Cost Factors in the Army

Volume 2—Factors, Methods, and Models

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Preface

This report presents partial findings from the DoD Cost Factor Project, a study being conducted for the Assistant Secretary of Defense (Program Analysis and Evaluation). The study is being performed in the Defense Manpower Research Center, a component of RAND’s National Defense Research Institute, a federally funded research and development center sponsored by the Office of the Secretary of Defense and the Joint Staff.

As defined in this study, “cost factors” are measures used to estimate the cost implications of changes in defense missions, force structures, weapon systems, or operating levels. Such measures may be in the form of numerical values, equations, or models and may measure resource quantities as well as dollar costs.

This report examines Army cost factors and is presented in two volumes. Volume 1 describes the Army decisionmaking context—terminology, organizational structures, and decision processes—with particular emphasis on information important to cost factor users and developers. Volume 2 identifies and describes data sources and methods used to develop cost factors in the Army and the models that use the factors in support of the Planning, Programming, Budgeting, and Execution System and the weapons acquisition decision process.

Other documents from this project will examine Air Force, Navy, and Marine Corps cost factors. Together, the entire series of documents will provide a detailed view of the status of cost factors in the Services circa 1991 and should serve as useful reference documents for analysts concerned with costing defense functions and activities.
Summary

This is the second of two volumes of a report on the purposes, use, development, and reporting of cost factors in the Army. As defined in this report, cost factors are measures and models used to relate resource costs to indicators of Army output: force size, structure, and basing; weapon systems; and peacetime operations. The first volume placed factor development and use in context by reviewing Army organizational structure, terminology, decision processes, and decision issues. The current volume examines Army factors and the models that use them.

Cost Factors Addressed in This Study

Cost factors are measures of the input costs associated with units of defense output. Conceptually, defense outputs consist of military capabilities within various force structure, technology, and mission areas. For measurement purposes, however, outputs are usually specified in terms of the design and performance characteristics of weapon systems, numbers and types of force structure elements (such as battalions or divisions), and peacetime operating levels. Changes in these outputs imply changes in the quantities and types of resources—such as manpower, supplies, and equipment—that generate defense costs. Cost factors show how input costs vary with outputs.

The cost factors considered in this study address recurring operating and support costs (such as tracked vehicle maintenance), nonrecurring operations and maintenance costs (such as resources for base closures), and certain other investment costs (such as construction of air traffic control towers). The study also examines “intermediate” factors that are used to develop cost estimates in the foregoing categories, such as personnel pay rates. This study does not examine the Cost Estimating Relationships (CERs) used to estimate major procurement costs or major procurement-related research and development and construction costs and does not examine factors used for costing the research, development, or acquisition of management information systems.

Decision Processes and Cost-Factor Criteria

This study is concerned with cost (and intermediate) factors that are (or, if readily available, would be) used in the Planning, Programming, and Budgeting System (PPBS) and in the weapons acquisition decision process in the Department of Defense, both in the Office of the Secretary of Defense and within the Services. Although there are some differences in the way costs are measured and aggregated for these two processes (see below), they both entail “decision costing.” It is concerned with decisions to alter defense outputs in ways that would (or could) alter overall defense costs; the objective is to project how a decision would change aggregate resource use and then to determine the
cost implications of that change. Thus, decision costing requires cost factors that measure "incremental" costs.

In contrast, some PB/BS activities call for what we term "budget allocation" or "budget refinement" exercises. When the objective is to show how a given total expense within a resource or appropriation category is to be distributed among programs, the costing exercise may use average cost measures that would be inappropriate for decision costing. And when the objective is to develop a budget for a particular category of resources, the costing exercise may use factors that do not relate inputs to outputs. Budget preparation is a specialized activity that quite properly uses some specialized factors.

In many cases, factors designed for budget preparation are the only factors readily available for decision costing. In other cases, separate factors are developed, but it is unclear which of the alternative factors is most appropriate for a decision costing application. Consequently, even though this study is concerned with factors for decision costing, we also examine budget allocation/development methods and compare and contrast the factors used for that purpose with factors suitable for decision costing.

Army Decision Issues and the Costing Environment

All of the military Services regularly deal with five basic categories of output decisions:

- Force size and structure (the numbers and types of field units, including the level of aggregate deployable strength, the mix of mission capabilities, the active-reserve balance, and the "tooth-to-tail" ratio).
- Unit modernization (the technological capability of units, especially as embodied in weapon systems).
- Unit status (the extent to which units are adequately manned, equipped, and trained to carry out their missions).
- Unit optempo (peacetime operations for both peacetime missions and training).
- Unit basing (the locations of forces relative to their potential wartime theaters of deployment).

For much of the past decade, the focus of Army decisions in all these areas changed relatively little from one year to the next. The Army maintained a fairly stable active component troop strength, and the reserve components grew substantially. In the active component, major modernization efforts were under way, including substantial procurement of new and sophisticated materiel systems, and accompanying changes in training programs, organizational structures, and management systems. For the U.S. Army Reserve (USAR) and Army National Guard (ARNG), management tradeoffs emphasized unit activations, even when that involved constrained resourcing of some (especially USAR) units within the force structure. Support for active-unit training activities was generally ample, with operating and ammunition requirements being close to fully funded.
Throughout the decade, the USAR had much heavier responsibilities for combat support and especially combat service support than the active component or the Army National Guard. And, until the end of the 1980s, Army basing was rarely questioned.

At the close of the decade, however, the decisionmaking environment changed dramatically. Events in Europe and the Soviet Union, combined with domestic U.S. interest in reaping a "peace dividend" by reducing defense expenditures, are now forcing the Army to consider major near-term reductions in troop strength; substantial shifts in the active-reserve balance and a more balanced combat-vs.-support role for the USAR; postponements and perhaps reductions in deliveries of modernization equipment; opportunities for cost savings in training operations and operational support (such as the depot maintenance system); and base consolidations and closures, not only within the United States but abroad.

All of this is occurring at a time when Army costing capabilities are in the midst of a massive revitalization. Although the Army had established decision costing models and published standard factor sources in the early 1980s, those tools fell into disrepair by the middle of the decade. However, the decade's broad-based modernization process gradually extended to Army management information systems and processes. By the end of the decade, the Army was investing widely in new models, data collection and analysis activities, automation systems, and databases to support costing activities.

This transition is apparent in two features of Army factors and models. One is that a vast array of Army factor sources and models are currently under development, often using different methods and data sources to address ostensibly similar costing needs. Some variation is attributable to differences in the line items of detail and levels of aggregation required for different parts of the Army (and OSD) decision processes. Some is attributable to the process of change, with some older methodologies remaining in use while new ones are under development. Some is attributable to inconsistencies in Army coding systems and database structures, leading to different sources being more or less readily usable in different contexts. And, because a number of different organizations have been involved in cost-capability development, some variation can simply be attributed to different resolutions of difficult conceptual issues, different judgments about the accuracy and reliability of various data sources, and different assessments of decisionmaking needs. In any case, there is no major costing topic for which alternative models, methods, and factors are not in concurrent development or use.

The second transitional effect we observe is that many of the factors, methods, and models under development still reflect premises from the past decade. Relatively little attention has been paid to cost effects that might accompany major reductions in active troop strength—such as changes in the mix of active-duty personnel and retirees among the beneficiaries of Army health care services, or the costs associated with disposal of equipment, or the nonrecurring operational costs associated with unit deactivations.
Army Costing Approaches

One explanation for the disparities among Army cost models lies in the Army’s different approaches to costing decisions about force structure and weapons acquisitions, as illustrated in Fig. S.1. The force-unit approach associates resources with combat arms units and is analogous to Air Force methods that estimate costs per squadron. However, in what this report calls the “modernization approach,” the weapon system is viewed as the primary cost driver, demanding resources from combat arms units as well as other support. Whereas the Air Force builds its operating and support (O&S) cost estimates for a new weapon system from models for squadron operations, the Army projects O&S costs for the entire fleet of modernization equipment and uses force-unit factors only to identify the manpower support implied by the numbers and types of units to be modernized.

The two approaches are not simply different ways of formatting cost information for force-unit and weapons acquisition decisions. Each reflects a different concept of how costs are generated, and both concepts can be observed in models that address the same issue. For example, the Army’s Battalion Level Training Models (BLTM) project operational training objectives for an entire battalion based on the complement of equipment it contains, whereas the Operational Baseline Cost Estimate (OBCE) model treats operating requirements as specific to an individual weapon system that may be used in several different types of battalions.

Although the distinction between force-unit and modernization costing approaches is peculiar to the Army, another prominent variation in costing approaches—for manpower—is found in all the Services. For Program Objective Memorandum (POM) and budget development purposes, all the Services develop costs for military personnel inventories in the aggregate, based on expected gains, losses, promotions, etc. However, for costing the
manpower spaces personnel will fill in units (and in support of weapon systems), the Services generally use some kind of per-capita average cost.\textsuperscript{1}

### Sources of Army Cost Factors

In the early 1980s, the Army published two major sources of factors for general-purpose costing. One was the \textit{U.S. Army Force Planning Cost Handbook (AFPCCH)}, and the other was the two-volume \textit{U.S. Army OMA and MPA Cost Factors Handbook}. However, neither of these sources has been updated since 1984.

The sources discussed most thoroughly in this report are in current use or development. Four are handbooks that Army major commands regularly publish for their own programming/budgeting uses, and are indicative of factors used by other MACOMs. The two other sources are data from the Operating and Support Cost Management Information System (OSMIS) and The Army Force Cost System (TAFCS) database.

The OSMIS project was initiated by the Comptroller of the Army in 1979. Today, the Army’s Cost and Economic Analysis Center (CEAC) continues the project under a contract with Calibre Systems, Inc. One purpose of the project is to satisfy DoD Directive 7220.33 that calls for the Services to use existing databases to accumulate information on the actual operating and support cost experience of individual weapon systems. Another purpose is to supply O&S factors for a wide variety of Army costing, budgeting, and programming activities. The project publishes an annual report that contains the past year’s cost experience, by weapon system and major command/component, for fuel, spare and repair parts, operating rates, depot maintenance, ammunition, and other O&S resources. In addition, the project uses three years of historical data (or engineering estimates for systems without sufficient history) to develop factors for replenishment spares and repair parts, petroleum/oils/lubricants, ammunition, and selected depot maintenance costs. These factors are updated annually and submitted to CEAC in memo format.

The TAFCS is another CEAC project but under contract with Management Analysis, Inc. The TAFCS reflects the force-unit approach and has been developing models that address not only unit recurring costs but also costs of activation, deactivation, conversions, and relocations. The TAFCS project has established a factor database covering essentially all the types of factors relevant to our DoD Cost Factor Project (including OSMIS factors). These factors are available in machine-readable format.

In addition to the foregoing factor sources, this report also examines a vast array of models under Army development that either compute factors or contain default factor values in their supporting databases. Several of these models are not currently available for use outside specific Army offices but show promise as potential sources of factors or cost estimates for broader-based analytical use.

\textsuperscript{1}For further discussion of this point, see Palmer and Osbaldeston (1988).
General Observations About Army Factors

This report contains a great many specific observations about Army cost factors—their availability, comprehensiveness, suitability for alternative uses, and (based on their methodology and underlying data sources) probable validity. The following observations provide a selective overview of our findings:

- Unit modernization is clearly an important aspect of Army capability improvement and has received much attention in cost analyses. However, cost studies rarely treat modernization as part of a larger process of equipment realignment and hence may neglect relevant (primarily nonrecurring) costs. In particular, costs associated with equipment redistribution and disposal are particularly difficult to estimate with existing factors.

- There is a need for comparisons among unit-level requirements, authorizations, and actual resourcing. Requirements data are particularly easy to access and use, but may differ considerably from typically authorized or actual resourcing, and hence may produce misleading cost estimates in some decision contexts. Comparative statistics would enable analysts to make better-informed choices among alternative factor measures.

- Army data sources make it very difficult to associate command overhead and supporting-unit costs with combat arms units. Systems for identifying both command and functional linkages are in development and should be useful in a very wide range of costing studies.

- Some important changes in Army accounting procedures are currently under way: Secondary items that have been funded by procurement appropriations will now be financed through the Army Stock Fund, and depot modification labor will be charged to procurement accounts. These changes will affect cost factor development and interpretation for the next several years, until there is a base of historical data accumulated under the new funding rules.

- Factors for central supply operations (other than stock-funded items) are in an especially limited state of development.

- Although a variety of factors have been developed for distinct aspects of Army maintenance, the complexity of the overall maintenance system raises questions about the comprehensiveness of cost treatment. Available factors capture repair parts but not all labor costs incurred in unit-level maintenance organizations other than equipment-owning units, such as Area Maintenance Support Activities.

- As in all Services, the proper treatment of stock-funded and depot system overhead is questionable. To the extent that such overhead is insensitive to workloads, it is a fixed cost that should not be associated at the margin with force units or weapon systems. However, the costs charged to units for stock-funded items and depot services automatically include overhead costs. Army data sources provide separate estimates of depot overhead costs, but that is not the case for stock-funded prices.

- As is commonly true of medical support models, the Army's Non-Tactical Medical Support Model estimates retiree populations by assuming they are proportional to
current military manpower. This procedure could produce serious misestimates if troop strengths decline rapidly because there will be a lag before the retiree population declines. On the other hand, the Army’s models for costing base operating support properly recognizes that some support is provided to civilians as well as military personnel, a feature that is not common to some other defense models.

- The Army has been developing a specialized system of models, the Army Manpower Cost System (AMCOS), to estimate the "life cycle" and "budget" costs associated with manpower spaces (active, Reserve Component, and civilian). The system's underlying database is exceptional in its coverage of personnel-related costs, including recruitment, institutional training, and medical support (but not base operating support other than in connection with training and medical care); the TAFCS has accessed most of these data. However, the Army is reviewing the utility of the AMCOS models and may not continue to support and maintain them.

- The Army has made an important advance in construction costing by developing a database and model (R-PLANS) that relate facility needs to force-unit manning and equipping. This information is likely to be used in the TAFCS database.
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I. Introduction

This report examines the current status of Army cost factors—including the methods and data sources that support them and the models in which they are used. The findings are presented in two volumes. Volume I describes aspects of the Army context that influence costing objectives, methods, needs, and challenges. This second volume surveys currently available Army cost factors.

The description provided here is current as of the fall and winter of fiscal year 1991 and includes some information on historical factor developments and future trends. Inevitably, some of this information will soon be outdated by new techniques, data sources, and models under Army development. In future years, however, this document may still serve as an initial introduction to Army cost assessment and factor usage and as a general guide to where and how a user may obtain more current information.

The remainder of this introduction describes the focus, scope, and structure of our cost-factor review, special features of the Army context, and basic themes that will recur throughout this report.

What Are Cost Factors?

In general terms, defense management consists of making interrelated decisions about how much to spend on defense (that is, choices between defense and competing nondefense priorities) and how to provide the most effective national defense feasible within the selected fiscal constraints. Effectiveness depends on the quantities and mix of defense "outputs"—i.e., military capabilities within various force structure, technology, and mission areas. Fiscal constraints limit the acquisition and use of "inputs"—e.g., manpower, equipment, supplies, and utilities. To support defense decisionmaking, the DoD needs to be able to associate the inputs that generate costs with the outputs they can produce.

Defense accounting systems do not readily relate input costs to outputs. Defense output itself is difficult to represent and can only be quantified by using such indicators as numbers of force units and...
weapons. Budgetary accounts are designed to support the appropriations categories, such as Military Personnel and Procurement, used by Congress to fund defense; these accounts are essentially input rather than output oriented. Even the DoD's program element structure, designed to implement the Planning, Programming, and Budgeting System (PPBS) in the 1960s, does not allocate all defense costs to output. For example, depot maintenance and individual training costs are aggregated separately rather than associated with the general and strategic missions they support. Finally, both of these accounting systems categorize total defense costs, whereas defense decisions—about altering force structure, deploying and operating new weapons, and conducting peacetime operations to improve and maintain force readiness—require information about incremental costs.

Cost factors are measures specifically developed to support defense decision-making, especially by predicting how a change in defense output would affect defense spending.

Conceptually, cost factors associate input costs with measures of output to predict the cost consequences of output decisions. For example, the output measures might be activity levels (e.g., flying hours), force structure elements (e.g., squadrons or battalions), numbers of weapons systems, or their design and performance characteristics; the input measures might be expenditures on fuel or maintenance manpower. The cost factor might be a simple ratio, such as fuel expenditures per flying hour, or it might be an equation (commonly termed a Cost Estimating Relationship, or CER) or a model that shows how expenditure varies with output. In general, however, cost factors predict how a change in an output would affect defense spending.

At times, each Service has published cost factors for use in various planning, programming, and budgeting exercises, or to support longer-run investigations of defense management issues. Nonetheless, analysts sometimes find that the factors they need are not available or not readily accessible, or they cannot identify a source for a needed factor, or they are unsure how to interpret and apply a factor that is readily available. The motivation for this report is to help defense analysts find, interpret, and properly use Army cost-related data and models to help inform defense decisions.

The Scope of This Study

Broadly defined, cost factors could include estimators of any type of resource cost that might be triggered by a decision to alter defense

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1 Since cost factors attempt to associate input costs with levels of output, the quality and usefulness of a factor depends as much on its definition of output as on its measurement of costs. For that reason, Sec. II discusses Army output indicators.
outputs. Thus, cost factors include estimators in all of the following categories:\(^2\)

1. Major procurement, including research, development, testing, and evaluation (RDT&E), and related construction;
2. Recurring operations and support (O&S), including manpower, fuel, supplies, munitions, repair parts, facilities maintenance, etc.;
3. Nonrecurring O&S costs, such as resources used in initial force deployment and transport costs related to base closures;
4. Other investments, such as increments to war reserve materiel inventories and construction of conventional facilities (barracks, classrooms, warehouses, airstrips, etc.).

However, this study largely excludes cost estimators in category (1)—costs for major equipment and related construction, such as aircraft, radar sites, and nuclear sub pens. These are usually unique, high-technology items; they are produced by private industry, GOCON\(^3\) plants, or government R&D facilities; the costs of these projects are relatively well identified within existing DoD accounting systems; and most of the costs are obtained from a specialized methodology that develops CERs using engineering judgments, cost-quantity curves, and production-rate adjustments. In light of these special features, and in accord with conventional DoD terminology, we exclude major RDT&E and procurement CERs from this examination of cost factors.\(^4\)

Furthermore, this study excludes factors used in costing information system acquisitions. All other types of factors used in the PPBS and in the materiel system acquisition process are included.

Much of this study pertains to cost estimators in categories (2) and (3). Together, these costs currently account for more than half of the annual defense budget.\(^5\) Given current defense accounting systems, most of these costs are quite difficult to associate with defense outputs.

\(^2\)The categorization of cost elements varies widely over time, among Services, and from one type of costing exercise to another. The categorization offered here is for discussion purposes only.

\(^3\)Government Owned, Contractor Operated.

\(^4\)However, we include non-CER factors in category (1) when they are commonly found in Baseline Cost Estimates for new weapons systems. Such factors are covered in Sec. IX.

\(^5\)Quantitative measures of aggregate O&S funding vary. The estimate given in this paragraph is based on Pierrot (1988).
Items in category (4) do not account for a large percentage of overall DoD costs and have traditionally received little attention in cost-factor estimation. However, they can prove important in the assessment of particular decision options and hence are included in the scope of this study.

In addition, this study also identifies intermediate factors that are commonly used to develop or apply cost factors. For example, the crew manpower cost per aircraft would often be calculated by multiplying a crew-size factor by a military personnel pay factor. Although crew sizes and personnel pay rates do not relate costs directly to measures of defense output, they are often considered “cost factors” in conventional DoD terminology—and fall within the purview of this study.

Furthermore, this study examines factors that do not represent incremental costs but are commonly described as “cost factors” in the DoD. These factors are used primarily to distribute total defense budget costs among mission and functional areas and may include “fixed” or “joint” costs\(^6\) that would not be affected by changes in the programs or functions to which the costs are distributed. Although budgetary factors are not always suitable for assessing the cost effects of changing defense outputs, they may represent the only available factors for that purpose and hence deserve discussion in this report.

In summary, this study aims to cover all types of factors—except major RDT&E and procurement CERs—that might be sought or used by an analyst to support a cost assessment or budget development study.

The Structure of This Report

Our goal is to provide information useful to the broadest possible cross-section of factor users, despite the fact that different users address very different types of costing issues using a wide variety of models and methods. Thus, rather than organize this information by reference to a particular costing model or issue, we use a generic framework.

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\(^6\) A “fixed” cost is one that does not depend on changes in output, at least within some relevant range. A “joint” cost is one that is triggered in its entirety by any one of several different outputs, so that the cost is not affected if just one of the outputs is reduced or eliminated. Overhead costs often contain both fixed and joint elements.
To explain the generic framework, let us begin by describing how it would work if the DoD were a very simple producer of "widgets." That is, suppose it produced a single product and purchased all its inputs from the civilian sector. Then, an analyst wanting information on how to project the costs of changes in widget output would want information in five topical areas:

- About measuring widgets: What is a widget? Has it changed significantly (in size, function, technology, etc.) in recent years, and how might it change in the future? How is it packaged/counted/weighed/measured? What data sources provide information about widgets, their past and projected future levels of production?

- About producing widgets: What production process is used? What are the inputs to production? How are they measured? Have they or the production process changed in the past, and how might they change in the future? What data sources provide information about the production process and its inputs?

- About obtaining inputs: Where do they come from? What determines their prices? Have input markets changed recently, or are they expected to change? What data sources provide information about input markets and prices?

- About costing widgets: What models or formulas are used to compute the cost of producing widgets? What costs do the models include or exclude? Are the models supported by their own databases? In what costing context are the models used (e.g., to compare alternative widget designs, alternative levels of output, alternative modes of production)?

- About the state of widget costing: What is the current state of the art in costing decisions about widget production? What are the main shortcomings in current methods? Are improvements under way?

Of course, the DoD is not such a simple producer of widgets. Its ultimate output, whether viewed in terms of deterrence or military capability, is multidimensional and resists quantification. Its production processes are not only complex but multilayered, i.e., the DoD produces many of its own inputs (such as training and depot maintenance services). And, as a large consumer of resources from the civilian sector, the DoD not only faces normal market price fluctuation but can influence the prices it pays.

Nonetheless, our discussion still covers the same five topics listed above but with adjustments to accommodate the special features of the defense environment. Specifically:
• Since the ultimate defense output is multidimensional and non-quantifiable, cost analysts use several interrelated indicators to represent a decision’s effects on military capability. In Sec. II, we describe the indicators used in the Army context and issues in interpreting them.

• The basic mechanism for producing defense output is to construct military force elements—units—containing assets (primarily manpower and equipment), and to exercise these units in peacetime so they will be prepared for wartime contingencies. Section III describes factor information concerning the asset configuration and peacetime operations of Army force units.

• Assets and other inputs supplied to force elements are generally provided by supporting functions within the DoD. Sections IV through VIII discuss these supporting functions, their production processes and inputs, the cost rates for the inputs they supply, and the prices they pay for the resources they purchase.

• Section IX examines Army models that combine information from many sources to estimate costs associated with major output indicators.

• Section X summarizes our observations on the current state and future trends in Army cost factors and models.

We have provided some aids to help the reader navigate through the detailed information in this report. Figure 1.1, which illustrates the factor subtopics covered in Secs. II through VIII, is repeated at the beginning of each section, with highlighting to indicate the portion of the figure to be covered.

We have also provided reference materials at the end of this document: Appendix A presents an overview of several generalized Army factor sources. Appendix B offers a basic reference guide to Army coding systems. Appendix C provides supplementary detail about Army Manpower Cost System (AMCOS) models. Finally, an Index defines acronyms and indicates the pages where they are used in this volume.

