, may be the most desirable option. MOS 68F and 68J have some significant differences in the field, but the MOSs draw on similar basic skills, and Apache maintainers have claimed that 68Js perform both 68J and 68F tasks on that aircraft. Unfortunately, assault units—which have no attack aircraft—have no need for 68J skills, but do require 68F.

Some consolidations among the avionics and 68F MOSs may be possible. MOS 68F resembles avionics MOSs at a broad level, in terms of the pattern of workload across functions. For these MOSs, as Table 8 shows, time is split among removals and replacements, installations, troubleshooting, and inspection. Moreover, the UMSDC data also show that avionics work involves electrical systems and instrumentation, as well as avionics.

The strongest candidate for consolidation with 68F among the avionics MOSs appears to be 68N, because it is found at both levels of maintenance and shares an "on aircraft" role similar to the 68F. In contrast, the other avionics MOSs are found primarily at AVIM and are component repairers (e.g., of radios and radar systems). They

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might be combined within themselves. However, the fact that 68F is taught at Fort Eustis whereas avionics MOSs are taught elsewhere might pose institutional problems for consolidation.

In short, although we do not have conclusive data, we believe that every unit type has either 68N or 68J, and so absorption of the 68F into these two MOSs might be possible if skill similarity is judged sufficient to make train-up requirements acceptable.

Combinations Across 67 and 68 Series

Some SMEs felt that 67 series maintainers could be more effective if given more depth on specific subsystems, such as powertrain/rotor (68D), airframe (68G), and pneumatics (68I). This is consistent with the rationale for AMI, which is (in part) to develop stronger mechanics by exposing them to subsystems in more depth. However, it appears that such options are more consistent with bolstering existing MOS 67 series skills than actual consolidation, because shops specializing in subsystem work still seem necessary. If MOSs were consolidated, maintainers assigned to these shops would likely sub-specialize. As noted above, 68H may be an exception.

MOS CONSOLIDATION: SUMMARY

MOS consolidations are pursued to improve maintenance and to achieve cost savings in course development, instruction, and personnel management. Consolidation's potential contributions also include redundancy of skills (e.g., flexible work allocation at the unit or replacement of attrited personnel in combat) and more flexible assignment of personnel across units. The benefits of consolidation do not, however, increase proportionally with the scope of MOS crosstraining. In helicopter maintenance, we find that the dynamics of flexible work allocation and the nature of Army unit structures lead to a trend of quickly diminishing returns as the scope of consolidation increases.

Moreover, benefits from the positive aspects of consolidation must be weighed against the risks incurred. The type of FBCT program we have described would combine the responsibilities of currently distinct MOSs while reducing formal training. Thus, consolidation under this FBCT concept: (1) causes the depth of an individual's experience in a MOS to decline, because depth is traded off for exposures to other MOS areas during OJT, (2) causes a corresponding potential loss of capability (depending on train-up times), and (3) may lead to a decrement in unit capability, depending on how much capability the
unit requires of its members and whether the benefits of breadth can offset loss of depth.

Given the rather lengthy (12- to 18-month) train-up times estimated to be common in helicopter maintenance, MOS consolidation presents serious risks to unit capability. In particular:

- Large-scale consolidations to a single or a few MOSs require trainees to be concentrated at AVIM and appear ill-advised. Such plans are likely to offer little, if any, additional benefits to the unit relative to more conservative consolidations. At the same time, the risks are great that the influx of trainees to AVIM for broad crosstraining will seriously decrease AVIM unit maintenance capability. Although AVUM may incur an increase in experience that could decrease the workload at AVIM (as discussed in Section 2), such effects would have to be balanced against the dramatic reductions in AVIM capability implied by our analysis.

- Smaller-scale consolidations (to three–five MOSs) are less certain in terms of their likely impact on unit capability. Potentially, they offer significant benefits in flexible work allocation. At the same time, they create a significant decrement in individuals’ experience and capability within the current specialties. We cannot directly assess the net impact of these positive and negative factors.