**Special Features of the Army Context**

Three features of the Army context will be referenced repeatedly throughout this document. One is a set of generalized factor manuals and factor development projects that cover factors for many types of Army costs. Another is a distinction between Army modeling approaches for force structure and weapons acquisition decisionmaking. The third is the Army’s internal decisionmaking process.
Army Factor Manuals and Factor Development Projects

Although many of the Army factors and models discussed in this report have been developed for specialized use by particular users, the Army has also developed some sources for generalized costing purposes. These sources are:

- Major command factor manuals. These are manuals MACOMs publish for their own programming/budgeting uses; they generally include a varied menu of factors, such as personnel pay rates and equipment fuel costs. Most widely known among these manuals is the Resource Factor Handbook (RFH), traditionally published in two volumes by the Army Forces Command (FORSCOM) and Training and Doctrine Command (TRADOC).
• The OSMIS project. The Operating and Support Cost Management Information System (OSMIS) accumulates, validates, and organizes data on actual operating and cost experience for weapons systems and is a major source of data for Army costing exercises.

• The Army Force Cost System (TAFCS) project. Managed by the Army Cost and Economic Analysis Center (CEAC), this project has been developing models and supporting databases for force structure costing. The TAFCS database incorporates many OSMIS factors but also captures other factors necessary to support the models.

Factors in these sources fall under several different topics in the report and are referenced in those contexts. However, a cohesive discussion of these sources provides additional insight into their purpose and usefulness. Therefore, Appendix A examines each of these sources in its entirety.

**Army Modeling Approaches**

A noteworthy aspect of Army costing methodology is that it uses two distinct costing approaches, illustrated in Fig. 1.2, for weapons acquisition and other PPBS decisions. The force-unit approach used for many PPBS decisions parallels our generic framework: The combat unit is viewed as generating primary demands for manpower, equipment, operational, and other resources. In contrast, the "modernization" approach used in weapons acquisition decisions views equipment as generating demands for operational resources (primarily fuel and repair parts), and other support (primarily manpower) from units.

Though the two approaches are closely related and use many of the same factors, there are significant differences. For example, force-unit costing usually includes costs for overall base operating support, whereas weapons acquisition studies usually include only the portion of base operating costs that pertains to equipment maintenance. This report covers factors for both force-unit and modernization costing, and Sec. IX contrasts models used in the force-unit and modernization approaches.

**The Army Decision Context**

Volume 1 of this report details the Army’s decisionmaking context, including its processes for PPBS and weapons acquisition decisions. In that discussion, we introduced some basic concepts or themes that will reappear throughout this volume:
• *The Army is in transition*. Major changes are occurring in missions, organization, resourcing, funding structure, management information systems, databases, and costing methodologies. Two implications were noted above: One is that the factor information presented here may soon be outdated by new developments; the second is that some factors developed to summarize historical organizational and resourcing conditions may poorly represent future cost/output relationships.

• *Army force integration involves coordination among competing perspectives*. The force-unit and modernization costing approaches reflect two perspectives, and Vol. 1 described another based on functions, such as manning, equipping, training, and providing logistics support. In this volume, we show that different perspectives have encouraged the development of many competing information systems and alternative factor measures.
• Army units are not homogeneous. An individual unit comprises a very wide variety of equipment and associated manpower, and units with similar missions are differentially resourced. This makes it especially difficult to characterize a "typical" unit for costing purposes and can lead to substantial differences between "typical" costs and those related to a specific unit.

• Army coding systems make it costly and time-consuming to develop cost factors. A consequence is that Army factors developed for different purposes do not necessarily use the same databases or reference the same coding systems—making it difficult to reconcile information from alternative sources.

This report does not attempt to resolve the problems raised by these considerations. In the sections that follow, however, our aim is to provide information that may assist cost analysts in negotiating these difficulties.
II. Output Decisions

Most of this report will examine measures and data sources concerning the quantities and costs of resources used by Army force elements and their supporting organizations. However, it is important to recognize that a cost analysis is not concerned solely with pricing out resource changes. Part of the task is also to determine what kinds of resource adjustments are associated with changes in Army missions and capabilities.

Although a full consideration of the linkages between resourcing and ultimate military capabilities is clearly beyond the scope of this report, some discussion of the issues and the modeling techniques the Army uses is relevant to this investigation. Some new Army models offer insights into how Army analysts view the relationships be-

A cost analysis is not exclusively concerned with associating costs with defense resources. Addressing the linkage between resourcing and ultimate military capabilities is also an important part of the costing task.
between resourcing, organizational structure, and capabilities—and also motivate the collection of data that might prove useful in other costing exercises. In other areas, however, current analysis techniques do not fully capture links between capabilities and resourcing that should be considered in costing studies. This section presents information on both the strengths and limitations of current Army modeling.

This discussion is organized around the five dimensions along which cost analysts commonly measure a Service’s military posture. A typical costing exercise begins with a proposal to alter resourcing, or perhaps to cut costs, in one or more of the following areas:

- Force size and structure, especially the numbers and types of units and the active-reserve balance;
- Modernization, especially weapon system procurement;
- Unit status, the extent to which units’ resource requirements are funded and filled;
- Peacetime operating level, for either training or peacetime missions; and
- Basing, i.e., the location of units and the availability of supporting facilities.

**Force Size and Structure**

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When a cost analyst is asked to assess the implications of a proposed change in force size or structure, the first question to be asked is whether the proposal is fully specified. Specifically, the analyst should ask:

- **Will supporting combat arms units also be affected?** Above-the-line theater forces require support from below-the-line forces (see Vol. 1) that might not be mentioned directly in the proposal for force structure change.
- **Does the proposal refer to the peacetime or wartime resourcing of the affected units, and will other organizations be affected indirectly?** Army mobilization plans call for considerable training and reassignment of personnel—sometimes described as “leveling”—to occur in the early days of a major war. Peacetime units may contain resources needed to support other units in wartime or may lack resources
they would receive in wartime. And the leveling process itself requires resources that should be altered to accommodate a force structure change.

- Will the proposal actually alter resource requirements for the Army as a whole, or will resources simply be redistributed to accommodate the change in force structure? In particular, will aggregate Army troop strength or the aggregate inventory of weapon systems change?

Until recently, answering these questions, even within the Army, has been difficult and time-consuming. Force structure development took two years—one to design the force and a second to assess its affordability, limiting the Army’s opportunities to compare and contrast alternative options. And, at the Program Objective Memorandum (POM) development stage, analysts found it difficult to visualize the combined impact of decisions about troop strength, numbers of units, weapons acquisitions, and resource allocations among units and to analyze indirect support needs.

However, new Army decision support models promise to help specify and evaluate complex force structure alternatives. Here, we describe three modeling systems—SABRE, Force Builder, and the AFIA (Alternative Futures and Their Implications for the Army) project—that vary in scope, purpose, and stage of development. Each suggests insights into the nature of Army force structure development and resourcing, and each represents a potential source of techniques or data to support a wide variety of costing activities.

**The Single Battlefield Requirements Evaluator**

SABRE is an automated program analysis tool developed by the U.S. Army Artificial Intelligence Center under the direction of the Program Analysis and Evaluation Division (PAED). The system allows an analyst to examine data on force structures from Total Army Analysis (TAA, see Vol. I) or from operations plans by theater, year, day of the war, and other criteria and can forecast the units’ equippage status based on programmed acquisitions of new or existing materiel systems.¹ SABRE’s AACES (Alternatives Analyzer, Comparer, Editor, and Source) module enables a user to create alternative forces whose resourcing profiles can be analyzed via SABRE.

¹More generally, SABRE can forecast unit readiness status, as defined below.
SABRE provides a "tree chart" with command relationships along with unit resource data. The AACES module enables a user to construct national or novel force elements.

The SABRE/AACES system is not a costing model, and it does not associate indirect resources (e.g., the training base) with the deployable force structure. Nonetheless, the system is noteworthy in our context because two of its capabilities could be useful to cost analysts who need supplementary information about the types of units that might be affected by a force structure change: First, SABRE itself provides a "tree chart" showing command relationships along with detailed unit data taken from the Force Accounting System (FAS), Time Phased Force Deployment Listings (TPFDL), and Total Army Equipment Distribution Program (TAEDP); an unclassified database based on notional forces is also available. Second, AACES allows a user to construct notional forces or combine notional and real units into alternative forces that can then be examined using SABRE.

**Force Builder**

Force Builder is a multi-element decision support system being developed by Vector Research, Inc. (with the assistance of Calibre) under contract to the Office of the Deputy Chief of Staff for Operations (ODCSOF). The system is intended to support the Army programming process and hence is being designed to develop force structures defined in terms of Management Decision Packages (MDPs) and consistent with fiscal and manpower constraints. A full set of production prototypes for the Force Builder system should be available in Spring of 1991.

The centerpiece of the Force Builder system is a set of force models that effectively simulate the combined processes of force structure design and resource allocation. As illustrated in Fig. 2.1, the force models subsystem will contain five sets of models:

- The Macro Total Army Definer (MTAD) models will generate active and reserve combat forces (Divisional Increments, Non-divisional Combat Increments, and Special Forces), preliminary indicators of combat service support and the TDA (Table of Distribution and Allowances) Army, and a first-cut estimate of overall resource requirements.

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2Force Builder is also intended to meet the DoD requirement that CINC (Commanders in Chief, Unified Commands) requirements be fully integrated into the force development process.

3Specifically, the models will produce macro-level assessments of the Tactical Support Increment (TSI) and General Support Forces (GSF).
• The Micro Deployable Army Definer (MDAD) models will derive detailed requirements for combat service support.\(^4\)

• The Micro General Support Forces Definer (MGD) models will derive detailed definitions for the TDA Army, including training, medical, base operations, and other indirect functions.

• The Control Level Assigner (CLA) will match the actual inventory of Unit Identification Codes (UICs) against the Total Army Force Structure produced by the first three sets of models. The CLA models will identify shortfalls and excesses in the existing structure compared to the required one and develop a preliminary resourcing structure.

![Diagram](image)

**Fig. 2.1—Force Builder’s force models subsystem**

• Finally, the Resource Analyzer (RA) models will specify detailed resource requirements for the Total Army Force Structure in MDEF format.\(^5\) In particular, these models will estimate required Military Personnel Appropriations based on the end-strength values carried in all other MDEFs.

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\(^4\)According to the Force Builder developers, MDAD models will perform essentially the same functions as the Army FASTALS (Force Analysis Simulation of Theater Administrative and Logistics Support) model but will be enhanced.

\(^5\)Rudimentary Resource Analyzers within the MTAD, MDAD, and MGD models will ensure that their outputs conform to user-specified constraints, and feedback loops will allow retractions of the macro-level models to account for combat support and TDA results from earlier runs.
The optimization will be subject to certain initial conditions and constraints. The models will start with a baseline force projection, either from the current POM or a specified alternative. The baseline also embodies resource partitions, i.e., shares of total spending allocated to theaters, missions, and resource categories. At each stage in the analysis, these partitions represent constraints that must be satisfied. Thus, Force Builder will rely on expert judgment for rules concerning the threats to be countered, the allocation of fiscal resources to those threats, the combat/comb support service mix, and total military personnel end-strengths.

Furthermore, Force Builder will simply “through-put” resourcing levels that are particularly difficult to associate with force size and structure.

Given those constraints, however, Force Builder will select a mix of active and reserve units and will allocate manpower, unit equipment, nonunit equipment (war reserves and “float” items to replace equipment temporarily out of service or lost to peacetime attrition), most O&M dollars for Army Programs 2, 5, 7S, 7M, 8T, 8M, and parts of 12 (see Vol. 1), procurement dollars for selected equipment, and lift.

Within the Army, Force Builder promises to overcome some of the challenges in relating resources to force structure and capability de-

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6The DAMPL (Department of the Army Master Priority List, see Vol. 1) will be used to set the priorities for the objective function, though the precise specification remains to be determined.

7The model will attempt to maintain the current ALO (Authorized Level of Organization, see Vol. 1) in mobilization deployment plans for every Table of Organization and Equipment (TOE), but if strength limitations prevent that, ALOs would be reduced for the last-to-fight units.

8That is, the model will not optimize resources for RDT&E, military construction (MILCON), family housing, other procurement, Joint Chiefs of Staff (JCS) exercises, TRADOC combat development activities, communications and intelligence (Program 3), recruiting, examining, education and training (Program 8O), administrative activities (Program 9), other nation support (Program 10), special operations (Program 11), mandated projects, command and control headquarters (Program 2), Information Systems Command, and Intelligence and Security Command.
decisions. The system is expected to address active-reserve balance considerations, distinguish between the cost effects of troop strength and force-unit decisions, and help select resourcing options by reference to capability objectives. Inevitably, the output from Force Builder will be subject to review and the results may be modified to account for issues or complexities the system cannot fully incorporate, but it should help generate a wider range of options for consideration during the POM development process.

For other analysts, the structure of Force Builder suggests a basic paradigm for visualizing the force structure development and resourcing process. In addition, the system might offer linkage files for other uses. Among the system's supporting modules is a command tree that shows "parent-child" relationships within a command; Force Builder modelers also foresee uses for a "functional parent-child file" that would link support functions to combat units, but this has not yet been added to the system development schedule.

**Alternative Futures and Their Implications for the Army**

Another force analysis and costing effort similar in scope to Force Builder is currently under way at RAND's Arroyo Center (a federally funded research and development center sponsored by the Army). The objective is to project and analyze how changing threats, new mission requirements, declining budgets, and evolving technology can or should affect Army size, force mix (e.g., heavy vs. light), active/guard/reserve mix, peacetime deployment, and modernization programs. A family of research projects designed to accomplish this goal operates under the general project title: Alternative Futures and Their Implications for the Army.

Major project areas under the AFIA heading are conducting (a) combat analysis (to design in-theater combat forces for ten to 15 years from now), and (b) resourcing analysis (to design in-theater support forces, a future peacetime Army that can support the in-theater forces, and a path or sequence of programs to move the Army to that future outcome).

The force elements used in the combat analysis represent typical Standard Requirement Codes (SRCs) for categories of battalion and company-size TOE units, such as M1A1 tank battalions or AH-1 attack helicopter battalions. The analysts have developed an "orgchart" program that combines data on people and equipment by subordinate unit into larger units (divisions and separate brigades) commonly used in combat force design exercises. Current AFIA

**The AFIA project is developing a modeling system similar in scope to Force Builder but with greater emphasis on the effects of changing threats and new Army missions.**

AFIA's orgchart program combines subordinate units into the larger organizations used in combat force design exercises.
plans call for using a simplified version of the Army’s FASTALS (Force Analysis Simulation of Theater Administrative and Logistics Support) model to generate related requirements for theater support forces, and a “transition-to-war” model considers the time-phased requirements for deploying units in a theater during wartime and the activities required to supply those units (i.e., train-up, personnel movement, equipment movement) and to assess the peacetime force and support structure necessary for the desired wartime in-theater combat and support forces.\(^9\)

Once the desired future peacetime force structure is determined, the resourcing analysis will identify a sequence of changes in force structure designed to achieve the desired future structure within annual peacetime constraints on Total Obligational Authority (TOA). This part of the analysis accounts for gains and losses to equipment and personnel inventories over time. A cost assessment will apply cost factors taken in part from the TAFCS database to capture non-recurring costs associated with inventory gains as well as recurring costs associated with annual inventory stocks.\(^10\) Some costs, such as tech-base R&D, will not be modeled but just “passed through” to the totals that must meet TOA limits. The Total Army Cost Analysis (TACA) system is the resourcing-analysis subproject that is preparing the AFIA’s costing databases and models.

Both Force Builder and the AFIA models will cost alternative force structures using many of the same Army data sources (such as TOE requirements and OSMIS factors found in the TAFCS database), but the two projects differ in purpose and orientation. Whereas Force Builder is designed to analyze options for updating the Army POM, the AFIA project is concerned with designing Army forces for the more distant future and evaluating the fiscal feasibility of achieving them. In principle, therefore, the two modeling systems should prove complementary. For example, the AFIA models should provide insight into the evolution of the combat/support/service support mix consistent with achieving a future force alternative, whereas Force Builder could examine the specifics of a POM update consistent with that evolution. And any differences in the POM-year force structures and costs projected by the two systems should be a

\(^9\) The support structure includes such TDA units as supply depots, depot maintenance, procurement operations, research and development, personnel acquisition, schools, medical, combat developers, and administration. Depot stocks and equipment, excess equipment, and other equipment are also included as line items in the supporting structure.

\(^10\) Costs will be computed initially in “delivery dollars” (i.e., prices at the time of delivery) then converted to TOA using traditional patterns of TOA anticipation of buys.
fruitful source of insight into how alternative strategies for force structure development affect outcomes.

Modernization

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During the 1980s, the Army made major investments in new equipment development and procurement, and a central focus of Army planning was on the process of implementing those improvements over the next several years. For example, Fig. 2.2 shows a projection made in 1988 of how the number of selected active component units with modernized equipment was expected to change between fiscal years 1990 and 1996. Although recent events have greatly altered the Army’s future plans, the traditional strategy of strengthening Army capability by updating the resourcing of existing units establishes the context for understanding the Army’s view of modernization. Specifically, the Army has viewed modernization as a process quite distinct from changes in force size or structure.

Improvements in mission capability within a given force structure are particularly difficult to assess. New equipment may expand a given unit’s missions as well as improve its performance in established missions. Furthermore, other units may also benefit: A modernized unit’s older materiel passes down to other units, and a modernized unit may even release operational and maintenance resources to help fill unmet requirements elsewhere in the force. Even the units that do not receive the newest equipment may experience upgrades in their capabilities. Thus, modernization is a complex process of equipment (and other resource) realignment.

Resource realignment resulting from modernization also generates complex transitory costs. Resources may be absorbed, for example, to provide initial field training to acquaint unit personnel with replacement equipment. And transportation and other costs are incurred not only for the new equipment but also for older and less desirable equipment that either enters equipment reserves or is scheduled for disposal.

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11 The figure is based on an unpublished briefing chart used in the Army’s Force Integration course in 1989.
Army models for analyzing modernization costs, like those used throughout the DoD, are applied only to major materiel acquisitions and generally do not attempt to capture the full range of equipment realignment costs. Although the Army views modernization as a realignment process, Army models that deal with modernization systems (see Sec. IX) follow general acquisition-costing guidance. Hence, the models are applied only to major materiel acquisitions; they do not address modernization costs for many less costly items, such as trucks, generators, and field kitchen equipment, that can have an important bearing on Army capability. The models include cost measures for unit manpower, even when modernization will not be accompanied by changes in end-strength. And the models do not attempt to capture the full range of equipment realignment costs that can be triggered by equipment improvements within a stable force size.

Identifying the modernization implications of a decision is a useful supplement to information about force size and structure changes, particularly for the active component Army. However, the analysis should not rely exclusively on modernization-costing methods to assess the full cost implications but should evaluate whether there are likely to be additional resource realignment effects. This is an area of costing methodology that is unlikely to improve in the current environment of force downsizing and procurement postponements, but

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12DoD Cost Analysis Improvement Group (CAIG) guidance indicates that manpower costs should be measured as an opportunity cost of the new systems, even if end-strength will not change. This guidance affects only the results of acquisition-costing models, however, because the Army costs the aggregate personnel force separately when developing the POM and budget.
it is an area that will undoubtedly deserve greater attention over the longer term.

Unit Status

Output Decisions
- Force size, structure
- Modernization
- Unit status
- Operating level
- Basing

Measures of force size, structure, and modernization provide considerable information about military posture but convey only limited information about how well individual units within the structure are prepared to carry out their missions. Additional information is needed to judge unit "readiness" to fight and assess the resource implications of achieving intended readiness.

Short of direct performance measures, unit readiness is commonly judged by reference to how fully the units are resourced relative to some standard for what is needed. Like the other Services, the Army uses a system of unit status reporting (governed by Army Regulation 220-1) to develop readiness indicators. Here, we describe Army unit status reporting and then the status projection system that uses status information to aid resource allocation decisionmaking.

Unit Status Reporting

The unit status reporting system supports wartime operations planning by the Services and Joint Staff and transmits timely information relevant to war plan implementation. To those ends, all Services submit unit status reports covering four individual resourcing areas: personnel, equipment on hand (ECH), equipment readiness (ER), and training. Each (UIC-level) unit is given a rating in these four areas and overall, using the codes and interpretations listed in Table 2.1. The data are recorded in the Status of Resource and Training System (SORTS).

In the Army, the commanders of combat, combat support, and combat service support units—as well as about 150 TDA units—report unit status to their installation or division, MACOM, and the Joint

Unit readiness is commonly judged by reference to how fully the units are resourced relative to some standard for what is needed.

13 Like the other Services, the Army conducts skills tests and grades exercises to evaluate individual and unit performance. However, grading measures are not directly incorporated in centralized resource allocation decisions.
Table 2.1
UNIT STATUS RATINGS: CODES AND INTERPRETATION

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<th>Code</th>
<th>Interpretation</th>
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<tr>
<td>C-1</td>
<td>Unit possesses the required resources and is trained to undertake the full wartime mission for which it is organized and designed.</td>
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<tr>
<td>C-2</td>
<td>Unit possesses the resources and has accomplished training to undertake the bulk of its wartime mission.</td>
</tr>
<tr>
<td>C-3</td>
<td>Unit possesses the resources and has accomplished the training necessary to undertake major portions of its wartime mission.</td>
</tr>
<tr>
<td>C-4</td>
<td>Unit requires additional resources or training to undertake its wartime missions but may be directed to undertake portions of its mission with resources on hand.</td>
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| C-5  | Unit is undergoing directed resource change and is not prepared to undertake its wartime mission. This rating is restricted to units:  
  - Undergoing major equipment conversion/transition;  
  - Placed in cadre status;  
  - Being activated, inactivated, or reactivated;  
  - Not manned or equipped but required in wartime force structure;  
  - In training that could be tasked to perform a wartime mission. |


Staff. Active component units report monthly, USAR units report semiannually, and Guard units report quarterly.

Ratings for personnel and equipment are based on objective criteria. In contrast, unit training and the overall unit ratings are based on the unit commander’s subjective assessment. The overall rating is generally the lowest of the ratings in any of the four areas.

In all cases, however, the ratings are developed in the context of the specific unit’s particular missions and taskings. For example, the standards for personnel and equipment ratings are the wartime re-

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14 Equipment readiness codes (ERCs) in the Modified Table of Organization and Equipment (MTOE) identify the equipment relevant for status reporting by each unit: Code A means mission essential, and code P means a pacing item of equipment. Pacing items are defined as a unit’s major weapon systems, aircraft, and major items of equipment that are central to an organization’s capability to perform its designated TOE/MTOE missions. For units that have pacing items, the ER and EO11 ratings can be no higher than the lowest level of the least ready pacing item. According to Army Regulation 700-138 (1990), the standard for determining most equipment readiness is 90 percent fully mission capable, but for aircraft the standard is 75 percent.
quirements specified in each unit's MTOE (described more fully in Sec. III). Those requirements are unit-specific and reflect the unit's particular missions, the theaters in which it will operate in wartime, and the time of deployment under mobilization. Two apparently comparable units can have the same ratings and yet be differentially resourced—and have different wartime capabilities.

According to AR 220-1, one purpose for unit status reporting is to assist the Department of the Army and intermediate commands in allocating resources. The Army currently used two models to support such allocations. One—the Battalion Level Training Model—Training Resource Model (BLTM-TRM) methodology for unit training management—will be described below under Operating Level. The other is the Status Projection System (SPS).

The Status Projection System

Although intended to support resource allocation decisions, unit status reports neither project future status nor analyze how changes in resource allocation would affect unit status. The Status Projection System (SPS) developed by CACI, Inc.-Federal (in Arlington, Virginia) supports Army POM development by projecting future unit status and recommending status-improving resource allocations.

SPS has been installed on the HQDA Decision Support System (DSS) and can access personnel, equipment, and training status projections and report on consistency between resource allocations and unit status ratings. The projections are developed from the following data sources:

- Personnel Management Authorization Document (PMAD, see Sec. VI) data for active component personnel authorizations;
- Personnel Structure and Composition System (PERSACS) (see Vol. 1) for Guard and Reserve personnel authorizations and all component personnel requirements;
- Regressions using historical Guard and Reserve data to project actual personnel supplies in those components and ODCSPER Unit Level System (ULS) data to obtain active component operating strength projections;
- TAEDP for equipment; and

\[15\text{In particular, units with later deployment times may be assigned lower Authorized Levels of Organization (ALOs) and hence have lower MTOE personnel requirements than other units that share the same notional TOE.}\]
The BLM-TRM methodology for active component training resources (see below) and ODCSOPS data for the Guard and Reserve training costs.

For personnel, the projected rating is based on the Authorized Level of Organization a unit would achieve with projected operational manpower; the system treats ALO 1 as equivalent to a C-1 personnel rating, ALO 2 as equivalent to C-2, etc. For equipment, the projected Equipment on Hand rating is based on AR 220-1 formulas for ratings as a function of equipment on hand.

Ratings by year and Unit Identification Code can be aggregated by Standard Requirements Code, major command, component, and operating plan. Just as a unit overall rating is (generally) the lowest of the unit's area ratings, a roll-up rating is the lowest of the overall ratings for all units in the aggregate category.

In addition, SPS has a Resource Allocation Module (RAM) that uses integer programming to allocate limited resources by maximizing the Army's overall status rating in each projection year. The objective function weights the ratings of various units based on their DAMPL and Force Activity Designator (FAD) levels (see Vol. 1) and hence will tend to allocate resources in favor of units that would be first to fight.

The RAM does not optimize the allocation of personnel (i.e., it takes personnel authorizations as given). The RAM does, however, optimize the allocation of constrained training dollars and equipment inventories. The optimization includes resources not subject to SORTS ratings, but constraints prevent the model from stripping resources from TDA units and functions not subject to status reporting. Other constraints prevent the model from deleting units.

Since the SPS RAM module provides resourcing recommendations for POM development, the model could serve as a predictor for the spending consequences of improvements (or reductions) in unit status and hence prove useful in a wide range of costing studies. However, users should recognize that RAM output simply provides recommendations that may be subject to modification during the POM development process. For example, the model does not associate costs with transporting equipment among units and does not provide for additional "ramp-up" training (if any) to move from one rating to another. Consequently, whenever the model recommends a marked change in resource allocation (which is likely in the initial years of application and whenever there are major changes in force structure or DAMPL priorities), intervention will be
necessary to avoid sudden and possibly large costs for resource realignment.

Moreover, even if status ratings were adequate for measuring the relative readiness of comparable units (a matter of some dispute\(^\text{16}\)), ratings are a limited metric for evaluating increments in readiness. For the two hypothetical units in Fig. 2.3, for example, it might appear desirable to reallocate equipment to unit A, raising its rating to C-1 and leaving unit B unchanged at C-3.\(^\text{17}\) But that presumes that overall capability rises when all units have a more balanced set of equipment, personnel, and training resources.

If, as seems likely, resources are substitutable in producing defense capability, then balancing resources could actually reduce overall capability. For example, depriving unit B of equipment inventories that helped compensate for personnel and training shortfalls could seriously erode that unit's capability, perhaps more than enough to outweigh the benefits to unit A.

This argument does not invalidate the benefits of SPS as a tool for identifying objective resource allocation options. However, the argument highlights the importance of treating unit status measures as indicators rather than as precise measures of readiness.

*Moreover, status ratings are a limited metric for evaluating increments in readiness.*

*If, as seems likely, resources are substitutable in producing defense capability, then redistributing resources to achieve balanced C-ratings within units could actually reduce overall capability.*

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\(^\text{16}\)For a cogent discussion of the shortcomings of status ratings as capability indicators, see Shishko and Paulson (1981).

\(^\text{17}\)In an optimization model that can reallocate all resources, it is possible to devise a set of weights that would instead reallocate personnel and training resources from unit A to unit B. The argument made in the text remains the same. We chose the illustration described in the text because SPS-RAM does not optimize the personnel allocation.
Operating Level

The Army develops operating requirements and programs to cover three types of peacetime operations: collective (unit and combined arms) training, school-based training, and peacetime missions (e.g., intelligence gathering). Although collective training is reflected in unit status measures, the other two types of operations are not. The following discussion describes how the Army develops requirements and programs for all three types of operations, including the use of BLTM-TRM models to assess the readiness implications of collective training operations.

The primary sources for all operating requirements are the major commands. TRADOC develops requirements for school-based training programs (also known as Point of Instruction (POI) operations) and passes the information to ODCSOPS where it is combined with other operating requirements to program operational resources. Requirements for collective training and peacetime missions are submitted by the combat commands, including the ARNG (Army National Guard).

Although requirements continue to be specified by the commands, the Army has been expanding a systematic methodology for determining how requirements (and hence costs) vary with readiness objectives. This methodology is embodied in the family of Battalion Level Training Models (BLTMs) and an associated Training Resource Model (TRM) developed by CACI-Federal, Inc. These models are currently used to program active component training operations for ground combat and combat support units. Analogous models for aviation units are in development, and there are plans to develop models for the Reserve components as well.

The following discussion begins by describing the BLTM-TRM methodology for ground-unit training. Then we explain how the overall flying hour program is currently developed (and how the new aviation BLTMs would support that effort) and how operating levels for new materiel acquisitions are measured.


**Ground-Unit Training**

The Army specifically reserves the term "optempo" to refer to collective training operations. These operations involve carrying out many different kinds of exercises, some that are narrow in scope (such as map exercises) and others that encompass complex maneuvers using a variety of equipment.

The complexity of collective training has made it difficult for the Army to establish concise optempo indicators. The Army used to characterize optempo in terms of Battalion Field Training Days (BFTDs). However, optempo costs do not rise or fall uniformly with the number of BFTDs; a decline in training days could be associated with a change in the training program that increases daily (and even total) costs.\(^{18}\)

Today, purely as a shorthand reference, the Army sometimes describes its training optempo in terms of miles for the M1 tank. (For example, a cut in the training program might be described as decreasing optempo from 900 to 800 miles.) This graphically portrays the impact of a change in the training budget but should not be construed as evidence that total Army optempo costs rise or fall in proportion to changes in M1 tank miles. Instead, more complex models are needed to represent unit training operations and their costs.

At the HQDA level, ground-unit collective training requirements are modeled in the family of BLTM. Currently, each of 217 BLTMs pertains to a particular "type unit"; it comprises SRCs that share a major cost driver (e.g., the M1 tank), aggregated to the "Army generic" or "MACOM generic" level.

Command-generated data in each BLTM characterize the optempo required to achieve five alternative levels of readiness (i.e., training C-ratings). For any desired rating, the BLTM can compute the total unit annual optempo in hours or miles by type of equipment and the total ammunition requirement by type of round. In addition to the major cost driver, a BLTM can capture up to 15 items of equipment that have optempo measured in miles and another 15 items with optempo measured in hours; the models also allow for up to 15 types of ammunition. BLTM worksheets identify 26 standard training events and report the average number of days, equipment miles or

\(^{18}\) Furthermore, the number of BFTDs has become a matter of policy. The current perspective is that unit commanders should attempt to use all available time for training, even if resource availability limits the amounts or types of training that can be done.
To resource the Army training program for active component ground units, ODCSOPS assigns a desired readiness level to each organization and BLTMs supply the required miles, hours, or rounds of ammunition.

To translate requirements into costs for active component ground units, HQDA uses the Training Resource Model (TRM). ODCSOPS assigns a desired readiness level to each organizational MDEP (normally an Army Division, see Vol. 1), and the BLTMs for type units in that MDEP supply the required miles, hours, or rounds for that readiness level. The TRM computes the associated costs.\(^{19}\)

Figure 2.4 illustrates the TRM costing structure. Since the BLTM data do not cover all Army units, the TRM allows its users to enter additional costs for “nonoptempo units” within the MDEP; the user can enter these costs as either a whole number or as a fraction of the modeled units’ total costs. For the modeled (i.e., BLTM) units, the TRM computes both optempo and nonoptempo costs.

![Diagram of TRM costing structure]

Optempo cost refers to equipment-related O&M costs; this included only FOL and replenishment repair parts in early versions of the TRM but is being expanded to include depot maintenance. Nonoptempo costs include (a) personnel support costs (costs that are directly related to the number of military or civilian personnel in the organizational MDEP); (b) annual operating costs (recurring items not related to personnel, such as rail transportation); and (c) distributed support costs (costs related to the unit’s personnel or operations but not included in the unit’s MDEP). Costs are classified by Element of Resource (EOR) codes (from Army Regulation 37-100-

\(^{19}\) The TRM also accepts data linking MACOMs to specific corps so that costs can be rolled up to that level.
XX) so that costing results can be compared with actuals reported in the STANFINS data system.

The TRM is designed primarily as an automated costing methodology. Many of the cost elements and factors must be supplied by the user. However, the TRM includes a factor database that supplies some factors for the current year and escalated values for the succeeding eight years. The database includes CSMIS factors for POL and replenishment parts used at the organizational and intermediate maintenance levels and depot maintenance factors supplied by ODCSLOG. For nonoptempo costing, the TRM database also includes:

- Civilian and military manpower authorized for the MDEP, taken from the Program Optimization and Budget Evaluation (PROBE) database and reported by MACOM and Army Management Structure Code (AMSCO).
- Civilian manpower cost factors provided by OASA (FM) and reported by MACOM, AMSCO, MDEP, and civilian employment category.

Since BLTM do not capture optempo for 100 percent of a unit’s equipment, the TRM includes a scaling factor based on the type unit. The scaling factors are: 1.05 for combat arms, 1.15 for combat support, and 1.25 for service support. The sources for these factors are not reported in TRM documentation.

The TRM addresses a very wide range of costs, including costs incurred outside the organization under consideration (such as depot maintenance). Indeed, the TRM captures costs related to the existence or size of a unit rather than to its operating level, such as the chemical defense equipment costs (“NBC supplies” covered by CTA 50-901). Since the TRM is the only application used for organizational MDEP costing in the Army, the inclusiveness of the model’s cost structure is highly valuable. However, if the TRM were used in other contexts, where it might be used in combination with other costing models, users should be careful to avoid double-counting.

Since the BLTM-TRM methodology is not yet developed for USAR and ARNG units, they are programmed at a fraction of active component optempo. The surface optempo program for the Guard is currently about 36 percent—and for the USAR, about 25 percent—of the amount for comparable active component units. Lower Re-

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20The escalation factors are the standard OSD inflation factors.
serve optempos are sensible because Reserve personnel are on duty only a small fraction of the year. However, the basis for developing Reserve optempo does not appear to be a systematic assessment of training resource needs. That may explain why the Army plans to develop BLTMs for the reserve components.

**Flying Hour Programming**

Although prototypes of BLTMs for aviation units are being tested, flying hour programming continues to be based on the traditional process: TRADOC submits requirements for schoolhouse training.\(^{21}\) Meanwhile, unit commanders specify requirements for both optempo (i.e., training) and nonoptempo (administrative and intelligence) flying;\(^{22}\) the training requirements are based on pilot strength, experience, and equipment type, taking account of projected fieldings of new aircraft.\(^{23}\) The MACOM or agency combines the unit requirements by aircraft type and submits them to ODCSOPS, which reviews them, proposes cuts if necessary to accommodate fiscal constraints, and submits the results for incorporation in the POM.

Without the benefit of flying program BLTMs to model variations in readiness objectives, the Army currently distributes funding cuts so that they are absorbed by the largest users. For the flying hour program as a whole (including POI and peacetime mission requirements), the cost breakdown for fiscal year 1990 was: active component combat MACOMs, 42 percent; USAR, 5 percent; TRADOC, 28 percent; ARNG, 21 percent; and others, 3 percent. Consequently, most cuts have been absorbed by active component units.

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In the POM data submitted to OSD, flying “requirements” are the resourced numbers of flying hours, not the ones originally submitted by the MACOMs. The Army does not consider the methods used for determining unit requirements to be a validated system. This should be rectified by the application of aviation BLTMs.

Like ground-unit training, aviation-unit training comprises a mixture of exercises involving a variety of aircraft. For example, an attack helicopter battalion usually includes reconnaissance and lift helicopters as well. Moreover, the same equipment may be used in units.

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\(^{21}\) POI training accounted for 28 percent of total flying costs in fiscal year 1990.

\(^{22}\) Requirements for nonoptempo flying are usually based on a formula, because maintenance services are provided under logistics contracts, and accounted for just 11 percent of total flying costs in fiscal year 1990.

\(^{23}\) The requirements cover only actual flying, not simulator time.
with quite different missions. The BLTM approach to developing optempo requirements is designed to deal with such complexity.

As in the case of ground optempo, the aviation BLTMs under development apply to the active component only. The MACOMs with USAR units (primarily FORSCOM) will continue to develop USAR requirements, and the ARNG will continue to develop its own requirements. Historically, optempo measured on a “per-bird” basis—which is how flying hours are programmed in the reserve components—was similar across all components.

Notably, aviation BLTMs model the entire operations program, including individual training, collective training, MACOM-unique requirements (for peacetime missions), and maintenance and flight test hours (which account for 5–10 percent of the total program). Individual training requirements derive from Aircrew Training Manuals, TOE requirements for numbers of crews as reported in the ODCSOPS Flying Hour Program Model (FHPM) database, and an estimated 30 percent annual turnover rate for newly assigned pilots. Simulator hours (from the FHPM database) substitute for and hence reduce actual flying hour requirements.\(^\text{24}\)

Costs for the flying hour program are currently estimated using OSMIS factors (see Sec. III) and will continue to be estimated the same way when the aviation BLTMs are implemented. BLTMs will be used only to estimate programmed hours by aircraft type.

**Operations Estimates for New Materiel Systems**

Whereas the Army generally treats training operations as unit- rather than equipment-related, that is not the case for new materiel systems that have not yet been fielded. The Army has no BLTMs for units yet to be modernized. Instead, peacetime operations for new materiel are system-specific.

For new materiel systems, expected operating levels are part of the required operational capability in the Operational and Organizational (O&O) plan. This is true for both aviation and ground equipment. Although there is no operating level for hand-held missiles, there is for large missile carriers.

\(^\text{24}\)Active component optempo requirements are currently based on average training hours per aircrew per month, and that method is also used by the aviation BLTMs under development. However, the models can compute hours per aircraft for each type of aircraft and mission.
For program development purposes (and specifically to provide necessary information to MACOMs that will field new equipment), new materiel operating levels are published in Army Pamphlet 25-5 (the Army Modernization Information Memorandum, AMIM).

Basing

In 1986, the Army Chief of Staff commissioned a Long Range Stationing Study (LRSS) to develop a methodology for long-range planning. The study produced a Stationing Decision Support System (STADSS) that includes a package of four threat scenarios developed by the U.S. Army War College; an Integrated Planning Model that links total Army costs to force structure, manning, equipping, training, sustaining, and basing; a Specific Unit Stationing Model that compares installation alternatives at a finer level of detail; and a time-phased strategic plan.

Three features of the STADSS are noteworthy. First, it recognized that basing is the most inflexible aspect of the Army’s military posture and hence examined the ability of alternative installations to support Army activities in future environments ranging from an “isolationist” scenario that precludes U.S. overseas basing to a “world peacekeeper” scenario with a much larger Army force and a strong overseas presence. Second, the system reflected the logic that basing decisions could not be made without identifying an affordable force structure, so that costing of future forces was an integral part of the analysis. Third, the analysis scored installations according to a codified list of attributes necessary to support various functions and developed “basing requirements packages” for combat and TDA Army force structure.

In effect, the Long Range Stationing Study developed a method for deriving installation resource requirements from the generic purposes of Army forces. Nonetheless, most Army costing related to basing decisions does not explicitly address the linkages between basing alternatives and military capabilities. Instead, the costing exercises relate to more specific, near-term, and delimited decisions.

The Long Range Stationing Study developed a method for deriving installation resource requirements from the generic purposes of Army forces. Nonetheless, most Army costing related to basing decisions does not explicitly address the linkages between basing alternatives and military capabilities.
Army Regulation 5-10\textsuperscript{25} governs decisionmaking responsibilities and analysis of reduction and realignment actions.\textsuperscript{26} Reductions and realignments that disestablish or convert activities fall under the broader rubric of changes in force structure or size. Relocations, however, represent actions that can affect Army capability with only indirect effects on force structure. For example, troops relocated from theater to CONUS bases may continue to man the same basic types of units, but their deployment times to regions of conflict (and the resources required to deliver them there) may increase substantially.

As in the other Services, the thrust of the Army’s analyses concerning base realignments is to capture the effects on installation support costs at the “gaining” and “losing” bases.\textsuperscript{27} Established cost estimation procedures presume that a specific realignment is under consideration and rely fairly heavily on individual installations to supply data on the effects on their own organizations.

However, policy issues are sometimes formulated too imprecisely to use this methodology; in particular, questions about the costs for troop withdrawals from Europe have proved difficult to answer because of uncertainty about whether and how many troops would be relocated to CONUS locations and which bases would accommodate them. In short, the main challenge in estimating base realignment costs lies in predicting which bases will absorb gains or losses and precisely how the changes will be implemented.

**Highlights for the Cost Analyst**

Ideally, every costing exercise should begin with the question, Does this decision aim, directly or indirectly, to maintain, increase, or reduce military capability to carry out one or more defense missions? The answer lays the foundation for inferring how a decision might be implemented when that is not spelled out; determining which re-

\textsuperscript{25}The version of AR 5-10 reviewed for this report is several years old. It states that the regulation does not apply to USAR or ARNG actions.

\textsuperscript{26}Reductions are defined as reductions in the civilian workforce that are not accompanied by deactivation of units or transfer of civilian or military job positions; they do not include conversions to contract, inactivation of units, disestablishment of activities/organizations, or actions involving transfer or relocation of military or civilian jobs (spaces). Realignments are defined as transfers, consolidations, conversions to contract, and actions that entail inactivation, disestablishment, or relocation of all, or portions, of any unit of the Army. Actions involving closure or reduction of the level of activity at an installation or the exceeding of real property are also realignments.

\textsuperscript{27}In addition, the Army pays particular attention to the effects of such changes on local communities and the costs associated with cleaning up chemical, ammunition, and other waste dumping sites.
Sourcing options might be most appropriate for the decision; assessing whether and how resource limitations might inhibit the decision's goals; and—most important—communicating cost findings to decisionmakers.

This section identified a number of difficulties in interpreting the military capabilities implied by output indicators, and in deriving their resource implications. The basic difficulties apply to all Services and components, but they also reflect special features of the Army's organizational structure and the complexity of its decision processes. In addition, however, the section also showed that the Army is developing new approaches to surmounting these difficulties in POM and budget development.

Traditionally, the Army has made force structure decisions using complex and time-consuming methods that accounted for major resource limitations but did not take detailed costs into account until late in the process. Meanwhile, resource decisions that would affect unit status used prioritization rules that did not necessarily coordinate ratings or anticipate the implications of resource shortages. The POM and budget implications of both types of decisions were difficult to anticipate and not readily amenable to the use of cost factors.

The Army has been developing optimization models, such as Force Builder (for force size and structure) and SPS-RAM (for resourcing units). These models should enable users to consider a variety of options relatively quickly.

However, the Army has been developing optimization models, such as Force Builder (for force size and structure) and SPS-RAM (for resourcing units). These models should aid Army POM development by enabling users to consider a variety of options quickly and to use objective criteria for selecting options for further consideration. Optimization models are not a substitute for human judgment, and observers should not anticipate that such models will perfectly predict POM outcomes. Nonetheless, both models show promise as objective predictors of how Army output decisions would influence resource use.

Cost studies often fail to treat modernization as part of a larger process of equipment realignment and hence may neglect important (primarily nonrecurring) costs.

Unit modernization is clearly an important aspect of Army capability improvement and has received much attention in cost analyses. However, cost studies often fail to treat modernization as part of a larger process of equipment realignment and hence may neglect important (primarily nonrecurring) costs. This remains true in Army acquisition costing models and even in the new optimization models for POM development.
Since major operating costs (e.g., for fuel and repair parts) derive from equipment usage, the Army is frequently queried on the optempo of its principal materiel systems. However, Army operating rates are not determined by the type of equipment but rather by unit training and other operating needs. The same equipment can be operated at very different rates by units with different missions, with different desired training status, or in different Army components. Consequently, changes in force size, structure, and status can alter optempo rates for a given type of materiel.

Fortunately, the family of BLTMs offers an automated technique for optempo analysis based on mission and unit status for notional (and eventually specific) units. The models allow a user to conduct "what-if" studies of optempo based on relatively standardized unit training requirements, and the results are likely to be quite good predictors of costs that will appear in the Army POM. Extending the models to the reserve components would be a desirable replacement for the current rules of thumb that guide Reserve component optempo programming.

The usefulness of BLTM optempo measures is evident in the fact that they have been included in The Army Force Costing System (TAFCS) database (see Appendix A). However, Management Analysis, Inc. (MAI), is dissatisfied with the fact that BLTMs do not account for all equipment operations; the TAFCS is not using TRM factors for rescaling optempo costs to account for unmodeled equipment or units and is considering other sources for more complete optempo data. However, we found no evidence that other data sources would support optempo estimates based on alternative training requirements or would be superior to BLTM data in projecting actual training optempo in the POM or budget.

The Army's development of a capability for assessing long-range stationing decisions is impressive and noteworthy. Nonetheless, the ability to link basing to other decisions in regular cost assessments, or to address basing costs without extensive case-specific information, remains quite limited in the Army, as in the other Services.
III. Unit-Level Resource Demands

This section describes factor sources for unit-level manpower, initial issue materiel, resources that support unit operations, and miscellaneous resources. The section covers resources for both deployable (TOE) and nondeployable (TDA) units.

The section begins with general information about types of unit-level resource measures. The section closes by summarizing available factors and by indicating which elements of unit-level costs can or cannot be estimated from readily (or soon to be) available factors.

*Factor sources in this section cover the resources directly used by TOE and TDA units.*
Measuring Unit Resource Demands

Unit-level resource demands can be measured in three ways—using required resources, authorized resources, or actually assigned resources. Since all three types of factors can be found in Army sources, it is important to recognize how these measures differ and what uses they serve best.

Requirements

Wartime requirements for manpower and equipment can be obtained from documents described in Vol. 1—Tables of Organization and Equipment (TOEs) and Tables of Distribution and Allowances (TDAs) or their precursor documents, the Basis of Issue Plan (BOIP) and Qualitative and Quantitative Personnel Requirement Information (QQPRI).

The TOE portrays a notional unit—a standardized paradigm that is not specific to a particular location, MACOM, Army component, or year\(^1\)—and hence is convenient when affected units or the timing of unit changes are not specified precisely. Because TOE requirements are vetted statements of the resources necessary to fulfill stated mission objectives, many analysts consider the data useful in decision contexts where military capability is to be held constant. For these reasons, the Army commonly uses TOE requirements for general-purpose force-unit costing. By Army directive, weapons acquisition costing uses TOE requirements to estimate manpower in support of modernization equipment.