- The magnitude of potential damage to readiness is reduced by selective combinations. Such combinations are most promising when transferability among the skills and opportunity for cross-utilization at the unit are high.
5. CONCLUSIONS AND RECOMMENDATIONS

This section is arranged as follows. First, we draw on our findings to form a “field-readiness constrained” model for FBCT in helicopter maintenance. Next, we draw implications of the analysis for the larger picture that includes the Reserve Components. Third, we consider the effect of possible changes in the future Army. Last, we note key issues that remain to be resolved in helicopter maintenance, and we comment on the applicability of the helicopter maintenance findings to other occupations.

A FIELD-READINESS CONSTRAINED PROGRAM FOR HELICOPTER MAINTENANCE

We have seen that the FBCT concept carries both risks and benefits to field readiness. We therefore pose the question: “How much progress can the Army make toward FBCT’s cost and operational objectives without incurring a serious risk to field capability?” In answer, we describe a model that pursues FBCT’s objectives while presenting relatively low risk to field capability. It incorporates (1) results of our analyses, (2) “low-risk” choices when the analyses do not reveal clear preferences, and (3) augmentations to the FBCT concept that work toward the same objectives but do so with minimal perturbation to the current system.

Features of a Field-Readiness Constrained Model

1. Selective MOS Consolidation. Consolidation from 13 MOSs to a single MOS, or even to a small number of MOSs, appears to incur a high risk of decreased unit readiness and trainee proficiency. Yet it offers little additional potential payoff relative to a more conservative scheme. Instead, we recommend selective consolidations, along the lines suggested in Section 4.

Augmentation: Fungible use of remaining specializations. By consolidating only a few MOSs, the Army need not forfeit all the benefits sought from wider consolidation. It could augment the program with provisions to enhance cross-utilization and flexible assignment of maintainers in units. These could include:

- Cross-utilization of maintainers at the unit. Even without formal MOS consolidation, maintainers who specialize in one area might
be used as "apprentices" in others. Such cross-utilization already takes place in some units.\textsuperscript{1} Steps could be taken to make cross-utilization more formally acceptable and more practical in the field.

- Training packages to support flexible unit assignment of similar MOSs. Consolidation of MOSs is not the only means of gaining flexibility in making unit assignments. Some MOSs found in different types of units may have significant skill transferability, permitting cross-unit assignments. (MOS 67N and 67Y skills, for example, are highly transferable, but the MOSs might remain distinct because of unit structure considerations discussed in Section 4.) Packages covering the less transferable skills could be provided to facilitate assignment to the different unit and training for the new MOS.

These two augmentations recognize similarities among MOSs in the context of a "just-in-time" approach: crosstraining the individual if and when a specific need is encountered.

Finally, the upper limit of field-based consolidation probably would best be gauged through a phased implementation plan. Where more ambitious consolidations are contemplated, the school might consider allowing individuals of one MOS to "field qualify" in another. Over time, the incidence of such qualifications would signal that certain consolidations are readily achievable at the unit (given workload, time, etc.) and these would become candidates for formal consolidation.

2. Reliance on Workload for OJT. Given the high work demands already placed on helicopter maintenance units and the low availability of "outside time," we would not include training during "outside time" as a central element of the OJT program.\textsuperscript{2}

3. Limited Shift to OJT. Minimizing the OJT shift appears particularly important in helicopter maintenance. The high-workload operational environment and readiness concerns suggest a strained system that should not have additional burdens placed upon it. In addition, it appears that the workload in many areas may not be sufficient to support an extensive OJT program. Instead, FBCT programs with only selective consolidations and a limited shift of training from AIT to OJT might yield cost savings at lower risk.

\textsuperscript{1}In these cases, formal consolidation might offer limited additional flexibility in work allocation, making "official" what already happens.

\textsuperscript{2}Exportable training packages could still be useful if oriented to facilitate flexibility in unit transfers or to assist with performance of infrequent, hard tasks.
For example, under AMI all students would attend a course of at most ten weeks, touching upon the full range of MOS areas. In contrast, a "field readiness" model with selective consolidations might also use shortened courses—perhaps to ten weeks—but they would be much more specialized than under AMI. As a result, students would receive greater depth of training, reducing the operational risk to units, but potentially at substantial cost savings.\(^3\) In addition, the cost of the Field Training Detachments placed into units to ensure OJT might be reduced (or eliminated) with less ambitious consolidation plans and a smaller OJT shift. In fact, the investment in FTDs might be better placed in AIT for longer courses that avert some of the need for OJT and hence risk to the field unit. We reiterate that both the AIT and OJT training regimens need to be adapted to the presence of many infrequent tasks. To the extent that OJT is inadequate for training important tasks—a problem we expect will vary with the MOS—AIT must compensate.

**Augmentation:** Accommodating unit operations to OJT of new graduates. A possible option for reducing AIT at low risk is to consider how field operations might be altered to fit the graduates. Particularly as the Army transitions to new structures (see the subsection below on the changing Army), it may be possible to define a "training bay" (pools of work) for AIT graduates in the field.

From the unit perspective, the training bay should be of relatively low priority, thus concentrating new trainees where they have the least potential adverse impact. As the trainees acquire more experience, they would progress to other jobs. The training bay notion would contribute to the goal of an "experience forward" operation, because it places the most experienced personnel on the highest priority jobs. From the school perspective, the work included in the training bay should be fairly predictable force wide, helping to standardize the trainees' initial field experience. This would make it easier to design AIT programs that are both concise and relevant to young maintainers' needs.

In helicopter maintenance, it appears that phase maintenance might provide such an opportunity. Some maintenance officers already use

\(^3\) We do not recommend that all remaining courses be reduced to ten weeks, since for at least some areas (e.g., 68J and 68F) this would appear to incur serious risks. We present this as a boundary case. Further, the savings from course reductions will vary with MOS (depending on current length, throughput, and so forth), and hence more selective course reductions may be possible.
this work as a training ground for new arrivals, though the policy is not uniform across the force.⁴

4. Placement of OJT: AVIM, or Both AVIM and AVUM. With only selective consolidations and a limited shift to OJT, the risk of an AVIM-based system would be much lower than under more sweeping revisions. With only selective consolidations, it also may be feasible to assign trainees to AVUM, at least for some MOSs. However, this would depend on the particular consolidations chosen (e.g., 67 series MOSs could be consolidated only where the relevant aircraft are collocated), and it might aggravate AVUM maintenance problems such as No Evidence of Failure (NEOF) rates, urgency of work, and so forth.

Comparative Advantages of the Field-Readiness and AMI Models

The field-readiness model presents considerably less risk to readiness than does a program like AMI, in that it avoids very broad consolidations, major increases in OJT, and presumed availability of outside time in which to execute OJT. At the same time, it has a number of potential strengths.

AIT Course Reduction. The field-readiness model may offer significant potential savings, although probably less than AMI. If formal OJT can be minimized to the point where FTDs are not required, savings might be comparable between the two models.

Course Development Savings Through Consolidation of MOSs and Reduction in Number of Different Courses. The field-readiness model could yield significant savings, although less than AMI (because only selective consolidations would be made).

Personnel System Savings. The field-readiness model would yield some personnel savings from consolidations. The extent of savings under AMI is not clear, since AMI reduces the number of existing MOSs only in the first term. If the more limited consolidations proposed under the field-readiness model could be maintained beyond the first term, the savings might equal or exceed those under AMI.

⁴It should be noted that “phase teams” often perform both phase and unscheduled maintenance; the term seems to be used to distinguish these teams from the 68 series “shops” and from crew chiefs in the flying units. Hence, training an individual on a phase team is not synonymous with training on phase maintenance, whose character is more predictable and of lower urgency than many unscheduled jobs.
Flexible Work Allocation at the Unit. Both programs probably offer roughly the same potential and have the same potential for cross-utilization.