Although TDA documents specify requirements in much the same way as TOEs, TDAs are less convenient because they are unit- and year-specific. In a costing exercise that does not prespecify a particular TDA unit and year, the analyst must either assume that a selected TDA requirement is representative or compute some average of TDA requirements.

For units that have them, Modified TOE (MTOE) documents report unit-specific requirements. These reflect the unit’s specific ALO and special operating conditions and recognize that some wartime requirements might need to be filled only upon mobilization. It is

\(^1\)A partial exception is “Living” or L-Edition TOEs. They provide a sequence of TOEs for various stages in a unit’s transition from older to modernized status and hence contain an implicit time dimension. However, L-TOEs are still in development by TRADOC and we observed no cases in which L-TOEs had been used in a cost assessment.
these specific requirements that are used to develop the manpower "programmed structure strength" reported to OSD. Like TDA requirements data, MTOE requirements are difficult to use when the affected unit is not specifically identified.

Fiscal and resource scarcities lead to tradeoffs between the numbers of units and the level at which their resource requirements are authorized and budgeted. Therefore, resource demands estimated from TOE/TDA/MTOE requirements reportedly can be quite different from the resources authorized to man and equip a typical unit.

**Authorized Resources**

Authorizations data on manpower and equipment are available in MTOE (Modified TOE) documents, for those units that have MTOEs, and in TDA documents. Although authorizations documents generally pertain only over the two-year horizon covered by The Army Authorization Documents System (TAADS), longer-range projections for equipment can be obtained from the Total Army Equipment Distribution Program (TAEDP), and aggregate projections for manpower are in the Force Accounting System (FAS).

Authorization data correspond to resources costed in the Army Program Objective Memorandum (POM) and budget and hence are superior to requirements as predictors of a decision's POM and budget consequences. However, authorizations data are unit-specific, making them difficult to use for notionall costing exercises. And authorized resources might not be adequate to support all the unit's missions. As Sec. II suggested, for example, when a decision entails shifts in the active-reserve balance, authorizations data might show cost savings that are attributable to reductions in warfighting capability rather than to greater efficiency.

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2 However, a reported obstacle to accessing authorizations data is that a complete file of MTOE data would be classified. According to MAI, the database under development for The Army Force Cost System (TAFCS) uses TOE documents for this reason.

3 The FAS has been criticized as an unreliable source for authorized manpower because it is not accurately updated during the programming process. However, the Army is working to rectify this.

4 Army organizational MDEPs in the PROBE database also note authorized manpower. Since these MDEPs refer to divisions or separate brigades, division-level command personnel are included in organizational manning. However, intermediate maintenance manning appears in the separate MDEPs that cover installation management, and MDEP measures only show officer/enlisted breakdowns for active and reserve personnel.
**Assigned/Actual Resources**

Although projected authorizations are good predictors of programmed or budgeted costs, a number of analysts both within and outside the Army report significant differences between authorized and assigned unit resources. For example, manpower authorizations permit a unit to request personnel, but the positions may not be filled throughout the year, or may be overmanned to absorb recruiting surpluses.  

Assignment data on manpower and major equipment resources are relatively difficult to use in decision costing exercises. Centralized data on personnel assignments by UIC can change daily and have been criticized by some users as unreliable. Furthermore, many cost studies address resourcing over a future time period for which actual assignments are not observed; instead, analysts commonly assume that future assignments will equal projected requirements or authorizations.

In contrast, "actuals" are commonly used to estimate costs for peacetime operational resources—POL and replenishment parts in particular. Consumption rates are estimated by relating actual POL or parts consumption to actual equipment density (or occasionally, to operating levels). These historical rates are then applied to the equipment requirements or authorizations for a unit under analysis. "Actuals" are commonly used only to measure consumption rates for operational resources, such as fuel and repair parts.

Though commonplace, mixing historical consumption factors with required or authorized equipment density factors is questionable if resource consumption rates depend on how a unit is actually manned and equipped. For example, if maintenance manning were severely constrained, some equipment might be idled rather than repaired, and actual repair experience would not be representative of repairs under full manning conditions. If major changes in organization or overall resourcing are under consideration, the analyst should be wary of assuming that past experience—however accurately measured—is a valid predictor of future outcomes.

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5 For example, an unpublished case study of a Guard AH-64 unit found that it had 123 percent of its authorized personnel. Both Guard and reserve units are subject to the availability of personnel in their local area, and shortfalls in one locale may be offset by overmanning in other units where personnel are available.

6 For technological reasons, it seems likely that POL consumption rates per operating hour depend more on operating conditions (e.g., terrain, climate) than on whether units are fully manned and equipped.
Unit Manpower

The basic procedure in costing unit-level manpower resources is to identify the number of spaces (positions) to be filled in a unit and then to associate dollar costs with those positions. This section covers factors for the numbers and types of spaces; Sec. VI will review the sources for the personnel cost rates.

The following sources, discussed below, provide information on unit-level manpower requirements and authorizations:

- TOE/MTOE/TDA files.
- Troop lists and the FAS.

TOE/MTOE/TDA and TAFCS Files

These files report required and authorized manpower spaces, by paygrade, occupation (MOS), and unit (SRC in TOE files, UIC in MTOE and TDA files). The data can be accessed through automated databases maintained by TRADOC.

Many costing exercises aim to capture not only the manpower in a particular unit but also related command-level and intermediate maintenance manpower. This requires processing the data to select related units, when using TOE/MTOE/TDA files. For example, processing is required to associate a brigade headquarters to the other units in that brigade.

Using cross-references from the Army Force Accounting System (FAS), the TAFCS (The Army Force Cost System, see Appendix A) has established a linked “master file” of command-related TOEs. However, this file will show only requirements and, because of its very large size, will not be part of the TAFCS exportable database for use on personal computers.

As Sec. II indicated, however, functional linkages between supporting (e.g., intermediate maintenance) units and the units they serve remain especially difficult to identify in Army unit-based data systems.
Although TOE and TDA documents record requirements for units that have been or will soon be activated, modernization cost studies may require data on units for which TOEs and TDAs have not yet been prepared. In these cases, information can be obtained from Basis of Issue Plans (BOIPs) maintained by TRADOC and associated documents.\(^7\)

**Troop Lists and the FAS**

Troop lists and the Force Accounting System (FAS) are additional sources of manpower data by UIC but report manning at a much more aggregate level—officers, warrant officers, enlisted military, and civilian personnel, by component. Grade and Military Occupational Specialty (MOS) detail is not provided.

Both sources report structure strength and authorized manpower. However, troop lists cover only a particular year, whereas the FAS covers all years through the FOM and includes data on structured and operating strengths.

Extracts from the FAS are accessible via the automated, interactive HQDA Decision Support System (DSS), and in the ODCSOPS FDMIS (Force Development Information System). Troop lists are published as:

- Office of the Deputy Chief of Staff for Operations, Headquarters of the Army, Department of the Army Force Accounting System Active Army Troop List, Washington, D.C., June 30, 1990. (This document is produced semi-annually by ODCSOPS.)
- Program Coordinator, National Guard Bureau, Department of the Army, Reserve Components Troop Basis of the Army: Annex I, Army National Guard Unit Program, Washington, D.C., September 30, 1989.

These documents have also been made available on diskettes for IBM-compatible personal computers.

\(^7\) Additional information on detailed unit manning can be obtained from the QOPRI documents initiated by the Army Materiel Command (AMC); they show the manpower skills required to support modernization equipment. And TRADOC's Manpower Requirements Criteria (MARC) provide guidelines for manning combat support and combat service support positions; an example is workload factors for tracked vehicle mechanics.
Initial Issue Materiel

When an Army unit is activated, it is issued quantities of various types of materiel determined by its intended mission. Initial issue materiel represents potential procurement costs to activate a unit—or procurement avoidances if a planned activation is deleted from the Army program. Or, if an existing unit is deactivated, the initial issue materiel may be made available to other units or scheduled for disposal. Thus, measuring demands for initial issue materiel is important for estimating the nonrecurring cost of activating or deactivating a unit.

The Army classifies materiel according to the supply categories listed in Table 3.1. Each class is discussed below.

<table>
<thead>
<tr>
<th>Class</th>
<th>Army Supply Categories of Materiel</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Subsistence, including gratuitous health and welfare items.</td>
</tr>
<tr>
<td>II</td>
<td>Clothing, individual equipment, tentage, tool sets and tool kits, hand tools, etc.</td>
</tr>
<tr>
<td>III</td>
<td>Petroleum, oil, and lubricants.</td>
</tr>
<tr>
<td>IV</td>
<td>Construction materials.</td>
</tr>
<tr>
<td>V</td>
<td>Ammunition and small missiles.</td>
</tr>
<tr>
<td>VI</td>
<td>Personal demand items (nonmilitary sales items).</td>
</tr>
<tr>
<td>VII</td>
<td>Major end items (final combinations of end products that are ready for their intended uses, e.g., launchers, tanks, mobile machine shops, vehicles).</td>
</tr>
<tr>
<td>VIII</td>
<td>Medical materiel.</td>
</tr>
<tr>
<td>IX</td>
<td>Repair parts and components.</td>
</tr>
<tr>
<td>X</td>
<td>Materiel to support nonmilitary programs.</td>
</tr>
</tbody>
</table>


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The Army also has other systems for classifying materiel, such as distinctions among combat-essential equipment and equipment needed for safety or legal reasons.
Classes VII and VIII Equipment Provisioning

<table>
<thead>
<tr>
<th>Unit Resourcing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manpower</td>
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<tr>
<td>√ Equipment</td>
</tr>
<tr>
<td>Initial repair/spare parts</td>
</tr>
<tr>
<td>Initial ammunition</td>
</tr>
<tr>
<td>Other initial materiel</td>
</tr>
<tr>
<td>POL</td>
</tr>
<tr>
<td>Replenishment parts</td>
</tr>
<tr>
<td>Training ammunition</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>

Army equipment procurement provides for:

- Operational equipment in units;
- Operational Readiness Float (ORF) to allow for equipment nonavailability during unit- and intermediate-level maintenance;
- Repair Cycle Float (RCF) to allow for equipment nonavailability during depot-level maintenance; and
- Reserves to replace anticipated wartime losses and peacetime attrition.

This section deals with operational equipment in units. Quantities for ORF, RCF, war reserves, and peacetime attrition are addressed in Sec. IV.

Data on Initial Issue Quantities (IIQs) of Classes VII and VIII equipment are recorded in various sources, as follows:

- Requirements by SRC and Line Item Number (LIN) are in TOE documents;
- Requirements and authorizations by UIC and LIN are in MTOE and TDA documents;
- POM-year requirements, authorizations, and projected distribution by UIC and LIN are in TAEDP files (see below and Vol. 1);
- Currently assigned equipment by LIN, Standard Study Number (SSN), National Stock Number (NSN), and UIC is in the Consolidated Balance System-Expanded (CBS-X) database.
- Historically assigned equipment by weapon system and UIC is in the OSMIS database.

TOE/MTOE/TDA documents were described previously, and the following discussion elaborates on the other sources in this list.

The TAEDP is fundamentally an execution system—dealing with the specifics of equipment distribution (both quantities and timing) at the UIC level—and is not tailored to generating data for notional units. Furthermore, its authorizations, which also appear in MTOEs, include not only initial issue quantities but also replacement operational equipment quantities exclude equipment needed for maintenance float, war reserves, and peacetime attrition.
equipment. For these reasons, TAEDP and other equipment authorizations data are most useful in programming applications when the objective is to estimate how the Army POM or budget would be affected by altering equipment deliveries to a specified unit. Since TAEDP files project inventories through the POM years, they also identify units that will receive modernization equipment.

CBS-X data also refer to specific units but cover only currently assigned equipment. This source would be useful for determining what materiel would be released if an existing unit were deactivated in the near term.

The OSMIS database usefully summarizes current and historical inventories of equipment, listed by Weapon Identification Code and UIC.

As Appendix A explains, the OSMIS system forms weapon system definitions that identify all equipment NSNs involved in configuring a system for combat use, including all on-board components as well as system-peculiar associated equipment (ASIE) and tools. Using CBS-X data, the OSMIS database usefully summarizes current and historical inventories of weapons systems within units, listing them by specially devised Weapon Identification Code (WIC) and UIC.

Class IX Repair Parts and Components

Provisioning

Two approaches have been used to estimate costs for initial issue repair parts and components. The standard approach is weapon-system-oriented—relating demands for parts to the major end items that use them. Models using that approach are described in Sec. IX.

The TAFCS, however, uses a force-unit approach that may more closely parallel the actual process of distributing most initial issue parts to field units. They generally receive a coordinated package of materiel, sometimes called the Total Package Fielding, that includes materiel tailored to the overall unit's resource needs. Using data supplied by the Materiel Readiness Support Activity (MRLA) within AMC, the TAFCS database reports unit-level factors that account for reduced issues of repair items common to multiple end items within a unit.

9Army Pamphlets 710-2-117/118,120 will provide the prices for these items by LIN.
The items covered by the MRSA estimates are developed from a Support List Allowance Master File that lists PLL (Prescribed Load List) support items for combat units and ASL (Authorized Stockage List) support items for intermediate maintenance units. The TAFCS factors report repair costs by PLL/ASL, TOE and alternative ALOs, and funding source.\textsuperscript{10}

**Class V Ammunition Provisioning**

<table>
<thead>
<tr>
<th>Unit Resourcing</th>
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<tbody>
<tr>
<td>Manpower</td>
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<tr>
<td>Equipment</td>
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<tr>
<td>Initial repair/spare parts</td>
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<tr>
<td>√ Initial ammunition</td>
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<tr>
<td>Other initial materiel</td>
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<tr>
<td>POL</td>
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<tr>
<td>Replenishment parts</td>
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<tr>
<td>Training ammunition</td>
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<tr>
<td>Other</td>
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</tbody>
</table>

For ammunition and missiles, the TAFCS project developed a methodology for computing initial issue costs based on the number of people and numbers and types of equipment in a unit. Data are from files on initial quantities and costs maintained at Letterkenny Army Depot. The quantity and cost factors have been incorporated in the TAFCS exportable database.

**Other Initial Issue Materiel**

<table>
<thead>
<tr>
<th>Unit Resourcing</th>
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<tbody>
<tr>
<td>Manpower</td>
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<tr>
<td>Equipment</td>
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<td>Initial repair/spare parts</td>
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<tr>
<td>√ Other initial materiel</td>
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<tr>
<td>Other initial ammunition</td>
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<tr>
<td>POL</td>
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<tr>
<td>Replenishment parts</td>
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<tr>
<td>Training ammunition</td>
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<tr>
<td>Other</td>
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</table>

In this study, we did not encounter any general factors pertaining to POL initial issue costs, nor does it appear that they will be included in Army cost factor databases under development. This probably reflects the fact that the Army supply system does not distinguish between initial issue and regular recurring

POL requisitions, discussed below.

TOE/MTOE/TDA and TAEDP sources do not specifically identify requirements or authorizations for many smaller and less expensive items regularly issued to units. Instead, the documents reference

\textsuperscript{10}The ASL costs represent a "slice" of intermediate maintenance associated with a TOE unit.
Common Tables of Allowances (CTAs)—tables that specify (by LIN) the kinds of items units may requisition.\textsuperscript{11}

The TAFCS project uses CTA 50-900 to develop factors for Clothing and Individual Equipment (CIE)—CTA items used to clothe and equip individual soldiers, including special combat arms equipment. The TAFCS database also includes costs for other selected CTA items, including medical items, first aid kits, tents, vehicle accessory kits, and food containers. However, there are no plans for covering general CTA equipment, such as tables, chairs, and office machines.

Class I subsistence or Class IV construction materials are not usually treated as unit costs. Subsistence is generally treated as a personnel-related cost (see Sec. VI) and estimated by reference to subsistence cash allowances. Construction materiel is treated as part of installation support (see Sec. VII).

Unit Operating Costs

Operating costs include fuel, maintenance parts, and other resources consumed in a unit’s day-to-day activities. Along with personnel, operations are a major source of a unit’s recurring costs.

Although this subsection will focus on recurring operations, it should be noted that some measures of nonrecurring operating costs have been developed. In the old \textit{U.S. Army Force Planning Cost Handbook} (AFPC\textit{H}) nonrecurring costs resulted from operations during unit activation (or inactivation); the AFPC\textit{H} did not estimate nonrecurring costs but recommended that analysts use some fraction of normal recurring costs to estimate costs during a unit’s start-up period. A different kind of nonrecurring operating cost might appear in the TAFCS database: “displaced equipment rebuild/repair” factors. When equipment is transferred from one unit to another, repairs may be needed to bring the equipment to proper, usable condition. Several databases might permit TAFCS to capture these repair costs.\textsuperscript{12} If so, they would represent the only Army factors for nonrecurring operating costs that we encountered in this study.

For recurring cost estimation, detailed factors on unit operations provide separate values for:

\begin{itemize}
\item \textsuperscript{11}Units “pay for” these items from their general O&M funds.
\item \textsuperscript{12}These are the Army Maintenance Management System-Equipment Data Base (TAM\textit{MMS-EDB}), the Central Demand Data Base (CD\textit{DB}), and the Work Order Logistics File (W\textit{OLF}).
\end{itemize}
• Operating rates.
• POL consumption and/or cost rates.
• Replenishment parts cost rates.

However, some sources combine data for all operating costs. We discuss the combined factors, which are found in MACOM publications, followed by the more detailed factors found in the OSMIS and TAFCS databases.

**Combined Factors**

Appendix A of FORSCOM Pamphlet 11-1 reports averages of direct, recurring Operations and Maintenance, Army (Appropriations) (OMA) obligations\(^\text{13}\) for divisional and nondivisional active component TOE units. The data are for Army Program 2 funds only and hence exclude base operating costs the Army reports in its Program 12 (see Vol. 1). The values are based on actual experience, including Class IX repair parts and unit supplies, reported in installation-supplied data.\(^\text{14}\) The pamphlet reports averages (per unit and per military man-year supported) among units with the same SRCs and averages for entire divisions and nondivisional brigades/regiments. Since these averages do not depend on optempo, they are good predictors of future parts costs only if parts usage is unrelated to operating rates or operations are stable over time.

In addition, Table 34 of USAREUR Circular 37-11 reports nontactical vehicle (e.g., ambulance, bus, truck) consumption factors—average miles per gallon, average miles per year, and average cost per mile. The factors are from “actual experience” shown in the 200th Materiel Management Center Agency Report of Motor Vehicle Data. The average cost includes not only POL but also “maintenance labor and spare parts, and repair contracts.” No further explanation of the cost factors is given.

As we note in Appendix A, operating cost factors reported in MACOM publications may soon be replaced by factors consistent with OSMIS results. The MACOM-reported factors are sometimes

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\(^{13}\)The pamphlet specifically refers to the costs as “obligations,” even though the TUFMS data source reports commitments rather than obligations (see Vol. 1).

\(^{14}\)The RCS AFRM-54 report is used to eliminate obligations arising from nonrecurring projects (e.g., kitchen modernization, flood damage repair). Obligations for repair parts and unit supplies are from TUFMS (see Vol. 1); amounts that cannot be traced to units are attributed to them in proportion to authorized active military end-strengths.
found to be based on old or erroneous data and do not reflect OSMIS methodology. In particular, the MACOM estimates do not include spare parts that will soon be funded by OMA rather than procurement appropriations.

Operating Rates

Target operating levels for training (and some nontraining) purposes are developed in the Army programming process as described in Sec. II. The TAFCS database contains optempo rates taken from BLTM models and hence provides target optempo by unit status rating, SRC, and LIU. For modernization equipment, a source of target optempo is the Army Modernization Information Memorandum (AMIM).\(^\text{15}\)

In contrast, the operating rates in the following sources are based on actual experience for specific items or categories of equipment:

- FORSCOM Pamphlet 37-1: FORSCOM active component installations submit a summary report (APCO-188) every six months to indicate usage, along with fuel and parts consumption, for equipment identified as “cost drivers.” The operating data measure average daily operations (miles or hours) for the period while equipment is at the installation; FORSCOM analysts average two-years’ worth of daily rates (when available) and then multiply by 365. Pamphlet 37-1 lists the cost-driving equipment (by LIU, Weapons/Equipment System Designator Code (WESDC), and installation) as well as the annual operating rate and other factors.

- USAREUR Circular 37-11: As we noted under the “combined factors” heading, this circular reports average miles per year for a variety of non-tactical vehicles.

- The OSMIS database: It reports annual operating miles or hours for all OSMIS-tracked systems. These data are taken from the Army Aircraft Inventory, Status, and Flying Time (AAISFT) and TAMMS-EDB databases, described below, but are validated before use. For example, anomalies such as negative mileage readings are corrected.

The AAISFT is an automated system that collects, on a monthly basis, availability status and flying time in hours for Army aircraft.

\(^\text{15}\)USAREUR Circular 37-11 is a secondary source for AMIM optempo data.
worldwide, by serial ("tail") number. The data cover all types of aircraft, including simulators and trainers, identified by UIC, MACOMs, and Mission Design Series (MDS)—but not by LIN or NSN. OSMIS processes these data to accumulate flying hours by unit and aircraft system.

The TAMMS-EDB (The Army Maintenance Management System-Equipment Data Base) covers ground equipment in all components, by NSN and reports mileage and some overhaul data. The database includes vehicles covered by the Army Oil Analysis Program (AOAP) in which oil samples are taken on a regular basis (for maintenance evaluation purposes) and non-AOAP vehicles that are "usage reportable." AOAP usage data recently replaced previous readings that were considered less reliable and cover all combat vehicles and about half of all tactical vehicles. Since these data are by NSN, they are relatively easy to associate with systems in the OSMIS database.

Petroleum, Oil, and Lubricants (Class III) Usage Rates

Factors for actual POL usage can be found in:

- USAREUR Circular 37-11: Flying hour POL costs for selected aircraft; miles per gallon for categories of nontactical and tactical vehicles; and POL costs and gallons per mile/hour for large categories of equipment (including electronics equipment).

POL consumption rates are estimated from historical experience in MACOM handbooks and in the OSMIS and TAFCS databases.

16 These files were maintained at Aviation Systems Command (AVSCOM), but have recently been transferred to AMC's Materiel Readiness Support Activity (MRS).
17 Vehicles such as trailers that do not have odometers and vehicles for which TACOM does not consider usage data necessary for training oversight purposes (such as jeep-like vehicles) are excluded.
18 The 1987 circular showed fiscal year 1987 and projected fiscal year 1988 aircraft POL costs. Notably, prices for both JP4 turbine flight fuel and AVGAS piston engine flight fuel fell for 1988, yet the POL costs per hour rose for more than half the aircraft in the tables. No sources for the estimates and no explanation for the cost increases are given.
• FORSCOM Pamphlet 37-1: Two-year moving averages of POL consumption by "cost-driving" equipment at active component installations. The factors are total consumption divided by total equipment usage; since some installations report usage without POL consumption data, the FORSCOM-wide average is artificially depressed.

• The Standard Army Aviation (SAA) chart published by the U.S. Army Aviation Center, Fort Rucker, Alabama: Aircraft POL consumption rates based on manufacturer's data and "locally generated estimates" during 1976. The data have not been updated and source methodologies (operating conditions, locations, time periods, etc.) are not documented.

• OSMIS factors for OSMIS-tracked systems, as described below.

OSMIS uses POL consumption rates from AMC's Sample Data Collection (SDC) program whenever possible. SDC collects mileage, main engine fuel consumption, and oils and lubricants consumption on selected air and ground systems by sampling all such items at selected installations. Since the SDC data on oils and lubricants do not cover oil changes, OSMIS relies solely on the main engine fuel data. SDC covers all aircraft not under Contractor Logistics Support (CLS) contracts and many ground combat vehicles.