Flexible Unit Assignment. On the surface, AMI appears to offer greater flexibility because of greater consolidation. However, over the longer term we would expect the gap to close because: (1) subspecialization probably would take place under the AMI model, eventually creating difficulties in matching personnel skills to unit needs, (2) augmentation through exportable training packages would increase flexibility under the field-readiness model, and (3) consolidations under the field-readiness model might not be limited to first-term enlistees.

Experience Forward. Both models can be configured to include (1) AVIM-based OJT and/or (2) purchasing a forcewide increase of SL30 level personnel to man flying units. However, it is not clear whether either is desirable. A “plus-up” of SL30 personnel should be considered against alternative investments such as more training, hardware improvements, and the like. In addition, field personnel felt such a program would work against maintainers’ incentives, which are to progress away from the high pressure at the flightline.

In regard to “experience forward” at AVUM, it is not obvious how much relevant experience there will increase under either model. The AVUM unit would presumably have trainees who have completed the AVIM OJT in place of its current SL10 maintainers. At first glance, this would seem a benefit. However, Section 4 demonstrated that the AMI trainee would have little real depth in any specialty at the end of OJT. Hence, when such a maintainer arrives at AVUM it is not clear he is significantly more valuable to that unit than would be a current graduate of specialized AIT courses. An AVIM-based field-readiness model also would place 18-month OJT “graduates” at AVUM. They would have greater depth but less breadth than AMI trainees. What kind of “experience forward” they would supply is again an open question. To resolve this further, forcewide personnel flows should be analyzed to verify that 18 months (or some other time frame) provides the appropriate transfer point. After that determination, additional analysis could help in better understanding the effects of having “experience forward” under alternative training programs.
THE RESERVE COMPONENTS

Training decisions must include the Reserve Components (RC). Here, we consider the significance of the RC in helicopter maintenance and the suitability of FBCT for these components.

How Significant Is the Reserve Contribution to the Army Aviation Mission?

Reserve Component units account for a significant percentage of the Army helicopter inventory. About 29 percent of Army helicopters reside in the National Guard (ARNG) and nearly 7 percent in the United States Army Reserve (USAR).\(^5\) Some 36 percent of Army helicopter maintainers are in the Reserve Components.\(^6\)

How Important Is AIT to the Reserve Components?

Personnel can enter the Reserve Components in two ways: after completion of a prior active duty commitment or as a new recruit. Prior service personnel come with their MOS skills intact, or, if they change MOSs upon entry into the RC, they can receive skill transfer training at United States Army Reserve Forces (USARF) schools (used by both USAR and ARNG personnel in the case of helicopter maintenance). In contrast, new entry personnel attend basic training followed by the same AIT courses attended by active duty recruits in their MOS. Hence, an indicator of RC reliance on AIT is the percentage of personnel that are new entries (i.e., must attend AIT). In helicopter maintenance MOSs, over 50 percent of personnel are new entries.

How Viable Is an OJT-Oriented Training Program?

Reserve aircraft are maintained in peacetime at Aviation Support Facilities (ASFs) that are manned during weekday operations by full-time civilian maintainers. On the weekends, the "M-day" unit personnel assemble for monthly training. As a rule, full-time civilian personnel also are members of the M-day unit, and usually, though not always, fill maintenance slots in the unit that trains at that ASF.

\(^5\)These data are drawn from the Army Materiel Command's Army Aircraft Inventory Status and Flying Time publication (known as the "gold book"), February 1991. These holdings are weighted toward the older aircraft, such as AH-1, OH-58, and UH-1, and the older models within those types.

“Go to war” units hence are composed of a mix of full-time and M-day personnel.