For ground vehicles not covered by SDC data, OSMIS uses factors from the FORSCOM Cost Factor Handbook or directly contacts FORSCOM personnel. For unknown reasons, there has not been a high correlation between the FORSCOM estimates and those in the TAMMS-EDB.

Before developing these OSMIS factors, Calibre examined SDC data for three aircraft—the AH-64, UH-60A, and CH-47D—and compared them with data in the SAA chart and other sources. The study (see Kennedy et al., 1989) found substantial differences among estimates from alternative sources: For all three aircraft, total usage indicated by the SAA chart was considerably higher (by 10 to 30 percent or more) than in the SDC data; SDC data on active component aircraft were sometimes much lower and sometimes much higher than estimates from the National Guard Bureau; and data from the AVSCOM Maintenance and Operating Cost Model, which estimates

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19 SDC aviation systems are AH-1E, F, P, S; AH-64A; CH-47C, D; EH-1H; OH-58A, C, D; RU-21H; RV-1D; UH-1H; V; UH-60A.

20 The SAA values should be higher, since they include all oils and lubricants, but the observed differences are larger than we would anticipate for that reason alone.
fuel consumption based on engine technical characteristics, predicted much higher rates of UH-60A fuel consumption than were found in all other sources. The study concluded that SDC data were suitable for use in OSMIS factors, but evidence in the report also suggests that average POL consumption in active units might differ considerably from consumption in special-mission and Guard units.

OSMIS uses actual experience only for systems with sufficient history. New system factors are based on engineering estimates from AMC’s Provisioning Master Record data files. These estimates are based on expected peacetime operating tempos that are not necessarily updated when optempos change. Furthermore, the evidence cited above suggests that engineering estimates might be poor indicators of actual fuel usage. In general, fuel consumption for new systems appears quite difficult to predict accurately.

The TAFCS exportable database is a convenient source for POL factors developed from the OSMIS database. The database reports POL consumption rates by weapon system identified by LIN, title, and model and indicates the unit of measure for cost and fuel consumption. Notably, although the database shows separate average consumption rates for FORSCOM, USAREUR, the Eighth Army, WESTCOM, and TRADOC, all the values are identical; that is because the OSMIS factors used as the source are not estimated by MACOM. In addition, TAFCS identifies the source of the OSMIS data and reports costs per barrel and per gallon by fuel type, taking the data from the latest President’s Budget.

Replenishment Parts

<table>
<thead>
<tr>
<th>Unit Resourcing</th>
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<tbody>
<tr>
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<tr>
<td>Other</td>
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</tbody>
</table>

Sources that provide POL factors usually provide replenishment parts factors as well. The following sources refer to actual replenishment parts usage for existing systems:

- USAREUR Circular 37-11: Aircraft OMA parts costs and costs for parts at the organizational and intermediate maintenance levels for large categories of equipment (including electronics equipment).
• FORSCOM Pamphlet 37-1: Two-year (if available) moving averages of costs for OMA-funded Class IX repair parts used by "cost-driving" equipment at active component installations. The factors are total parts commitments divided by total equipment usage, reported by equipment type and installation.\textsuperscript{21} The factors include replenishment parts at both organizational and intermediate maintenance levels but exclude parts funded by procurement appropriations.

• OSMIS factors for OSMIS-tracked systems. Like the foregoing sources, OSMIS factors include parts used in intermediate as well as organizational maintenance. But unlike the foregoing sources, OSMIS factors cover procurement as well as OMA-funded replenishment parts.

• TAFCS exportable database.

\textit{OSMIS Factors.} OSMIS obtains data on repair parts and spares obligations from the Logistics Intelligence File (LIF). It covers parts, by NSN, requisitioned for use on all Army equipment and identifies the units requisitioning the parts.

OSMIS allocates parts that are common to multiple weapons in proportion to the numbers of weapons in a unit.

OSMIS associates the parts obligations with weapons systems by referring to inventory and technical data. CBS-X inventory data identify the equipment found in each unit, and AMC Provisioning Master Record files identify all the parts used on that equipment. OSMIS attributes common parts to end items in proportion to density.\textsuperscript{22}

OSMIS also uses automated troop list extracts to determine which intermediate maintenance units serve specific combat units. In the future, the Army hopes to be able to derive separate factors for DS/GS and organizational maintenance, primarily to support BLTRM-TRM costing for the Army programming process. At present, however, the intermediate and organizational costs are combined.

Before the fiscal year 1992 factors, OSMIS valued most repair parts at their stock-fund price and spare parts at their procurement price; both price measures came from Army Master Data File (AMDF).

\textsuperscript{21}As in the case of POL usage rates, the FORSCOM-wide average is artificially depressed by missing consumption data from some installations for some equipment.

\textsuperscript{22}The allocation is just among the densities at units supported by a particular inventory control point. In any case, common parts are not allocated among units in different MACOMs. According to Calibre, a test was done to determine whether the values varied with optempo, but there was too little variation in optempo to tell.
In the case of repair parts that are depot-level repairables (mainly aviation items), however, the OSMIS factors accounted for the estimated cost of parts to the using units. When a unit turns in a DLR for depot repairs, the unit is billed for the stock-fund price of the item less a percentage credit designed to reflect the probability that the part will actually be repairable (that is, not condemned upon depot receipt). The credit rate is set by Army policy and was 85 percent in recent years. Thus, older OSMIS factors measure 15 percent of the DLR stock-fund price.

Beginning with the fiscal year 1992 factors, however, OSMIS uses separate methodologies for the spares and repair parts estimates. OSMIS replenishment repair parts factors are estimated as described above, with two adjustments. First, the stock-fund price values are adjusted to reflect projected stock-fund surcharge rates provided by ODCSLOG. Second, the cost to the unit for DLRs reflects an updated credit rate, also provided by ODCSLOG.

Meanwhile, the OSMIS factors for replenishment spares reflect the fact that such spares will become stock-funded items in fiscal year 1992. Thus, high-value components that had been priced at procurement cost values will be subject to Army Stock Fund (ASF) surcharges for wastage, freight, and supply system overhead. Furthermore, OSD specifically anticipates a reduction in secondary item demand under the new pricing policy—and has reduced the Army spares budget by 10 percent for that reason. Consequently, spare parts consumption based on historical experience would produce higher projected future usage than the reduced Army budget would allow.

The OSMIS methodology for replenishment spares factors recognizes that all spares requisitions should be accompanied by unserviceable items turned in for depot-level repair. Some portion of the items will be repaired at the depot. The remainder of the items will prove to be unrepairable (washouts) and hence will be replaced with an item supplied by the stock fund. The factors begin with the projected quantities of spares requisitions, estimated from past experience but adjusted to reflect the expected reduction in spares use under the new policy. Next, the share expected to wash out is estimated from a rate supplied in requisitions data files, and that share is costed at the

OSMIS prices depot-level repairable parts at the amount that would be charged to the using unit when the unserviceable part is turned in for repair.

The OSMIS methodology for replenishment spares accounts for the depot-level repair costs for items that can be returned to service.

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23. This is also true of the MACOM factor sources listed above.
24. AMDF indicates the surcharge rate that was applied to the most recent parts purchase price to obtain the stock-fund cost reported in the file.
current AMDF procurement cost and the projected stock-fund surcharge rate. The remainder is costed at the average cost for depot-level secondary item maintenance (rebuilds and overhauls, excluding modifications), estimated from the Depot Systems Command (DESCOM) Master File Maintenance (described in Sec. VI). Thus, the unit-level replenishment spares factor projects the costs of replacing spares with a combination of new purchases and rebuilt items.

OSMIS replenishment factors are based on three years of actual experience whenever possible. However, if a weapon system lacks sufficient history, OSMIS factors are produced using engineering data. The Provisioning Master Record provides estimated failure rates per year and estimated washout rates for spares. Estimated procurement costs are available from program managers and AMC item managers.

OSMIS factor reports publish the average replenishment factors by Major Command, with the ARNG and USAR separately identified, and by the Work Breakdown Structure (WBS) categories used in CEAC's Independent Cost Estimates. However, the OSMIS factor database permits more detailed factor reporting (even by unit and installation) and can be used to call out subelements of costs for special studies.

TAFCS Database Factors. The TAFCS exportable database reports the OSMIS factors for replenishment spare parts, summarized as averages for equipment in FORSCOM, USAREUR, the Eighth Army, WESTCOM, TRADOC, the reserve components, and all Army components. The file reports these estimates in conjunction with POL consumption rates and hence reports the data by equipment LIN, title, and model. Plans also call for the database to include the OSMIS spares factors (supplemented with separate data on the depot repair costs), but they did not appear in the preliminary database CEAC supplied for our study. The TAFCS costing models have been designed to use OSMIS factors that vary by year because of changes in stock-fund surcharge rates and credit policies.26

26 During early development of the factors, Calibre compared them with FORSCOM Pamphlet 37-1 and AM Sample Data Collection results. The OSMIS factors were found to be similar to FORSCOM factors for older equipment that is less subject to changes in parts funding sources. The parts responsible for most SDC costs were also found to be important cost drivers in OSMIS data.
Training Ammunition and Missiles

Figure 3.1 illustrates the development of the Army procurement requirements for ammunition and small missiles. This section deals with the training requirement, and Sec. IV will discuss the determination of war reserve requirements.

Training ammunition programming is performed by the Training Directorate in ODCSOPS. The starting point is requirements compiled from the Standards in Training Commission...
(STRAC), TRADOC school programs, and special requirements. However, these requirements are idealized and do not allow for time required to reach training ranges, poor weather, or other limiting conditions; in practice, neither units nor schools have used all of the ammunition they have been allotted based on such idealized requirements. Except for new systems, for which STRAC is the only data source, data on historical idealized requirements and actual usage are now used to "factor down" the requirements.

The resulting "minimum training requirement," when approved for the Army program, is allotted to units and schools in terms of physical quantities of ammunition, by type, authorized for expenditure. In data reported to OSD and Congress, ammunition "requirements" refer to the minimum training requirement, which usually equals authorized ammunition.

The Training Ammunition Management Information System (TAMIS) tracks idealized, required/authorized, and actually expended ammunition and small missiles, worldwide, by UIC and Department of Defense Identification Code (DODIC). This database, which is maintained by ODCSOPS, reports the data in both physical quantities and dollar values. The dollar values are based on prices supplied by the Armament, Munitions, and Chemical Command (AMCCOM).

Ammunition cost factors in the OSMIS database are based on TAMIS expended quantities. The Ammunition Requirement Mobilization Data Base (AMSAMOB) reports the types of ammunition each type of system (by LIN) can fire, and OSMIS uses this information to associate a unit's ammunition use with its equipment inventories (as specified in CBS-X files). When a unit has several weapon systems that fire the same ammunition, the quantities from TAMIS are allocated among weapons by density. OSMIS uses AMDF prices to determine ammunition costs in dollars.

27 The percentage change in requirements over time is assumed to reflect changes in unit equipping, training, and missions, and that percentage is applied to a three-year average of historical usage to obtain a projected usage level. A further adjustment is made to allow for material lost to training (e.g., unusable munitions) and/or to respond to budget contingencies.

28 In published OSMIS reports, data on "rounds expended" are sometimes presented in physical units. These measure rounds fired from a system's main gun. However, OSMIS dollar cost factors include costs for all ammunition used by the system.
Note that the OSMIS factors refer to ammunition used in unit-based training. Although the OSMIS database includes school-based ammunition use, the OSMIS factors used for POM and budget development reflect usage only within combat arms units.

The TAFCS exportable database currently includes ammunition expenditures from the TAMIS database, reported by SRC and active vs. Reserve Component. Unlike the OSMIS factors, the TAFCS measures refer to unit rather than weapon system usage.

Other Factors

At present, no factors are available on other unit consumables, such as disposable shop items. However, the OSMIS project is looking into the Central Demand Data Base (CDDDB, maintained at the Presidio in San Francisco) as a source of consumables data. And the TAFCS database includes an “other P2 mission” factor; this reflects data on unit expenditures from the USAFAC 218 report, after removing costs for parts and POL. The “other P2 mission” factor captures a variety of miscellaneous items, including not only consumables but unit TDY (temporary duty and associated travel) costs.

Baseline and Independent Cost Estimates (BCEs and ICEs) require specialized “fielding factors.” Among the costs associated with acquiring, fielding, and sustaining an entire fleet of major new equipment items are the costs incurred to man and maintain the equipment. To obtain manning requirements from TOE documents, analysts must identify the numbers and types of units that will field the new items. Fielding factors obtained from acquisition program managers (or estimated from TAEDP data when the system will be fielded during the POM period) indicate how the operational portion of the fleet will be distributed among units of different types.

BCEs and ICEs use “fielding factors” to associate the total quantity of procured weapons with the units that will field them.

Note also that ammunition factors include smaller missiles used on materiel systems but not larger, stand-alone missile systems. Such larger missiles result in procurement rather than operating costs.
Most Army factor sources and models rely on requirements or authorization data for manpower and initial issue materiel but use actuals for operating costs per weapon system. Wherever TOE requirements are used to specify resources, the factors refer to a notional force unit. In contrast, where authorizations or actuals are used, the factors are for specific units or materiel systems or are averages over specific units or materiel items operating under resource-constrained conditions. Comparisons between TOE and MTOE requirements would be useful to cost analysts as a basis for judging whether TOE requirements are representative of the "typical" MTOE unit. Comparisons between requirements, authorizations, and actuals would be useful for judging the extent to which choices among these measures could affect a cost study's results.

Only factors that refer to quantities of resources in notional units can apply, at least conceptually, to all time periods—historical, current, and future. Authorizations are specific to a particular time period (and can change for a given unit over time), and actuals inherently reflect historical experience. Traditionally, resource availability projections for the out-years of the POM have been relatively optimistic and the Services have used notional requirements for costing force structure in those years, but have tightened up authorizations and spending as the implementation year approaches. Army program developers report that recent policy has moved in the direction of makingcutsin force structure rather than in the resourcing of approved units and activities, which implies that traditional discrepancies among TOE requirements, authorizations, and actual spending at the unit level may narrow in the future. Tracking this kind of policy change could be important to interpreting cost results based on data from different time periods.

Quantity factors for manpower and initial issue materiel are usually reported using the force-unit approach described in Sec. I. In contrast, factors for operational resources are associated with materiel systems, except when reported as a generalized factor for unit or installation OMA costs or in training program databases, such as TAMIS. The TAFCS database is specifically oriented to associating operating as well as manpower and materiel costs with force units.

As later sections will indicate, the measurement and coding systems for manpower and equipment are important to associating price rates with quantities. Manpower factors are usually reported in terms of strength rather than man-years, and most equipment quan-
tity factors are reported by LIN. Several of the sources for operating costs use general nomenclature to identify materiel systems, but OSMIS factors (many of which are included in the TAFCS database) use a special weapon system identification code. Since manpower price rates are usually measured per man-year and equipment prices are by NSN, special assumptions are usually needed to convert quantities to dollars.

All the reviewed factor sources for replenishment parts and components attempt to reflect costs incurred in intermediate maintenance. However, only the OSMIS factors include procurement-funded “spare” parts; MACOM factor sources include only OMA-funded replenishment items.

We did not find any factors that separately report command overhead associated with units; only the FORSCOM manpower factors specifically include command manpower within divisions.

Although TDA documents provide quantity factors for TDA units, associating them with the deployable military units they serve is difficult in Army data sources. In Army POM development, adjustments are made to TDA resources when there are changes to TOE density at a post or substantial changes in training operations or workloads. As a rule, however, most cost assessments pertaining to TOE units omit any related TDA cost effects.

Factors for operating costs during transitional periods (unit activation and deactivation) are not explicitly reported in Army factor sources. Instead, assumptions are made about operating levels during transitional periods, and the regular annual factors are scaled up or down to reflect those assumptions. This appears to be a reasonable approach in the absence of direct evidence on transitional operating rates.

Finally, whereas procurement costs and other prices are useful for evaluating the cost effects of acquiring additional unit resources, corresponding values for disposing of materiel are also needed and are not available in readily accessible data sources. However, since the TAFCS project intends to develop a model for costing deactivations, disposal factors might eventually be included in that database.

Replenished parts factors include usage in intermediate as well as unit-level maintenance.

The principal gap in Army factor sources for costing unit activations and deactivations is data on the cost of equipment disposal.
IV. Stockage, Supply, and Provisioning

Unit-level materiel does not account for all the Army's material. Additional inventories are in war reserves, supply system pipelines, and other locations.

Section III examined data sources and factors that indicate the requirements and authorizations for materiel within Army units. However, unit-level materiel does not account for all the Army's materiel; there are additional requirements for wartime reserves, prepositioned materiel, "pipeline fill" for the supply system, and repair parts used in depot maintenance, for example. Moreover, unit-level materiel factors for major end items and ammunition are measured in terms of quantities, and additional factors are needed to associate prices with those items. And unit-level factors do not
account for all the costs of managing and operating the Army’s centralized materiel management organizations.

Together, this section and the next one provide additional information about decision processes, models, and factor sources for Army materiel. The following section will examine materiel and other resources used in intermediate- and depot-level maintenance. The current section examines the overall Army stockage, supply, and provisioning system.

This section examines materiel requirements and acquisition objectives, prices, float items, war and other reserves, and costs for central supply management activities. In addition, this section explains how materiel items are treated in weapons acquisition costing, which uses the modernization costing approach described in Sec. 1.

Although current plans call for consolidating central supply (and maintenance) activities across Services early in this decade, this section examines the Army supply system circa 1991. Centralization will alter some features of the supply system and will affect the costs charged to Army using commands. However, even a centralized system will surely rely in large part on the processes, models, methods, and databases already established by the Army, as described in this section.

**Acquisition Objectives**

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<th>Stockage/supply</th>
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<td>Inventories</td>
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Acquisition objectives are developed using management methods and models specific to various class of materiel. The following discussion covers the processes used to develop acquisition objectives, the (often complex) models used in those processes, and the proce-

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1 According to Army Regulation 37-100-90 (The Army Management Structure), Central Supply Activities consist of: (1) Central Procurement Activities; (2) The Army Stock Fund (ASF); (3) Supply Depot Operations; (4) Logistics Support and Supply Management Activities; (5) Army Industrial Fund (AIF) Management; (6) Troop Subsistence Activities; (7) Base and Commissary Operations; (8) First and Second Destination Transportation; (9) Fort Operations; and (10) Industrial Preparedness Operations. This section addresses activities (1) through (4). Section V addresses the depot maintenance portion of (5), and Secs. VI through VIII address activities (6) through (8). We found no evidence of cost factors specifically developed for use in connection with activities (9) or (10).
The APR process develops requirements and acquisition objectives for major end items and for ammunition war reserves.

The Army Procurement Requirements Process for Major End Items and Ammunition/Missile Reserves

The Army Procurement Requirements (APR) process develops requirements for major end items (including large missiles, such as the Multiple Launch Rocket System (MLRS)), and war reserves for major items and all ammunition.

Major end items are always financed by the Army Procurement Appropriation (PA), are “free issue” to combat arms units, and are covered by the Initial Issue Quantities (IIQs, see Sec. III) identified in TOEs and other unit requirements documents. In weapons acquisition costing (i.e., BCEs and IIEs), expenditures associated with obtaining major end items are covered by the development and production cost categories (see Vol. 1 and Sec. IX of this volume); these items are not part of Army fielding or sustainment costs.

Ammunition and missiles are also purchased entirely with PA funds. However, ammunition and missiles used for peacetime training are considered sustainment items in BCEs and IIEs and are subject to the training requirements process described in Sec. III. After adjustments for affordability considerations, the sum of the training requirement and the APR war reserves requirement appears as the ammunition “requirement” in the Army POM and budget.²

The APR process develops requirements based on the time-phased wartime force structure plans of the Army. For each item, the process determines the Army Acquisition Objective (AAO),³ the “quantity of an item . . . required to equip the approved U.S. Army force and sustain that force, together with specified allies, in wartime

²Baseline Cost Estimates performed by AMC and Independent Cost Estimates performed by CEAC. See Vol. 1.
³Until recently, the Army normally expected to receive funding sufficient to meet its ammunition budget. However, some major ammunition prices have risen rapidly in recent years and that trend, combined with current efforts to control overall spending, is focusing attention on opportunities to cut ammunition budgets. An initiative receiving current attention, for example, is further development and use of training simulation devices.
⁴There are also “NonArmy Acquisition Objective Items”—items necessary to support TOE/TDA missions and functions but for which an AAO cannot be computed from LOGSACS.
from D-Day through the period prescribed in the latest OSD Defense Guidance.\textsuperscript{5}

Figure 4.1\textsuperscript{6} illustrates the composition of the AAO. It consists of:

- Initial Issue Quantity (IIQ), essentially the sum of all TOE requirements at ALO 1 and all TDA requirements.
- Maintenance Float (MF), "a quantity of selected end items authorized for stockage at a depot or MACOM stock record account. It will be used for replacement of like items turned in by using units for which an immediate replacement is required to maintain an acceptable level of materiel readiness during peacetime."\textsuperscript{7} MF comprises Operational Readiness Float (ORF)

\begin{figure}[h]
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\includegraphics[width=0.5\textwidth]{composition.png}
\caption{Composition of the Army Acquisition Objective}
\end{figure}

\textsuperscript{5}See Army Command and Management (1989), p. 18-14. D-Day refers to the first day of mobilized deployment.

\textsuperscript{6}The figure is based on an illustration in Army Command and Management (1989).

\textsuperscript{7}See Army Regulation 750-1, p. 23.
for intermediate maintenance and Repair Cycle Float (RCF) for depot maintenance.\textsuperscript{5} ORF is authorized for both active and Reserve forces; RCF is authorized for active forces only.

- Operational projects, an allowance to provide support for specific logistic/operational/contingency plans; this accounts for less than 1 percent of the dollar value of the Army's total AAO requirements.

- Post D-Day consumption for U.S. and allies, including MACOM overseas theater stocks (war reserve stocks,\textsuperscript{9} Prepositioned Operational Materiel Configured to Unit Sets (POMCUS), and a theater safety level). These requirements are derived from a computer program that deploys forces on a time-phased schedule and projects materiel attrition using a Wartime Replacement Factor (WARF).

The Army Acquisition Objective represents the total desired inventory. The Procurement Objective is the quantity the Army intends to buy.

Figure 4.1 also shows how the AAO relates to procurement programming and budgeting. Assets on hand (including undelivered prior buys) are reduced by projected losses, and the remainder is subtracted from the AAO to obtain the procurement requirement. When available funding is not adequate to finance the entire amount, priorities are set by reference to a Force Packaging Methodology related to the DAMPL. In practice, most TDA units are given low priority and not all of their requirements are procured. The affordable quantity is known as the Procurement Objective (PO).

The Research, Development, and Acquisition Information Systems Agency (RDAISA) performs the budgeting computations using:

- LOGSACS data on IIQs, and Republic of Korea IIQs from ODCSLOG;
- RDAISA's SSN tape;
- WARP/AMMO rates tape from ODCSOPS;
- Operational projects tape from AMC's Depot Systems Command (DESCOM); and
- Ammunition mobilization training tape from ODCSOPS.

RDAISA sends selected SSN data to the ASA (RDA) database and sends all SSN/LIN results to the Army Materiel Command's Major Subordinate Commands (MSCs).

\textsuperscript{5} Army Regulation 750-1 indicates that an NICP may issue RCF assets to fill MT0E/TDA or RCF shortages when other assets are not available.

\textsuperscript{9} AMC's War Reserve Automated Process (WRAP) provides information about war reserves for item managers and also for budget development.
Initial Provisioning of Secondary Items

The Provisioning Process. When a unit is activated, the Army provisions it with a package of secondary spares and repair parts and supplies. This package is tailored to the overall configuration of the unit and its missions and takes account of common parts that might be used for several of the unit's equipment items. The package represents a basic stock of materiel that should be maintained in the unit.

In the case of units that will field new materiel systems, plans for secondary item provisioning are developed during the RDA process. AMC initiates a Materiel Fielding Plan (MFP) tailored to each MACOM that will field the new equipment. The MFP includes plans, schedules, procedures, and command actions for deploying and sustaining the new items. For selected modernization systems, AMC formulates an entire package of initial issue logistics material, including ASIOE, called the Total Package Fielding (TPF). Historically, the TPF included both O&M and procurement-funded items. However, Congress has recently required that all costs associated with the initial fielding of modernization systems be covered by the procurement appropriation.

Acquisition requirements for initial provisioning are developed by AMC Headquarters using the SESAME (Selected Essential Item Stockage for Availability Method) model. It is an automated program that projects detailed provisioning needs for both new systems and additional fieldings of existing systems and is used in support of stock management as well as budget forecasting.

SESAME covers parts in essentiality classes C, D, and E—items that are combat-essential or necessary for safety and legal reasons—including support and test equipment. The model covers both PA2 and stock-funded parts and generates requirements by claimant (i.e., unit) and fund code. Data inputs are beginning and ending system density for the year, along with 26 data elements from the Provisioning Master Record (PMR) datafiles maintained by AMC MSCs. Especially important inputs are engineering estimates of items' mean times between failures.

[10] Previously known as the Total Package/Unit Materiel Fielding, TP/UMF. Note that "TPF" is sometimes used in weapons acquisition coding to refer to initial secondary items regardless of whether they are part of a specially designed package, but we avoid that terminology in this report.
DoD Instruction 4140.42 allows the Services to use optimization models that select the least costly mix of maintenance items for achieving desired end-item availability for operations. SESAME is the Army's implementation of this. It accommodates provisioning for five different geographic deployment areas (CONUS, Europe, Pacific, Southern Command, Alaska) plus a separate computation for training organizations. SESAME provides for initial provisioning at unit-level, intermediate, and depot maintenance activities.

The TAFCS database provides secondary item provisioning costs by unit. In weapons acquisition costing, the factors pertain to provisioning associated with individual types of equipment.

Provisioning Cost Estimation. For combat-unit costing, Sec. III described the initial spares/repair parts factors that will be in the TAFCS database. Those factors will be based on the Prescribed Load List (PLL) and an allocated portion of the Authorized Stockage List (ASL) loads in intermediate maintenance units.11

In weapon system costing, the initial production contract for a modernization system often includes some production of initial secondary items, and that portion of costs is included in the production category of BCE (and ICE) cost estimates. For those systems that have AMC-developed TPFs, BCEs and ICEs also pick up a specific estimate of Total Package Fielding costs.12 Otherwise, the initial provisioning cost is estimated in different ways as the modernization system moves from early development to early fielding stages.

Early in the development process, a common rule of thumb is for BCEs to allow 2 to 30 percent of the modernization system's production costs for initial provisioning of secondary items. The higher percentage would be allowed for items such as radar systems that have high operating rates and hence tend to require more parts. The rule of thumb is at least implicitly intended to include provisioning for depot maintenance as well as lower maintenance echelons.

In reviewing these estimates, CEAC analysts sometimes refer to experience with analogous existing systems; the ICE review would then consider the number of days of supply required for initial provisioning and apply that to the rate of replenishment consumption shown in OSMIS factors. Those estimates would not account for depot maintenance stocks but would lead to discussions with AMC if the discrepancy were noteworthy.

11 As Sec. III noted, the TAFCS will not provide distinct factors for TPF on the grounds that the fielding packages are case-specific and their costs are already recognized in the PLL/ASL cost factors.

12 TPF item prices are taken from the AMDP using the SB 700-20 crosswalk from NSN to LIN. The TPF might include software support.
Later, as the modernization system enters the fielding stage, BCEs use estimates (for both wholesale and retail items, by NSN) developed from the SESAME model. Presently, CEAC also must rely on SESAME estimates but confers with ODCSLOG and ODCOPS to review the assumptions underlying those values.

However, analysts will soon be able to estimate initial provisioning requirements on a personal computer. Under a CEAC contract, SAI and MAI are developing CASESAME (Cost Analysis SESAME). It will use initial spare and repair parts costs for an analogous system to calculate the corresponding costs for a developmental system. Databases for a family of analogous systems will be built from the Provisioning Master Record (PMR), and the analyst will be able to modify selected data such as failure factors, unit prices, and fielding schedules.

CASESAME will calculate stock levels and operational availability and will produce time-phased procurement schedules based on the modernization system’s fielding schedule. The model will also distribute initial provisioning costs between the PA2 and ASF accounts (corresponding to BCE/ICE line items 2.07 and 4.04 for initial spares and repair parts, respectively), although this will no longer be necessary when all initial provisioning will be supported by the procurement appropriation.

CASESAME will be a relatively small computer model that will permit quick-turnaround, what-if analysis. It should provide CEAC with an important independent review capability that accounts for the budgetary implications of modernization system initial provisioning.

Replenishment of Secondary Items

Requirements Development. Like initial provisioning, requirements for replenishment spares and repair parts are estimated by AMC Headquarters using an automated model. The model is RDES (Requirements Determination and Execution System). Along with SESAME, RDES is part of AMC’s Commodity Command Standard System (CCSS) information system.

RDES primarily handles Class IX items but includes some major stock-funded items in Class II as well. The model, which users describe as “incredibly complicated,” is used for budget justification as well as parts management. In some cases, program managers also refer to RDES results for existing systems to project replenishment secondary item demands by new materiel systems.

RDES is a complex, detailed model that projects requirements for replenishment spares and repair parts.

RDES is used primarily for budget justification and parts management but (like SESAME) can be used to support weapons acquisition costing.
To calculate requirements for individual items, the RDES uses the following factors:

- Average Monthly Demand (AMD), estimated from two years of historical requisitions;
- Program Change Factor (PCF), a ratio of programmed to historical equipment density;
- Safety Level (SL), a fractional addition to projected demand to allow for fluctuations around the forecast value;
- Repair Lead Time (RLT);
- Repair Cycle Time (RCT);
- Reorder Cycle Time (ROCT); and
- Procurement Lead Time (PLT).

Stated in simplified form, the model calculates a requisition objective as the product of the demand forecast (AMD*PCF) and \((1 + SL + RLT + RCT + ROCT + PLT)\).

Although RDES does not relate secondary item demand to optempo for ground equipment, it does for aircraft. AVSCOM supplies optempo data, and AMC incorporates the information in the aviation item program change factors. In many other ways as well, the model is more complex than the foregoing description implies.

**Replenishment Estimation.** Unlike initial provisioning factors, secondary item replenishment costs are estimated on a per-system (modernization approach) basis for both force-unit and weapon system decisionmaking. Both types of costing rely heavily on the OSMIS factors described in Sec. III.

Early in a modernization system’s development, BCEs and ICEs rely on rules of thumb for replenishment cost estimates; typical values are 2 to 10 percent of manufacturing costs. However, as the system approaches fielding, it becomes easier to identify analogous systems that provide OSMIS factors. For example, the BCE for replenishment consumption by the Avenger missile carrier combined OSMIS estimates for the Bradley and M1 fire control systems. ICEs also rely on OSMIS factors but may reflect alternative choices of “analogous” systems, and may refer to information available from other sources as well.\(^{\text{13}}\)

\(^{13}\)For example, CEAC commonly obtains specific factors from the Missile Logistics Center in Huntsville. In general, missile sustainment costs are very low (repair parts are mainly for training devices, grips, etc.), so detailed estimation from analogous systems may not be warranted.
To supplement the OSMIS factors, Calibre has recently developed a new model under a CEAC contract: the Replenishment Spares Cost Estimating Model (RSCEM). It simulates the operation of the complex RDES system and estimates wholesale-level life cycle costs for replenishment spares (life cycle cost element 5.012). Note that the model estimates the procurement costs for replenishment spares, which represent the cost to the stock fund, not the O&M cost that must be financed by units beginning in fiscal year 1992.

User inputs to the model are the materiel system name, optempo, deployment schedule (figured quarterly), system type, and a list of spares for the selected system. Basic component demand is calculated from the component's usage, a demand or failure rate, annual activity rate (optempo), and the number of fielded systems. Using a simplified version of the RDES logic, the RSCEM calculates additional demands based on factors for pipeline or wholesale supply—required Safety Level, Repair Lead Time, Repair Cycle Time, Reorder Cycle, and Procurement Lead Time.

The model computes stock on hand, plus stock due from procurement and depot repair facilities, and subtracts demands. The estimated shortage of stock is multiplied by the unit price to get replenishment spares cost for each component. To get the current quarter purchase cost, the model allows for a nine-quarter lag in the wholesale system between purchase determination and arrival of new stock.

Notably, the RSCEM database includes default values for many important factors. The model accommodates input of factors disaggregated by Work Breakdown Structure (WBS) for aircraft (i.e., airframe, power plant, communications, fire control, armament); combat vehicles (hull, power plant, communications, fire control, armament); tactical vehicles (frame, power plant, communications); armament (carriage, communications, fire control); missiles (launcher, guidance, radar, control center); and electronics (automated data processing, data display, communications, sensors). However, most of the default values are the same for all components. The factors, and their default values, are:

- **Field Repair Factor (FRF):** percentage of repairs accomplished in the field rather than in a maintenance facility. The default is set to zero because there is little field replacement of high-cost components and because the developers assumed analysts would normally use historical demand or failure data.
- **Depot Repair Rate (DRR):** percentage of all unserviceable components repaired at depot. The default value is 95 for all
cases, a level considered "generally representative of recent actual Army experience for high dollar value spares."

- Unsatisfactory Return Rate (URR): percentage of total unsatisfactory components that reach the depot in a given time period compared to the average demand for that component during that period. The default value is 85 for all cases, a level considered representative for high-value spares.

- Safety Level (SL): amount of stock in months of supply maintained to accommodate fluctuations in actual demand around forecast demand. The default value is zero, but the model documentation recommends a value of one if the case involves mostly medium-cost spares (i.e., less than $10,000).

- Repair Lead Time (RLT): time in months between receipt of unsatisfactory component at repair facility and its entry into the repair process. The default value is one in all cases.

- Repair Cycle Time (RCT): time in months needed by the repair process to restore the component and classify it ready for issue. The default value is three in all cases.

Since the RSCEM is designed to deal only with selected, high-value components, its coverage of replenishment secondary items is much more limited than that of the RDES. On the other hand, RSCEM exceeds the scope of RDES in that the new model also tracks depot repair costs for Depot Maintenance Labor, O&M Depot Maintenance Material, and Procurement Depot Maintenance Material. This portion of the model will be discussed in Sec. V.

Petroleum, Oils, and Lubricants

POL is financed entirely by the Operations and Maintenance Appropriation (OMA for the active Army, OMAR and OMNG for the Reserve and Guard), and divisions are billed for POL against their O&M allotments. POL is considered to be exclusively a sustainment item in B CES and IC ES. POL is managed through the Defense Logistics Agency (DLA), and POL pricing for POM and budget costing is based on OSD-established rates.
Item Pricing Factors

Stockage/supply
Acquisition objectives
Pricing
Inventories
Float
War reserves
Other (misc.)

Section III noted that costing for materiel frequently uses separate factors for item quantities and prices. The following discussion surveys data sources for materiel prices and identifies certain obstacles to obtaining appropriate price factors.

Prices for Major End Items, Secondary Items, and Medical Materiel

AMDF. The most comprehensive source of data on current materiel prices is the Army Master Data File (AMDF) maintained by the Catalog Data Activity at the New Cumberland Army Depot in Pennsylvania. In addition to prices, it provides a wide variety of data on individual materiel items, listing equipment by NSN. AMDF prices are those charged by the Army Stock Fund for stock-funded items or the latest procurement price for nonstock-funded items.¹⁴

Stock-fund prices are updated annually, using a formula that applies a surcharge for freight, wastage, etc., to the item’s latest contract price. This price is used for billing purposes, both for retail transactions within the Army and for sales to other agencies.

Procurement prices for nonstock-funded items (both end items and, for the time being, spares) are based on procurement contracts and normally include charges for first destination transportation (i.e., from FOB origin to delivery at a government inventory control point). Although some of the contract prices used in these exercises go back to the 1970s, items in regular use usually have recent contract prices. However, the procured items may not be configured for final use, and the contract “price” may include costs for ASIOE, initial spares, and other items not normally considered part of the NSN for which the price is recorded. According to officials at the Catalog Data Activity, AMC is currently reviewing the development of procurement prices.

¹⁴Or, in some instances, estimated price for items too new to have official prices or too old to have a reasonable procurement price.

The Army Master Data File is the most comprehensive source of official Army pricing data.

Both stock-fund and procurement prices normally include some transportation costs.
POM PDB. Another source for price data is the POM Procurement Data Base (PDB) maintained by ASA (RDA). The PDB provides procurement prices for items included in the current POM.

A basic difficulty in using equipment prices is that prices are NSN-specific whereas most costing exercises use equipment data identified by LIN. In some cases, the prices for NSNs within a LIN category vary considerably. For example, two versions of a six-ton tracked cargo carrier (the M548 and M548A1) were priced at $106,000 and $221,000 in 1989, yet both are in the primary (A) category for assignment to units.\textsuperscript{15}

\textbf{The standard source for equipment prices by LIN is Supply Bulletin 700-20. However, ODCSLOG also maintains a LIN price file, and the TAFCS database will also include one.}

SB 700-20. The standard procedure for pricing LINs is to rely on Army Supply Bulletin 700-20. It lists the NSNs associated with each Army LIN and indicates the “preferred” price among those NSNs; the preferred item is the one considered most desirable for equipping a unit and is often the newest of the NSNs. Although the AMDF also has an indicator code for preferred price, analysts familiar with the AMDF commonly claim that its indicator codes are not always accurate.

\textbf{RDAISA Data Files.} Prices for newly developed equipment may not be found in the foregoing files. When equipment is first under development, it is given a ZLIN code for use in RDA data files until a permanent LIN is established. Files maintained by RDAISA capture price and other information for ZLIN items but often with a very long lag.

\textbf{LIN Price File.} A source that includes an estimated price for new equipment is the LIN price file maintained by ODCSLOG. It uses LIN prices from the PDB, supplemented by prices from SB 700-20 for items not covered by the PDB. For ZLIN items that have no PDB price, the ODCSLOG file uses the SSN associated with the ZLIN, deletes the final character of the SSN to obtain a code at the next higher level of aggregation, and then uses the (unweighted) average of the prices for all LINs associated with the shortened SSN. Thus, the LIN price file uses the average price from the family of LINs to which a new ZLIN belongs.\textsuperscript{16}

\textbf{TAFCS Exportable Database.} Another source for LIN price data is the TAFCS exportable database. The primary source is SB 700-20

\textsuperscript{15}Values shown are from an unpublished RAND analysis, courtesy of the authors. The categorization is based on the equipment’s Logistics Control Code.

\textsuperscript{16}A further convenience in the LIN price file is that it shows escalated prices by LIN for the current year and the succeeding ten years. The prices are escalated using standard OSD inflation rate assumptions.
preferred prices, but revisions have been made when knowledgeable individuals found the bulletin identification of the “preferred” NSN for a LIN to be inappropriate. The price values are identified by LIN, logistics control code, the “preferred” NSN and NSN description, unit of issue, appropriation code, a flag to indicate that multiple NSNs pertain to the LIN, item weight, and item cube (volume).

**POL and Ammunition Prices**

**DLA Bulletins.** By DoD directive, POL is programmed and budgeted at standard prices published by the Defense Logistics Agency Administrative Support Center in Price Bulletin XX-1 (where XX is the last two digits of the fiscal year), as amended by Program Budget Decisions (PBDs). These prices were also regularly reported in the FORSCOM/TRADOC Resource Factors Hand Book, Volume I.

**AMDF Files.** Ammunition and small missile prices appear in the AMDF file by Department of Defense Identification Code (DODIC, an NSN-type code for ammunition). However, many analysts within the Army prefer to use ammunition price data obtained directly from the Armament, Munitions, and Chemical Command (AMCCOM), believing them to be more accurate and up-to-date than AMDF data. For example, AMCCOM prices are used in Army training requirements programming.

**TAFCS Exportable Database.** The TAFCS exportable database provides ammunition prices from the AMDF files. The TAFCS ammunition data file shows ammunition code, national inventory item number, unit of issue, ammunition nomenclature, ammunition LIN, materiel category structure code used for inventory management, logistics control code, a code to indicate whether the price is standard or estimated, and the unit.

**Inventories of Major End Items**

| Stockage/Supply | Acquisition objectives | Pricing | Inventories ✓ | Float | War reserves | Other (misc.) |

Section III described factor sources for major end items issued to TOE/MTOE/TDA units. However, such units do not account for the entire inventory of major end items.
CBS-X. The Consolidated Balance System-Expanded (CBS-X, also see Sec. IV) database covers current inventories of on-hand field equipment, depot stocks, and in-transit materiel by UIC for the active, Guard, and reserve components. Most items are covered via a transaction-reporting system, but transaction reports are not required for aircraft, missiles, or Communications Security (COMSEC) equipment; on-hand balances for those items are supplied by the Aviation Systems and Missile Commands (AVSCOM, MICOM) and the Communications Security Logistics Agency (CSLA), respectively. The CBS-X database reportedly covers about 90 percent of the dollar value of Army equipment and is quite accurate. CBS-X data are classified confidential, but data extracted below the division/separate brigade level or that do not identify organizations are unclassified.

The CBS-X and TAEDP both identify the large quantities of Army equipment located outside combat arms units. The TAEDP projects future stocks.

TAEDP. The TAEDP (Total Army Equipment Distribution Program) covers major end items found in Active, Guard, and Reserve units; POMCUS; and war reserve and other stocks. The system not only records inventories on hand (taken from the CBS-X) but current authorizations and requirements—and annual projections through the POM years. Hence, the TAEDP indicates which units will field modernization systems.

TAEDP data are stratified by UIC, brigade, division, installation, state, MACOM, theater, force package, war reserve, POMCUS, and depot stock. The data are available by fiche, magnetic tape, or paper reports from the Logistics Programs Support Activity in Chambersburg, Pennsylvania.

Although both the CBS-X and the TAEDP are commonly used to identify equipment inventories for combat units, it is important to note that these systems also report on the significant amounts of materiel found outside the combat arms, including POMCUS and units in the wholesale division of the Army supply system.

17CBS-X coverage is determined by Supply Bulletin 700-20. Materiel in Resource Identification Code (RIC) 2 is covered for the active component and ARNG, whereas materiel in RICCs 2 and 3 are covered for the USAR.
Float Factors for Major End Items

There are two basic types of float factors. Maintenance float (MF) factors—ORF for intermediate maintenance and RCF for depot maintenance—represent additional purchases of items necessary to support repair processes; the additional purchases are nonrecurring costs associated with the acquisition of a materiel system. Attrition float factors provide for additional purchases to replace items lost during peacetime operations and represent a recurring cost.

Float factors are used differently in cost studies using the force-unit and modernization approaches described in Sec. I:

- In force-unit models, MF factors are used to determine total procurement quantities required to support the operational equipment added to the unit. Replacement of attrition is an operating cost for the unit.
- In modernization models, the MF and attrition-replacement quantities are assumed to be included in the procurement quantities. The factors are used to reduce the total procurement quantities to the number of operational systems, which are then used to determine manning (by TOE) and other O&S cost items.

Army Regulation 750-1 requires that AMC publish ORF factors in SB 710-1-1 and publish MACOMs' ORF authorizations in the TAEDP. To qualify under this regulation, items must have an SSN and be in Class VII or Class II. Corresponding regulations for RCF reporting are in AR 710-1.

Supply Bulletin 710-1-1 reports ORF factors as a yearly percentage of required operating quantities by SSN, with separate factors for CONUS, Pacific, Europe, Alaska, other, and (in future editions) combat categories; for aircraft, the factors are estimated at the Mission-Design-Series level of detail.\(^{18}\) The same supply bulletin also reports RCF for the other, Pacific, and Europe categories. And the SB reports a Peacetime Replacement Factor (PTRF); it is a "monthly factor used to estimate percentage of in-use equipment

\(^{18}\) Aircraft ORF are baselined at 10 percent of the MTOE requirement and adjusted annually during the Worldwide Aviation Logistics Conference.
requiring replacement during a given period. Normally, the most recent eight quarters of in-use density ... and peacetime losses, reported through the ... CBS-X, are used to develop the PTRF.\textsuperscript{19}

For new systems, a possible source of MF factors is the Army Materiel Plan Modernization (AMP-MOD), an automated support system for major item management. It includes a Master Item Data Reference used to maintain the SSN system, maintenance float factors and replacement factors for Army procurement appropriation equipment items, component-to-assembly relationships, and a Major Item System Map showing the makeup of a major materiel system.

**War Reserve Factors**

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<tr>
<th>Stockage/supply</th>
<th>Acquisition objectives</th>
<th>Pricing</th>
<th>Inventories</th>
<th>Float</th>
<th>War reserves</th>
<th>Other (misc.)</th>
</tr>
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</table>

The Army budget for war reserves includes acquisition, maintenance, and transportation. The principal costs are covered by procurement funds for major items and spares, but a minor amount is incurred through the Army Stock Fund.

**Wartime Replacement Factors are available but they are rarely used in force-unit costing.**

With regard to estimating quantities of war reserve materiel, SB 710-1-1 reports a Wartime Replacement Factor (WARF). The factor is described as an average daily loss rate for major items of equipment, expressed as a percentage of daily authorized theater equipment density and based on historical data. More detailed WARF values, as well as war reserve ammunition factors, are also on the WARF/AMMO tapes in ODCSOPS; these tapes contain daily rates reported in 15- and 30-day increments to reflect equipment lost in combat and "firing rates per tube" based on Concepts Analysis Agency (CAA) scenarios.

Although these factors are used in APR requirements development, it is not clear to us how or when they are used in force-unit or modernization costing. As a rule, force-unit costing treats war reserves as a separate decision process and does not attribute such costs to units. A cost allowance for war reserves is included in BCE/ICE cost studies, but AMC officials report that they are dissatisfied with their current method of estimation and intend to establish a basic policy.

\textsuperscript{19}See SB 710-1-1, p. 1-2.
(e.g., "30 days of supply") for projecting war reserve requirements for new systems.

For war reserve planning purposes, ODCSLOG currently uses a Balance of Sustainment Model (BOSM). It is a "large" personal computer model that predicts war reserve requirements of materiel in Classes V, VII, and IX and is under continuing development to cover Classes I, II, IV, and VIII as well. The current version of the model was used for quick-turnaround planning in support of Operation Desert Shield.

The BOSM uses input data developed by the Army Concepts Analysis Agency to describe materiel attrition and ammunition expenditures by UIC and day for a wartime scenario. The TAEDF provides information on materiel on hand and LIN requirements. The BOSM then computes the reserves needed at the start of the war to sustain the force throughout the scenario. Reserves are measured in both quantities and dollar value. Thus, this tool could be quite useful in costing exercises that examine significant changes in Army missions and theater responsibilities.