Full-time personnel probably have even greater opportunity for OJT than do active duty personnel, who reportedly get about 2.5–4.0 hours per day of maintenance time. However, FORSCOM USAR advisors estimate that perhaps 70 percent of USAR personnel are “weekenders,” and ARNG HQ officials estimate that the figure is even higher for the Guard. These “M-day” personnel have little training opportunity. They are allocated only 39 days per year in the ARNG, and only 38 in the USAR. This typically consists of one weekend per month, with a two-week annual training segment. Moreover, the 39-day figure overstates actual hands-on maintenance time, because much time is taken up by administrative actions, other training, travel time, and so forth. SMEs consistently estimate that six hours of actual maintenance time over a two-day weekend is considered quite good.

Implications for FBCT

Training models similar to AMI seem impractical for the Reserve Components in helicopter maintenance, given the high proportion of new recruits and long train-up times in these specialties. In contrast, alternatives such as the field-readiness model, which avoids major OJT increases and large consolidations, may be feasible in some form across the total force. Still, even that model may be too demanding for the Reserve Components. Given the significance of RC aviation units, the Army may wish to consider special options for the RC, such as: (1) having specialized BNCOC courses (or simplified versions thereof) for Reserve Component students (as some developers at the Aviation Logistics School have considered), or (2) allowing Reserve Component trainees to replace lost AIT time with OJT at the ASF, serving as supplemental personnel to the weekday work force.

HOW THE CHANGING ARMY COULD AFFECT OUR ASSESSMENT

A major issue concerns how well the FBCT concept fits with changes that may be on the horizon as the Army transitions to its future structure. An FBCT program such as AMI, with its phased filling of echelons—first AVIM, then AVUM—would take several years to achieve steady state from the time actual fielding begins. Such programs must fit into the future world. At a time of rapid and deep change within the Army, this is a particular concern. In helicopter
maintenance, the following possible changes appear worthy of attention:

- New maintenance structures to accommodate AirLand Operation combat strategies.
- The continuing influx of sophisticated technology in Army helicopters, including the forthcoming light helicopter (Comanche).
- The role of civilian technicians.

**Future Helicopter Maintenance Structures**

During the past several years, planners at the Aviation Logistics School, in concert with experts from the Aviation Center at Fort Rucker, have been developing an alternative support structure consistent with the tenets of AirLand Operations. The plan has reportedly passed several key stages in the process to acceptance and seems likely to be adopted in some form. The core concept involves replacing the current AVIM and AVUM organizations with a new, single organization. This combined organization has been called an "Operational Maintenance Battalion" (OMB). An OMB might look as shown in the upper portion of Figure 15. It essentially places AVUM and AVIM under one roof, with sizable contingents of both on-aircraft (systems) and component (subsystems) repair. This has been described as "two-level management of three-level support," as distinct from two-level maintenance of the type contemplated for the Comanche. The OMB would be located much farther back in the theater than are the current organizations (in response to an anticipated nonlinear battlefield). Hence, significant reliance would be placed on mobile Forward Support Teams. The lower portion of Figure 15 shows the notional OMB concept from a wider perspective. Under the new force structure, aviation brigades would be assigned to the corps, increasing from the current one brigade to perhaps five. Each brigade would be supported by one OMB, under a corps aviation group. At the division, which would have a light attack battalion in the case of the heavy unit, a microcosm of the OMB—an Operational Maintenance Company—would provide support.

The most striking feature relevant to FBCT programs is the retirement of AVIM and AVUM organizations. The current AVUM unit, with its small component repair capability and predominant support of only one or two aircraft types, leaves little opportunity to take advantage of broadly cross-trained individuals. Under the new system,
Figure 15—Operational Maintenance Battalion (OMB) Concept
all maintainers would be assigned to an OMB that supports the full range of MOSs. Implications include:

- **MOS consolidation.** The OMB structure might provide greater opportunity to take advantage of broadly crosstrained maintainers, perhaps making more consolidations possible. However, OMB platoons are anticipated to maintain "habitual relationships" with certain aviation units. Thus, although a Blackhawk unit and an Apache attack unit may both be supported under one roof, individual maintainers may be absorbed in support of one or the other, not unlike the situation in the current AVUM structure. Therefore, although all MOSs may exist at one site, one must consider in how many MOSs an individual can realistically maintain day-to-day experience.