Other Central Supply Factors

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<th>Stockage/supply</th>
<th>Acquisition objectives</th>
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<tbody>
<tr>
<td>Pricing</td>
<td>Inventories</td>
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<tr>
<td>Float</td>
<td>War reserves</td>
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<tr>
<td>√ Other (misc.)</td>
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As noted above, ASF item prices include overhead costs for supply system operations and end-item storage. However, costing for major end items generally uses procurement prices that do not include such costs. And when making decisions about wartime reserves (including POMCUS), it can be important to estimate storage and storage-related maintenance costs that are not currently available in factor form.

Storage is provided primarily by AMC's Depot Systems Command (DESCOM). It operates Area-Oriented Distribution Depots that receive, store, and distribute secondary items (90 percent are repair parts) and common-user DLA and General Services Administration (GSA) items. DESCOM also operates Ammunition/Special Weapons Depots that store and also renovate and demilitarize munitions of all types. Storage costs for these CONUS depots are paid from the AMC budget, whereas storage for POMCUS and other Europe-stationed war reserves is paid out of the USAREUR budget. CEAC

Storage costs for POMCUS and other stationed reserve stocks are not currently covered by factors.
reportedly is looking for data sources to support factors reflecting these costs.

Army Headquarters has contracted with Automation Research Systems, Limited (ARS), in Alexandria, Virginia, to develop a family of resource-predictive models for use in POM development and review. One of these models is the Central Supply Resource Predictive Model (CSRPM).

The CSRPM is in the early stages of development. A functional description has been prepared, but it emphasizes the functionality of the proposed software (database management and user interfaces) and provides few details on the proposed estimation methodology.

The documentation calls for the model to predict the effect of changes in Army equipment density, distribution, and optempo on resource requirements for Supply Depot Operations, Central Procurement Activities, Supply Management Operations, Logistics Support Activities, and Army Industrial Fund (AIF) and Army Stock Fund (ASF) operations. These activities are currently covered by over 40 Army MDEPs.

The documentation also indicates that resource use will be related to the annual numbers of requisitions, estimated by reference to historical experience for a sample of major end items and related spare/repair parts. However, CSRPM documentation does not specify which resources will be projected (or whether the projections will be in terms of total dollars of expenditure) or what methodology will be used to estimate the historical relationships between resources and requisitions. It is also unclear whether or how the methodology for AIF and ASF resources would relate to methods used to develop industrial and stock-fund pricing.

At least in past years, funds budgeted for depot maintenance have been diverted to under-funded central supply and transportation activities.

If the resource relationships are estimated from historical budget data, the cost relationships might be underestimated. This is suggested by a 1988 Government Accounting Office report showing that funds budgeted for depot maintenance had been diverted to central supply and transportation. The study cited an Army official's response to the effect that the diversion was necessary because central supply had traditionally been underbudgeted and underfunded. The CSRPM should provide a more objective basis for allocating funds to central supply activities but only if the estimated relationships accurately reflect resource usage as a function of workloads.

While work is under way on the CSRPM, another factor for central supply system costs is under development for the TAFCS database. Plans call for developing a "T7S indirect sustainment" factor using
data from the Army O&M budget justification books. The method for deriving this factor is not yet documented.

Summary and Commentary

Methods for costing changes in force structure (activating, deactivating, and modernizing force units) commonly estimate the costs of equipment, ammunition, secondary items, and consumables by starting with the materiel used within the unit, adding in materiel costs for related organization (e.g., intermediate and depot maintenance), and making adjustments for such matters as Repair Cycle Float. This method often does not estimate costs for pipeline fill in the supply system, war reserves outside the unit, or central supply management and administration. Traditionally, those omissions have been considered appropriate on the grounds that relatively small force changes would not entail cost effects in the omitted categories.

Both this common methodology and newer methods designed to address large force changes can benefit from a review of the information presented in this section—on how aggregate materiel purchase objectives are developed and how their costs can be estimated for the supply system as a whole and for its various aspects. In particular, the information in this section leads to the following considerations in cost estimation:

- Army combat arms units do not account for the total of Army materiel inventory. In particular, a substantial portion of Army materiel procurement is held in POMCUS and other reserve stocks and in the wholesale supply system. To the extent that changes in force structure (i.e., in the numbers and types of combat arms units) are accompanied by changes in reserves or wholesale supply operations, additional costs arise outside the force units themselves.

- Army requirements for secondary item supply are developed from a methodology that does not account for ground optempo. (However, as noted above, RDES does account for aviation optempo.) To the extent that optempo affects secondary item demand, large changes in Army optempo could affect actual usage of secondary items in ways not anticipated by the requirements process. Similarly, the effects would not be anticipated by cost estimates based on OSMIS factors, which also are calculated per weapon system rather than per mile or hour.

Methods for analyzing the costs of small force changes traditionally omit costs for war reserves and central supply administration. Such costs might be affected by larger force changes and by supply system reorganization plans.

Secondary item factors are developed from a methodology that does not account for ground optempo variations—even though the factors may be reported per mile.

20However, stock-fund overhead costs are automatically included in the prices of stock-funded items.
• Acquisition budgeting must allow for procurement leadtimes to generate materiel supplies at the times they are needed. Procurement for major end items must be budgeted several years in advance, and procurement for repair parts and some consumables must be budgeted two to three years in advance.

• As the text noted, Congress has been reluctant to support reductions in ammunition purchases and has sometimes added amounts to the Army's budget, primarily for war reserves. This behavior abrogates the predictive value of ammunition reserve cost factors.

• Although it is common practice in cost studies to use transport cost factors (see Sec. VIII) to capture the costs of moving materiel to and from units, it is important to recognize that many pricing factors include at least a portion of transportation costs. First destination transportation (from manufacturer to Army delivery point) is often included in procurement prices for major end items. And Army Stock Fund prices include some freight costs within the Army supply system. Furthermore, procurement prices may well include elements of initial provisioning of secondary items and secondary equipment costs.

• The conversion of spares to stock-fund pricing will cause a number of anomalies in secondary item pricing, both for budgeting purposes and in costing studies. Analysts should be especially careful to ascertain whether factors have been adjusted for (a) the stock-fund surcharge, and (b) reduced spares budgets. These adjustments are incorporated in OSMIS factors for fiscal year 1992 and beyond.

• In unit costing, use of FLL/ASL factors to be included in the TAFCS database implies that a unit is added to the force, requiring acquisition of secondary items for initial provisioning. However, if a unit receives equipment from elsewhere in the force (e.g., if a Reserve unit replaces an active unit), initial provisioning purchases may not be necessary.

• The treatment of depot-level stocks of secondary items is ambiguous in Army costing. Unit-level analyses commonly recognize initial provisioning for organizational maintenance and a share of intermediate maintenance but omit depot provisioning. Methods for weapon system costing, on the other hand, sometimes include and sometimes exclude depot-level stocks. In principle, depot-level stocks should be taken into account in both types of analysis, but factors and factor models (including ones under development) do not automatically do so.

• Float factors are used differently in unit and modernization costing. In the former, the factors are used to determine additional procurement required in support of unit-level demands. In the
latter, the factors are used to determine the portion of total procurement that will be distributed to units as operational materiel.

- A new Army policy for determining war reserve estimates in BCE/ICE cost studies may be under development.
- Factors for the costs of central supply management and operations are in an especially limited state of development.

This section also made an observation that will recur throughout this report—that the Army is increasingly using modern computational software to generate cost estimates that traditionally would have used simple factors and short computations. In principle, this trend could support much more sophisticated, sensitive, and accurate costing projections than more traditional methods. However, that depends on whether the models are supported by adequate data and methodologies or are simply automated processes for manipulating rule-of-thumb measures.

*The Army is increasingly moving to modern computational software to generate cost estimates.*
V. Higher-Echelon Maintenance

The Army provides repair, maintenance, overhaul, and modification services for tanks and other ground combat vehicles, aircraft, missiles and launch vehicles, and other support and ground equipment. As Vol. 1 indicated, these items are serviced by organizational and intermediate maintenance units, by maintenance depots, and by contractors on a continuing or "interim" basis. In practice, a given type of repair might be done by any of the providers, and an individual materiel system may be serviced by all types of providers during its life cycle. Associating the many elements of maintenance with weapons systems or operations requires cost data from many maintenance organizations.
costs with weapon systems (or their operations) requires capturing costs that originate in a wide variety of organizations.

Section III identified Army factors for costs arising in organizational (unit-level) maintenance activities. The Army, like the other Services, measures unit-level maintenance cost by the unit’s use of replenishment parts and maintenance consumables; military maintenance manpower is considered to be part of the unit’s manning for wartime and is costed separately rather than as an element of maintenance costs. In addition, however, the Army’s OSMIS factors combine costs for replenishment parts consumed at the organizational and intermediate levels and even include secondary item overhaul costs at the depot maintenance level. In effect, the OSMIS factors for replenishment secondary items capture a portion of costs arising at all maintenance levels.

Additional information is necessary, however, to capture other maintenance costs at the intermediate and depot level. This section examines factors and models for intermediate and depot maintenance costing, including contract maintenance performed at those levels.¹

Intermediate Maintenance Costing

Section III’s factors for repair parts and spares included items used in intermediate maintenance. However, those factors do not include other intermediate maintenance resources (i.e., labor, equipment, utilities, and supplies).

Schank et al. (1986) noted a difficulty in associating DS and GS maintenance costs with individual units because the shops serve several units and do not track costs to specific units. This problem is typically overcome in repair parts and spares estimation (in OSMIS factors, for example) by identifying the installation at which the DS/GS/AVIM unit is located and attributing the secondary items to the combat arms units at that installation.² This approach is reasonable for allocating resources consumed during peacetime operations.

¹ The information discussed here reflects the current Army maintenance system before the planned consolidation of DoD depot activities.

² OSMIS, for example, relates the secondary items to the weapon system and allocates the costs according to the system density of combat units at the installation.
However, it is less clear whether or how the costs of maintenance equipment or other durable resources should be attributed to units that share an installation with a DS/GS/AVIM unit. The reason is that an intermediate maintenance unit can perform work on a wide variety of equipment, making it difficult to attribute generalized resources (facilities maintenance, storage space, utilities, etc.) to particular materiel systems or to the units that operate them. In practice, Army factor sources do not include intermediate maintenance equipment costs, except when the factors are based on civilian maintenance contracts (as described below).

*Intermediate maintenance factors cover the costs of labor but not supplies.*

We have not identified any sources of factors relating intermediate maintenance supplies (solvents, sheet metal, etc.) to weapon systems, combat units, or combat unit operations. However, factors are available or under development for intermediate maintenance labor.

In BCEs and ICEs, a separate sustainment line item is "Field Maintenance Civilian Labor."\(^3\) BCEs and ICEs have traditionally relied on data showing intermediate maintenance man-hours for both scheduled and unscheduled maintenance on weapons systems covered by the Sample Data Collection program operated by AMC. The BCE and ICE estimates use maintenance man-hours for analogous weapon system and maintenance method and a civilian hourly pay rate (see Sec. VI). This reflects the reasonable assumption that the manpower used in intermediate maintenance varies proportionately to the workload.

Calibre is currently implementing a methodology for estimating Civilian Field Maintenance Labor factors using data from FORSCOM and TRADOC installations. The factors refer to OSMIS-reportable systems at those installations. The values include actual contract costs for a given fiscal year, plus other civilian labor hours used in maintenance, divided by OSMIS op tempo estimates.\(^4\) Note that the factors would include nonlabor costs (such as administration, utilities, equipment depreciation, and fees) included in maintenance contracts.

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3Historically, it included installation costs for depot modifications, but it now covers only civilian labor, both TDA and contract, for intermediate maintenance.

4The other civilian hours are reported on DA Form 2404. The factors exclude the costs of AMC-sponsored Field Maintenance Technicians and specialized system-specific manufacturer support.
Depot Maintenance Costing

Volume 1 of this report explained that two changes are already under way in the funding of depot maintenance activities. One is a Congressional requirement that the installation of modifications (in addition to the modification kits themselves) should be financed by procurement funds. The other (as described in Sec. IV) is that secondary items previously financed by PA2 funds will now be included in the Army Stock Fund.

The implications of these changes are illustrated in Fig. 5.1. It shows the historical system, in which depot revenues for modification installations, major end-item repairs and overhauls, and secondary item repairs flowed from National Inventory Control Point (NICP) budgets. The figure also shows the revised system, in which the Army Stock Fund as well as NICPs will "contract" with depots for

Beginning now, the Army Stock Fund as well as item managers will contract with depot maintenance organizations to overhaul and rebuild secondary items that were procurement-funded. The effects on stock-fund surcharges and other costs are difficult to anticipate.
repairs and overhauls of stock-funded Depot Level Repairables (DLRs). Depot costs to theASF presumably will be passed on to combat arms units via stock-fund prices. Aside from that, it is too early to say what effect these changes will have on accounting structures and databases.

Future centralization of the depot maintenance system will further affect DLR cost rates.

Even while these changes are being implemented, a new plan calls for consolidating depot maintenance and centralized supply activities across Services. This will also affect maintenance cost rates, utilization, and data sources. However, maintenance users will still be billed for depot-level costs, and basic sources of Army depot cost information will still be needed for costing studies.

**Depot Cost Accounting**

Army Regulation 37-55 (“Uniform Depot Maintenance Cost Accounting and Production Reporting System”) provides methods and procedures for accounting for depot maintenance costs and recording and reporting depot activity and cost data. The regulation covers all Army installations and activities that perform depot maintenance, including maintenance contracted from private industry (“contract depot maintenance”). The regulation also covers activities financed by all appropriations. The data files and reports that fulfill this regulation are the Master File Maintenance (MFM) and DESCOM’s OP-25 report. Both are commonly used as a source for depot cost estimates.

Data records in the MFM are based on the depot “job order.” It is opened when a work authorization document is received for maintenance. Job orders are associated with work centers (“shops”) within the depot, and every work authorization contains the “name” of the item (generally, the NSN).

Because depot maintenance is operated as an industrial fund, 100 percent of costs, including overhead, are allocated to job orders.

One hundred percent of depot maintenance costs are allocated to the job order, including base operations, overhead, parts, and labor. The pricing of depot services is currently based on the following methods:

- Spare/repair parts are valued by standard stock-fund issue prices for stock-funded items; invoice purchase price of locally procured items; and estimated price (direct and indirect cost) for locally made items.

- Civilian labor, direct and indirect, is costed at current pay rates plus the cost of annual leave accrued and sick and other leave taken. PCS costs for transferred civilian employees are charges to “above shop” overhead.
Military labor, direct and indirect, is currently costed at a fraction of the annual composite rates in Army Regulation 37-108. For enlisted personnel, the fraction is 0.00077; for officers it is 0.00070. Time spent on military duties is not costed. All military labor costs are treated as “unfunded”—excluded from Army charges but billed to non-DoD customers.

- If a repairable item is exchanged, the customer is billed for the estimated repair cost. If a (procurement-funded) spare is not repairable, the replacement is treated as an unfunded cost.
- “Within shop” overhead (i.e., at the work-center level) is allocated to the job orders in that shop based on direct (funded and unfunded) labor hours charged.
- “Above shop” overhead (outside the work center but within the maintenance activity) is allocated to all job orders based on direct labor hours.
- Installation base operations and General and Administrative Expense (GAE) are allocated to all mission operations and the maintenance activity. The amount allocated to the maintenance activity is treated like above shop overhead.
- All headquarters costs of the U.S. Army Materiel Development and Readiness Command (DARCOM) are allocated to depot activities and are treated as unfunded GAE.
- On-the-job training that contributes to production is charged to the related job order as a direct cost. Other training for the depot’s benefit is charged to above shop overhead. This includes pay of trainees, travel, per-diem costs, pay of teachers, tuition, and materials.
- Costs of producing or fabricating a part are treated as inventory costs and are reflected in job order costs when the inventoried item is used in a maintenance action.

The MFM file, which is updated daily, includes funded and unfunded costs for all work performed by Army depots, on behalf of the Reserve and Guard components as well as active, and on behalf of other Services.

Header data on each MFM record identify the commodity group to which the serviced item belongs, the equipment category, and the customer. Together, codes for the equipment “major group” and “type reportable item” correspond to the Work Breakdown Structure (WBS) code, which is used in BCE/ICE cost breakdowns.

5This basis for costing military manpower will be revised under the new Defense Business Operating Fund initiative, due for implementation during the 1990s.
The Master File Maintenance uses a highly aggregative code to indicate the end item under repair. OSMIS factors require more detailed and accurate information.

The MFM uses a special Weapon Support System (W/SS) code—yet another Army code for the major end item that benefited from services performed. W/SS is a highly aggregative code; for example, the codes for aircraft indicate fighters, bombers, cargo/transport, trainers, and utility. Other major categories are automotive equipment, combat vehicles, construction equipment, electronics and communication equipment, missile systems, weapons armament, rail equipment, and general equipment.

According to Calibre, the W/SS codes are optional and often omitted from the file. Even when the codes are filled, they are only supposed to represent the "most common" application of the item being repaired—and there is no system for allocating common-item repairs among the systems that together may be responsible for a batch of repairs. Consequently, Calibre does not consider the W/SS code sufficient for OSMIS costing use.

Data in the MFM support DESCOM’s annual OP-25 report. Along with other breakdowns, it shows the yearly average civilian labor and parts costs for items in the various W/SS categories.

Depot Costing Methods and Models

Like organizational and intermediate maintenance units, depots stock initial provisioning materiel. When weapon systems are added to the force structure, the SESAME model (see Sec. IV) determines whether additional depot provisioning is needed, and the costs would appear in the initial secondary items costs shown under fielding costs in BCE/ICE studies. However, we did not encounter any factors specifically devoted to initial provisioning of depot secondary items.

Several Army interviewees reported that the Army has traditionally been reluctant to develop and use what-if models for depot maintenance costing. Unlike the Air Force, the Army does not use factors to develop the O&M budget for depot maintenance; instead, the O&M budget is built up from information about AMC’s expected depot maintenance requirements and current depot charge rates. Program managers for new weapon systems have tried cost-estimation models but reportedly found them unsatisfactory because of substantial changes in cost rates, depot funding, and overhaul

Traditionally, the Army has found simple models of depot costs to be unreliable predictors of weapons acquisition or O&M budget costing.

6The old APRCH computed factors by taking the ratio of depot costs by LIN to the total force LIN density, based on Master File Maintenance data for the preceding two years. However, these values were zero for some items and not representative for others.
scheduling. Depot maintenance estimates are not included in the
top-down MRIS model for estimating new weapons program costs.
And the depot costs used in the TRM (for BLTM-TRM costing, see
Sec. III) are supplied by ODCSLOG.

Nonetheless, factors are needed for BCE/ICE estimation and force-
unit costing, some depot cost measures have been reported and used
for those purposes, and recent initiatives attempt to provide costing
measures and models for a variety of costing purposes.

**BCE/ICE Methodologies.** BCEs and ICEs have traditionally broken
depot maintenance costs down into civilian labor; “OMA materiel”
(e.g., repair parts); “PROC materiel” (i.e., spare parts); and mainte-
nance support activity. Costs for modification kits and transpor-
tation (to and from depots) also appear in BCE/ICE studies but
under other sustainment headings.

Funding changes have revised the categorization somewhat. With
the elimination of the O&M/procurement distinction for replen-
ishment parts, there will be just a single “Secondary Item/Stock
Fund Repairables” category. Moreover, modification labor will now
be combined with modification kit costs as a procurement line item.
However, neither of these changes had yet been incorporated in the
factors and models we surveyed.

Traditionally, AMC and CEAC have referred to data in the OP-25
reports to develop estimates of depot labor and parts costs for new
weapon systems. With respect to modifications, the Army’s policy is
to cost the specific modification plan, if there is one, and otherwise to
use a rule of thumb. Modification kits are costed at up to 0.5 percent
of manufacturing cost per system per year. Now that installation
costs are to be included as well, initial plans call for using 30 percent
of the hardware cost estimate for installation labor.

**Programming and Budgeting Models.** Although depot factors are
not used for developing the Army O&M budget, we encountered
documentation on two models under development that deal with
depot costs in the programming and budgeting context.

HQDA has contracted with Automation Research Systems, Limited
(ARS), to develop a Depot Maintenance Resource Predictive Model.
The Functional Design document (Prettol, 1989) indicates that “Cost
estimating relationships [would] be developed for selected weapon
systems in each of the major commodity groups to link [force
structure, end-strength, op tempo, and other operating] changes to
funding requirement changes.” However, the Army Program Anal-
ysis and Evaluation Directorate recently reported that CERs would

Models that have been iden-
tified as under development to
do what-if depot costing do
not use sophisticated factors
and appear to be in limited
use within the Army.
not be developed. Initial versions of the model simply processed data from DESCOM's OP-25 annual cost report and allowed analysts to distribute a total dollar budget among MDEP subcategories. Although the system reportedly will eventually relate total depot costs to major commodity categories, 7 there is no plan to link depot funding requirements to force units. 8

Another modeling development project, performed by CACI, created a prototype of a Depot Maintenance Model (DEPMM). It was designed to relate depot repairs and overhauls to operating tempo and equipment density for modeled "intensively managed" systems, to project requirements and cost for eight program years, and to support what-if studies of optempo and density effects. However, this project has been completed and the model does not appear to be in use within the Army.

**Depot Cost-Factor Estimates**

In principle, there are depot costs associated with both equipment density and operating levels. The former would consist of scheduled overhaul costs and be the same for active and reserve component units (since overhaul policy is uniform), whereas the latter would be for unscheduled maintenance and might differ (even on a cost per mile or hour basis) between active and reserve units. However, Army factors do not estimate costs separately for equipment operated by active and reserve units.

All depot cost-factor sources begin with data from the Master File Maintenance database. However, factors differ in many ways, such as whether they cover maintenance for weapons and support equipment or secondary items, whether they cover overhauls or other maintenance (such as rebuilds), and whether the costs are associated with items or optempo. The following sources do not provide alternative estimates for the same depot maintenance costs but rather measures of different categories of depot costs.

**RSCEM Database Default Factors.** Section V described the Replenishment Spares Cost Estimating Model (RSCEM). In addition to estimating replenishment spares costs, RSCEM also tracks: Depot Maintenance Labor for BCE/ICE cost cell 5.041, Depot Maintenance

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7 Aircraft, combat vehicles, missiles, automotive, electronics and communication equipment, ships, munitions armament, weapons armament, rail, and general equipment.

8 This is consistent with the attribution of all depot maintenance costs to AMC rather than to the combat commands that use the equipment.
Material (OMA) for cell 5.042, and Depot Maintenance Material (PROC) for cell 5.043.

The RSCEM database currently includes default depot maintenance factors for all types of spares maintenance, measured as a percentage of component unit price and computed from Master File Maintenance data for fiscal years 1985–89. For each Major Group, WBS, and Type Reportable Item in the MFM, Calibre computed the ratio of labor or OMA material or procurement material to the product of the quantity completed and the unit price. After the deletion of a few outliers, ratios for separate components were summed and averaged within each category. The default values are published in Appendix A of the RSCEM User’s Guide (by Calibre, undated).

**OSMIS Annual Report Measures.** Appendix A emphasizes that Calibre reports two types of cost measures. Aside from selected factors normally developed from three years of cost experience, OSMIS analysts also compute annual measures of cost experience by weapon system and MACOM for the OSMIS annual reports.

One annual report measure is for depot maintenance of secondary items removed from major end items. These costs are for jobs completed within a given year and are reported solely under the AMC heading. However, some costing exercises relate the AMC costs to other MACOMs by relating the secondary items to the equipments that use them and then distributing the depot costs in proportion to equipment density or OSMIS-reported optempo.

**OSMIS Factors.** As part of the OSMIS project, Calibre has explored the development of factors from a combination of MFM and Provisioning Master Record (see Sec. V) data. Unlike the OSMIS annual report measures, these factors are for secondary item rebuilds, excluding overhauls and modification labor. These measures are included in fiscal year 1992 replenishment spares factors discussed in Sec. III.