The OMB structure may also make different types of consolidation more attractive. For example, a few MOSs might be defined to include the most frequently occurring tasks across helicopter maintenance. The remaining wide range of less frequent or more difficult tasks could then be supported by a larger number of more specialized MOSs that require more intensive and specialized training, with personnel perhaps housed in a central area from which they could be dispatched as needed. Since maintainers in the simpler, high-frequency MOSs would not be expected to grow into the more highly specialized MOSs, a key risk area of the AMI approach would be avoided.

- **Placement of OJT.** The OMB concept may lessen one of the key risks of centralizing OJT at AVIM: decreasing experience at AVIM so critically that it cannot sustain its mission. The OMB sidesteps the issue of AVIM vs. AVIM and AVUM placement, and it re-opens the issue of what should be targeted for train-up at the unit. If the OMB concept becomes reality, AIT and OJT will need to be allocated based on the new task frequencies, and there may be an opportunity to build in a "training bay" of low-priority, regularly occurring work, as suggested earlier in this section.

**The Challenge of Future Technology**

Problems in helicopter maintenance have been a high-profile topic for several years. They have been documented in Army briefings, RAND research, and in less formal discussions with aviation officials. The focus of these problems has been the influx of highly sophisticated and integrated technology in general, and the AH-64 in particular. Diagnostic software for isolating faults, such as the Fault Detection
Location System (FDLS), has proven less effective than hoped. Troubleshooting skills require highly developed logical and deductive abilities, understanding of electrical and electronic theory, and use of a variety of disparate and demanding technical manuals. Most important, perhaps, technological integration on the Apache is so complex that no explicit set of guidelines has been available to facilitate fault isolation across its subsystems (no “theory of the aircraft”).

AMI’s most direct contribution to this challenge is the “experience forward” concept. But since this depends on a force wide plus-up of SL30 personnel to fill the flying units, the option could be implemented today should the Army be willing to pay the cost. Even so, there are alternative investments that might be considered, such as the development and dissemination of breakout boxes (reportedly under way) and touring military maintainers through civilian sites such as those at Fort Rucker. Such sites potentially offer double training benefits of high operating temps and high “hands-on” maintenance time. In short, as the influx of high technology continues, FBCT programs will need to incorporate features addressed to remedying maintenance difficulties for such systems.

In particular, the forthcoming Comanche may ensure that the high-technology challenge remains at the forefront for the foreseeable future. The Comanche will replace the AH-1 and OH-58A/C. The Comanche maintenance concept differs fundamentally from current practice. It has two levels: fault isolation and removal of components down to the Shop Replaceable Unit (SRU) takes place at AVUM, and components are then sent to depot for repair. The AVIM unit does not play a role. The SRU capability at AVUM is expected to be made possible through sophisticated automated fault isolation features (including inflight recording of faults as they occur) and modular component design. The concept also calls for substantial MOS consolidation—on the order of 50 percent—and substantial reduction in maintenance personnel requirements.

The Comanche generally is considered to represent a leap in technology over that of the Apache, even greater than the Apache represented over that of the Cobra. If the Comanche’s design objectives—particularly the automated fault isolation features—are achieved, maintenance could be less troublesome than for the Apache. If not, the potential complexity of problems far exceeds that of the Apache. RAND has argued previously that the outcome will depend largely on a carefully designed maturational strategy for the aircraft prior to
and during fielding. To the extent maintenance goals are not achieved, the need for future training programs to address high-technology issues through special features will be all the more acute. More generally, since the Comanche will be fielded during the last half of the 1990s and will replace a significant portion of the current inventory, any FBCT program must be designed to be compatible with the maintenance and training requirements for the Comanche or training for the Comanche must be handled separately.

**The Future Role of Civilian Technicians**

Civilian technicians have been instrumental in peacetime support of the AH-64 and other newer aircraft. They are widely credited with playing an invaluable support role during Operation Desert Shield, and the sheer number of such technicians in the theater testifies to their contribution. As sophisticated technology characterizes an ever greater portion of the Army helicopter fleet, the role of civilians likely will continue to increase. The consequences for training are important. The role of civilians, if present in force, should be understood thoroughly vis-à-vis that of Army maintainers, so that training can be designed accordingly. For example, we have emphasized the dangers of decreasing the depth of expertise among young maintainers to gain more breadth. If units were heavily supported by civilians for the most difficult tasks, the loss of depth in Army maintainers would be much less troubling. Hence, it is important for the Army to decide what it will ask of its organic and civilian mechanics and to design those conclusions into training programs.

**REMAINING ISSUES**

This analysis has attempted to take a broad view of the field-based training problem. Nonetheless, several key issues must be resolved before training strategy details can be prescribed in the most cost-effective manner.

**Issues in Helicopter Maintenance**

**Cost.** Cost analysts should consider how costs vary from one FBCT program to the next, so incremental savings can be weighed against incremental risks. How do the savings from MOS consolidation

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(course development, personnel management system) compare with those from shortened AIT alone? Which courses carry the greatest costs? How does the cost of FTDs compare with that of more conservative reductions in AIT (or longer AIT coupled with consolidation)?

**Personnel System Implications.** The planned flow of personnel from AIT to AVIM to AVUM under AMI may not be a balanced system. Does the output of the schoolhouse match the requirements for SL10 personnel at AVIMs forcewide? If trainees complete OJT in about 18 months, are there sufficient spots at AVUMs to accommodate them? How many must remain at AVIM and what does this imply for the flow of new AIT graduates into AVIM? What are the consequences for experience levels at AVIM and AVUM? Conversely, what if the 18-month rate of OJT completion cannot satisfy the needs at AVUM? Analysis can determine how the personnel flows and experience levels at the various unit types would look in system steady state.

**ODS Experience Assessment.** Assessing the ODS experience would be highly valuable in understanding future wartime challenges for helicopter maintenance and in judging which features of FBCT programs may be preferable to the current system. At the same time, ODS represents only one “data point” and its generalizability to other scenarios should be reviewed carefully. Several aspects of the scenario were less demanding than one might wish to plan for: long warning and preparation times, plus-ups of unit personnel levels, large numbers of civilian supporting technicians, and much less combat damage than might be expected when encountering a more potent threat or fighting for a longer period than the “100-hour” ground attack.

**Applicability of Helicopter Maintenance Case Study to Other Areas**

In some respects, helicopter maintenance may represent a worst-case example of the risks associated with FBCT. First, helicopter maintenance performs a critical peacetime mission: supporting aircraft availability for training (and for the onset of conflict). This distinguishes the MOS area from others whose primary peacetime mission is training, such as tank crews. Such areas might more readily accommodate some increase in field training. In addition, train-up times in helicopter maintenance, estimated here on the order of 12 to 18 months, might be relatively long compared with many other MOSs, and the tasks may be harder, making consolidation of MOSs and development of expertise more problematic.
Aviation may be a difficult case even compared with other maintenance areas. Helicopter maintenance is widely perceived to be operating at full capacity with little room to accommodate increased burdens such as a significant OJT program. Evidence of this is found in FORSCOM directives and in the presence of large contingents of civilians, among other factors. In addition, the many different aircraft types supported, the wide range of technological complexity these span, and the difficulty of most of the specialties (as evidenced by long train-up times) may be unique. The 63B truck maintainer, for instance, performs unit-level maintenance on a range of vehicle types from jeeps to five-ton trucks; these vehicles, however, share a similar, relatively low technological sophistication. Conversely, tracked vehicle mechanics, although dealing with sophisticated technology on the Bradley and the M1 tank, essentially have only those two vehicles to support. Thus, in terms of breadth of skills required, one could imagine an FBCT truck or tracked mechanic more easily than an FBCT aircraft mechanic. Finally, although safety training is always of paramount concern in Army maintenance, it would seem especially pervasive in the case of aircraft.
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