When possible, the factors use three years of MFM data, including all O&M reimbursed costs per job—but excluding contract work—per NSN. The costs are associated with materiel systems using the OSMIS system “definition.” Common-item NSNs are allocated to systems based on density.

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9 Type Reportable Item usually matched RSCEM categories. For aircraft fire control, however, Calibre used the average of combat vehicle and armament values, and for electronics, Calibre used the average of basic equipment and components and accessories.
Since these factors deal with secondary items, they are treated as optempo-related. Calibre computes depot costs per hour or mile per system, using actual optempo measures from the Aircraft Inventory Status and Flying Time (AISFT) and The Army Maintenance Management System-Equipment Data Base (TAMMS-EDB) files.

**TAFCS Exportable Database.** The TAFCS exportable database currently includes two sets of depot cost measures. One is an average depot overhaul cost for weapon and support systems and is based on three years of data from the MFM. The overhaul factors are listed by stock item number (synonymous with federal stock number), along with item nomenclature, title of the major commodity group of the weapon or support system, weapon or support system (W/SS) code, and the total number of overhauls. These factors exclude depot-level contract maintenance and depot modifications.

In addition, the TAFCS database also reports OSMIS-derived factors for depot overhaul cost for secondary spares. These factors are reported by LIN, item nomenclature, LIN model number, unit of measure (mile, hour, or system), and date of the cost factor.

**Other Factors.** Although BCE/ICE studies also include a line item for sustainment transportation (primarily to and from maintenance depots), we did not encounter any existing factors dealing specifically with transport to and from maintenance depots, frequency of depot repairs requiring transport, or typical distances between units and depots. In principle, however, transport costs to and from depots should be included in ASF stock surcharges that will soon apply to all secondary items.

Although we did not identify any existing factors for second destination transport costs per unit or system, factor sources for transportation cost rates by mode, weight, distance, etc., are discussed in Sec. VIII.

**Summary and Commentary**

This section has shown that higher-echelon maintenance cost factors differ considerably in coverage. Intermediate maintenance labor factors differ primarily in whether they capture contract labor; available factors do not capture unit overhead, maintenance equipment, shop supplies, utilities, and other intermediate maintenance operating costs. Depot-level factors differ primarily in whether they pertain to weapons and support items.
Accounting for depot-level maintenance also raises a number of special issues. In particular, the proper treatment of depot system overhead depends on the costing exercise. If the change in force structure or equipping under consideration is fairly small, then we would not expect it to alter depot overhead costs, and hence they should not be included in the cost measures—yet the depot cost database is structured to allocate all overhead costs to job orders, and as far as we can discern, all Army depot factors include overhead in their cost measures. On the other hand, though, large force or equipping changes could influence total overhead; then the question is whether the overhead rates included in current depot cost factors would also apply to the increment or decrement in depot-level workloads.

Other matters related to maintenance that might be of concern in some cost studies are:

- A 1988 report by the Government Accounting Office notes that the annual Army depot budget includes funding for work that will be carried over to the next fiscal year (and correspondingly excludes funding carried over from the prior year). In 1986, the carryover was 4.9 months of funding, but in fiscal year 1987 it was reduced to 3.5 months, and by the end of 1988 the carryover was to be 3 months.\(^{10}\) Changes in funding carryover policy can cause noticeable discrepancies between annual depot costing estimates and depot budgets.

- The use of data from analogous weapon systems can lead to substantial misestimation of maintenance costs because of differences in maintenance policy. For example, data from the M60 tank suggested far higher depot costs than than the M1 tank requires but less in the way of field maintenance repairs.

- The factors and models discussed here deal only with recurring depot costs. Like unit-level and intermediate maintenance units, depots stock initial provisioning materiel, but we did not encounter any factors specifically devoted to initial provisioning of depot secondary items.

- Appropriate principles concerning the treatment of modification costs in weapon acquisition studies are debatable. From one perspective, modifications that are not explicitly scheduled as part of the system’s development are not part of the original RDA decision; from another perspective, however, modifications are such a normal part of a system’s lifecycle that some costs for them should always be anticipated at the outset. The former perspective suggests that only scheduled modifications should be

\(^{10}\) By comparison, the Air Force carryover was 2.5 months in 1985, 2.7 months in 1986, and 2.2 months in 1987.
costed; the latter suggests that historical experience on modification rates as well as costs should be used in estimation. Although modifications are currently treated as an element of acquisition and support costs throughout the DoD, this treatment may obscure the importance of decisions concerning specific, major modification programs.

- The extent and manner in which depot costs will be treated as driven by either equipment density or operating levels remain uncertain in Army models currently under development.

Finally, it should be noted that maintenance factors do not distinguish among Army components. Although it is uncertain whether there are important cost differences for maintaining the same equipment in alternative components, the prospect of a realignment of missions and equipment among the components raises the question of whether existing factors properly reflect the effects of such realignment. This is an empirical matter difficult to resolve using Army data because of AMC's central role in depot maintenance financing, but it might deserve further investigation.
VI. Personnel-Related Costs

By the Army's own accounting in fiscal year 1988, manpower costs accounted for 61 percent of the Army budget. This included military pay and benefits covered by Military Personnel Appropriations, and civilian pay and benefits, training, and other personnel support covered by the O&M Appropriation.¹

¹Another 26 percent was R&D and 13 percent was other O&M and military construction. These estimates are taken from unpublished Army briefing slides.

Personnel costs currently account for more than half of the Army's budget.
By convention, individual training and medical support factors include costs for related base operating support. However, other base operating support is treated in Sec. VII.

As our costing framework illustration indicates, this section covers pay and benefits acquisition costs and medical support costs. By Army convention, individual training and medical support cost factors generally include associated base operating support. However, other personnel-related base operating support is treated in Sec. VII along with facilities costs. This section also covers certain miscellaneous personnel-related factors.

Table 6.1 summarizes the databases and models we reviewed for this section. Seven of the sources are specific to a particular category of personnel-related costs. The other two—AMCOS and the TAFCS exportable database—contain data across all the major cost categories and hence deserve introductory comment.

<table>
<thead>
<tr>
<th>Model/Database</th>
<th>Pay and Benefits</th>
<th>Acquisition Costs</th>
<th>Medical Support</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Military</td>
<td>Civilian</td>
<td>Recruiting</td>
</tr>
<tr>
<td>Misc.</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>RFH (1)</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>USAREUR</td>
<td>X</td>
<td>X</td>
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<tr>
<td>RFH (2)</td>
<td></td>
<td>X</td>
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<tr>
<td>MOSB</td>
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<td>X</td>
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<tr>
<td>ATRM-159</td>
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<tr>
<td>ITPM</td>
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<td>NTMSM</td>
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<tr>
<td>AMCOS</td>
<td>X</td>
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<tr>
<td>EFCDB</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

*Misc. refers to various official sources; RFH (1) and RFH (2) are the two volumes of the Resource Factor Handbooks; USAREUR = USAREUR Circular 37-1; MOSB = Military Occupational Specialty Handbook, last published 1983; ITPM = Individual Training Projection Model; NTMSM = Non-Tactical Medical Support Model; AMCOS = Army Manpower Cost System; EFCDB = TAFCS Exportable Force Cost Data Base.
The Army Manpower Cost System (AMCOS) consists of a family of models and supporting databases for estimating military and civilian manpower costs for weapons acquisition and force structure decisionmaking. The "lifecycle" cost models reviewed here\(^2\) process data from a variety of Army and DoD sources and perform complex manipulations, both to amortize one-time costs over a military career and to compute distinct "average" and "marginal" cost rates. We reserve a detailed discussion of AMCOS for Appendix C. It should be noted here, however, that CEAC is currently reviewing the desirability of continuing to expand and maintain the AMCOS system, and its future is uncertain.

The other source that covers a wide range of personnel-related cost factors is the TAFCS Exportable Force Cost Data Base (EFCDB). The Version 3.1 reviewed here contains personnel-related cost data from a wide variety of sources, including AMCOS and the Non-Tactical Medical Support Model that is also reviewed in this section. The database also includes the miscellaneous factors noted at the end of this section.

Pay and Benefits Costs

<table>
<thead>
<tr>
<th>Personnel</th>
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</thead>
<tbody>
<tr>
<td>✓ Pay and benefits</td>
</tr>
<tr>
<td>Acquisition (incl. training)</td>
</tr>
<tr>
<td>Medical support</td>
</tr>
<tr>
<td>Other (misc.)</td>
</tr>
</tbody>
</table>

Military and civilian personnel are subject to different management systems, paid according to separate grade scales, and receive different kinds of benefits. These differences are important to interpreting factors for military and civilian pay and hence deserve discussion before we examine pay and benefit factor sources.

Military Personnel Management

Direct costs of military personnel are covered by the Military Personnel Appropriation specific to each component. They cover basic pay, basic allowances for subsistence and quarters, accrual charges for military retirement benefits, and a variety of miscellaneous ex-

\(^2\)Another subgroup of models is designed to provide budget cost estimates. These models have only recently been delivered to CEAC and are not reviewed in this report.
The personnel appropriations also cover costs of Variable Housing Allowances (VHA) that supplement basic quarters allowances but vary by location to account for local housing market costs. And the personnel appropriations cover Permanent Change of Station (PCS) costs for military personnel. Many compensation elements vary not only with military paygrade, but also with years of service (YOS) and marital and dependency status.

The total costs incurred under the Military Personnel Appropriations depend not only on pay and benefits but also on the size and composition of the military personnel inventories. Army active, Guard, and Reserve personnel are covered by separate end-strength authorizations, subject to differing acquisition and retention programs and managed and budgeted separately. The following briefly describes active component management and budgeting, then notes distinctive features of USAR and ARNG personnel management and budgeting.

**Active Army Personnel Management.** Army Program Budget Guidance (PBG, see Vol. 1) allocates authorized military spaces to MACOMs by "identity" (officer/warrant officer/enlisted), listing them by fiscal year, AMSCO, and UIC. Command plans for using these authorizations are entered in the Force Accounting System (FAS, see Vol. 1), the Total Army Authorization Document System (TADS, see Vol. 1), and the Personnel Management Authorization Document (PMAD). The PMAD is the detailed, current auth-

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3Including station allowance overseas, uniform and clothing allowances, family separation allowances, separation payments, social security tax benefits, death gratuities, service members' life insurance, reenlistment bonuses, apprehension of military deserters, and interest on uniformed services savings deposits.

4PCS costs are separately budgeted for five types of moves: (a) Accession moves are for travel to a new duty station or training school upon entry to extended duty (including reserve components), including moves by Academy and other officer training graduates to a new duty station; (b) operational moves are to and from permanent duty stations when no transoceanic travel is involved; (c) training moves are from duty stations to training schools, including moves from schools to a next duty station if not included under accession moves; (d) separation moves are from the last permanent duty station to home; (e) rotational moves are analogous to operational moves except they involve overseas relocation; unit moves are those undertaken as part of an organized unit movement.

5In the late 1980s, discrepancies among data sources pertaining to personnel and manpower (programmed, budgeted, and actuals) raised the issue of coordination among these processes. The Army established a task force with a near-term goal of active force data alignment by coordinating: (a) command plan and command operating budget submissions, and (b) the four major HQDA databases (FAS, PROBE, the President's Budget Submission, and TADS). These tasks were due for completion about the time of this writing. However, a longer-term effort must still deal with the USAR and Guard and is likely to include basic realignment among program element (PE) codes, changes in TDA treatment, and standardization and crosswalks among coding and identification systems.

6The PMAD is produced by the Soldier Support Center in conjunction with ODCSOPS and ODCSPER and contains grade, UIC, Military Occupational Specialty, and other authorizations detail.
rizations database used to identify manpower decisions for personnel inventory management purposes.

The sum of allocations in the PBG is based on the active Army end-strengths authorized by Congress but is reduced by an allowance for trainees, transients, holdees, students (TTHS), and cadets. The remainder is known as the Force Structure Allowance (FSA), as illustrated in Fig. 6.1. All of the FSA is allocated to MACOMs and agencies.

Not all active component personnel are in units. Trainees, transients, holdees, and students are counted in the TTHS allowance.

In practice, however, there can be discrepancies between the number of personnel available and authorized end-strength. This difference is known as the Operating Strength Deviation (OSD). One basic objective of the Active Army Military Manpower Program (AAMMP) is to minimize this deviation.

The AAMMP is developed using a computer model called ELIM-COMPLIMP (Enlisted Loss Inventory Model-Computation of Manpower Program Using Linear Programming) and input from the Officer Projection Aggregate Level System (OPALS). The method-

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7Commissioned officer management is subject to the Defense Officer Personnel Management Act (DOPMA), which governs promotions.
ology projects enlisted and officer personnel inventories and
develops a monthly management strategy (for gains, losses, promotions, etc.) for filling PMAD authorizations through the POM years. The strategy aims to minimize the Operating Strength Deviation while satisfying various user-specified constraints.

The MPA budget is projected by predicting total personnel inventory changes, including TTHS.

By associating pay rates and other costs with the inventories and the actions taken to shape them, one can project the MPA budget. The FORECAST Personnel Decision Support System is a modular, automated system that provides MPA projections for HQDA budgeting and does what-if inventory cost analysis.

Average per-capita costs can change if the inventory grows or shrinks because the seniority and grade mix change. Therefore, inventory projection models like ELIM provide better cost estimates when troop levels change.

During POM development, however, some decisions are framed in terms of force structure changes, such as adding or eliminating a division, rather than changes in personnel management. For initial what-if purposes, Army POM developers may use per-capita manpower cost estimates obtained from ODCSPER—estimates like those in some of the factor sources described below. Such estimates are useful when the presumption is that added force units would be manned by redistributing personnel within a given force strength but can be misleading if the overall personnel force were to be expanded or contracted, because that might alter the inventory's seniority composition and hence alter per-capita costs. Therefore, inventory projection models (such as ELIM) are sometimes used to test the implications of altered troop levels.

The Reserve Component does not have TTHS accounts, has more categories of military personnel, and differs from the active component in other ways that affect pay and benefits.

Reserve Component Personnel Management. Management of USAR and ARNG personnel is analogous to active component management in that policies are developed to shape each inventory over time in response to authorized strengths and fiscal limits, and budget costs are estimated for the resulting inventories as a whole. Differences arise, however, because:

- The reserve components use additional categories of military personnel—Active/Guard Reserves (AGRs), Military Technicians, and drilling (also known as "M-Day") Reserves—as described in Vol. 1.8
- Costs for drilling Reserves must account for full time spent in training (four to five months for initial basic and advanced individual training, and a half-month of annual Active Duty Training (ADT)) as well as part-time service.

8 A rule of thumb for building force structure is that about 7 percent of the ARNG would be AGRs and about 7 percent would be Military Technicians. Military Technicians are paid from Military Personnel Appropriations for the Reserve duty but are paid from the Operations and Maintenance accounts for their civilian time (which includes time spent in training).
• In addition to nonprior-Service accessions, the Reserve Components acquire many personnel with prior military service, so there is considerable lateral entry into the upper pay grades.

• Retirement accruals in the Reserves are lower than in the active component (currently about 13 rather than 43 percent of basic pay).\(^9\)

• Costs for Permanent Change of Station (PCS) moves are limited.\(^{10}\) On a per-capita basis, the result is substantially lower PCS costs for the Reserve Component than for the active component.\(^{11}\)

• The Reserves do not have individuals accounts (TTHS). Hence all end-strength is attributed to the force structure, even though individuals in training schools are not available to fill that structure.

• The USAR has higher enlisted turnover, running about one-third of end-strength each year, compared to about one-fifth for the active component and ARNG.

Modeling to assist in POM and budget costing for the Reserve Component is under way but in a less advanced state of development than for the active component. The FORECAST system is being implemented for the USAR, and application to the ARNG is planned as a separate contract. In the meantime, the Reserve budgets are developed using less sophisticated technology. The USAR, for example, uses the prior year inventory as the base, computes accessions and losses, and applies average cost factors from the prior year (actual dollars divided by actual strength) adjusted for pay raises and inflation rates. Similarly, the ARNG budget computation assumes uniform promotions and stable marital/dependency rates over time.

**Civilian Personnel Management**

In the late 1980s, the Army target for civilian strength was stable at about 410,000. Civilians constituted about one-quarter of total Army manpower and filled over 1,000 occupations at the turn of the decade, with the highest concentration in logistics, research and de-

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\(^9\)Military retirement benefits do not begin until age 60 unless the individual has 20 years of active duty service, and drilling Reservists accumulate so little active duty that their benefits are low.

\(^{10}\)The rule is that PCS costs are incurred only for travel to or from schools lasting over 139 days; examples would be War College and highly technical training, such as for medical and special forces personnel.

\(^{11}\)For example, travel is historically about 8–9 percent of payroll cost in the ARNG.
velopment, base operations, construction, and civil functions. Large cuts in civilian personnel are planned for the early 1990s.

The actual management of the civilian workforce is decentralized to installation/activity commanders and local managers. Installation manpower analysts set the civilian requirement based on workloads, personnel analysts classify the required positions, and budget analysts transform the requirements into an installation budget.

The Army has tried managing civilians by end-strength and workyear ceilings but now uses the Civilian Employment Level Plan (CELP) and the Annual Financial Target (AFT). Under these programs, MACOMs are allotted an annual budget for civilian manning and can vary strength by 5 percent from month to month—but are to remain within a 1 percent strength tolerance annually.

Installation Civilian Personnel Offices (CPOs) report actual strength data to HQDA using the Civilian Personnel Management Information System (CIVPERSINS) and Civilian Manpower Obligation Data (CIVMOD). MACOMs develop and submit monthly strength projections for the execution year. The HQDA Civilian Personnel Management System (CIVFORS) performs functions similar to those of military personnel management systems: identifying the objective force required to support the Army, formulating and projecting employment levels, and managing career progression.

About 85 percent of the Army’s civilian personnel are “direct hire” civil servants paid by appropriated funds. They fall into one of the following pay classifications:

- General Schedule (GS). This applies to white-collar federal workers in professional, administrative, technical, clerical, and other categories. There is a single, annually updated pay schedule for all GS workers, regardless of occupation or location. The pay rate is determined by paygrade (18 of them) and step (10) within grade.
- Special Salary Rates. These are authorized to permit higher salaries in situations where there are manpower shortages.12
- Merit Pay System (GM). This is a GS-based system with a separate pay plan based directly on performance evaluations instead of steps.
- Senior Executive System (SES). This is a system for top-level program managers.

12The largest category, accounting for 89 percent of special authorizations, is for special engineers.
• Executive Schedule. This applies to presidential and departmental appointees and is similar to the SES but with five levels of basic pay.

• Federal Wage System. This is a pay system for blue-collar employees, in which grades are defined by reference to civilian sector jobs and the pay in each grade is determined by a Wage Fixing Board based on local area prevailing wages. “Wage” employees under this system are paid according to separate schedules for nonsupervisory workers (WG), “leaders” (WL), and supervisors (WS).

Only about 3 percent of these direct hire civilians are temporary workers, and only a very small fraction work less than full time.\(^{13}\)

Foreign nationals living overseas may be directly hired by Army installations; these “direct hire foreign nationals” are not covered by the Civil Service Act, and their wages are determined by competitive conditions. Foreign governments also hire and pay employees to work in Army installations, using U.S. federal funds supplied under Host Nation Support programs; these workers are known as “indirect hires.”

The Military Technician program consists of full-time civilian direct hires who are also required to be members of the USAR or ARNG. These personnel generally receive compensatory time off in lieu of overtime pay.

Aside from civilians in the foregoing categories, the Army is also served by civilian contractors and their civilian employees. Data on civilian contracts do not readily distinguish contracts for direct services, such as facilities maintenance, and contracts for weapon systems, research, and other products. Except for the intermediate maintenance civilian labor factors discussed in Sec. V, we found no data sources on cost factors for Army-contracted services.

The costs of civilian personnel consist of pay, benefits, and other (relocation, training, and uniform) costs, as follows:

• Civilian pay includes base salary, premium pay for special duties, certain bonuses and incentives, and severance pay for involuntarily separated civil servants.

\(^{13}\)In addition, other civilians are employed in exchanges, clubs, commissaries, and other Nonappropriated Fund Instrumentalities (NAFI), financed in whole or part by fees and user charges. NAFI worker pay rates are based on GS and wage board schedules.
The primary civilian benefit is enrollment in the Civil Service Retirement System (CSRS) or the Federal Employees Retirement System (FERS). In addition, the DoD subsidizes participation in life and health insurance programs, provides unemployment benefits for involuntarily separated employees, and compensates workers injured or disabled on the job.

Other costs incurred on behalf of civilian employees include relocation, training, and providing uniforms for some employees.

Civilian pay and benefits are paid through the appropriation governing the functions civilians perform. For example, civilians engaged in RDA activities are covered by the RDT&E Appropriation, whereas civilians performing depot maintenance are covered by O&M appropriations. However, indirect costs for civilians are financed by the appropriation covering the indirect activities—such as O&M for training costs.

Budgets for civilian personnel are based on projected strength and civilian cost factors developed by ODCSPER.

**Pay and Benefits Factor Sources**

**Comptroller’s Office and USAFAC.** Official “Composite Standard Rates” are developed by the Army Comptroller’s Office. The rates are weighted averages of MPA-funded obligations for the entire active component, by grade (including cadets) and pay category and are designed to facilitate allocation of the overall MPA budget to commands and programs.

Composite Standard Rates are constituted as follows:

- Basic pay is a weighted average of pay across years of service.
- Military retirement is a percentage of basic pay determined by the DoD Actuary and was 50.7 percent for fiscal year 1988.

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14 CSRS is an older system that remains available to federal employees hired before 1984. FERS applies to employees hired since 1984 and prior employees who choose to enroll in it.

15 In the MPA account, obligations, expenditures, and outlays are all very similar.

16 Additional tables in RPH (1) average the composite rates by month, week, day (based on 7-day week), day (based on 5-day week), and hour (based on 2,080 work hours per year). For cost estimation based on direct labor hours (hours actually worked), RPH (1) advises adding 14 percent of the hourly composite rate to account for holiday and leave time (both officers and enlisted). This is a factor developed by the Comptroller’s Office.
• "Basic Allowance for Quarters" actually includes VHA and is computed as the total budgeted allowances by grade divided by total man-years in grade (i.e., a weighted average).

• Miscellaneous expenses include subsistence, station allowance overseas, uniform and clothing allowances, family separation allowances, separation payments, social security tax benefits, death gratuities, service members' life insurance, reenlistment bonuses, apprehension of military deserters, and interest on uniformed services savings deposits.¹⁷

• PCS costs are included as overall averages for officers, enlisted, and cadets.¹⁸ By Army policy, no distinction is made between CONUS and overseas usage.

• Incentive and special pay consists of aircrew, proficiency, and hostile fire pays and is an overall per-capita figure.

• Basic pay is a weighted average of pay by years of service.

The Comptroller's Office also establishes benefits factors that can be used in cost estimation based on direct labor hours; these factors indicate a percentage (14 percent in 1988, for both officers and enlisted) that can be added to base pay to account for holiday and leave time.

USAFAC Bulletin FINCY3 reports Reserve drill pay rates—amounts for a single 4-hour drill (a 2-day weekend would be four times the amount shown) by grade, category, and years of service.

The Comptroller's Office also records civilian compensation schedules for each GS grade and step and establishes percentage rates applicable to civilian compensation to account for the various benefits programs described earlier in this section. In costing exercises within the MACOMs, the Army commonly estimates the costs of civilian spaces using the rates for Step 5 GS employees, and those amounts can be obtained on an annual, monthly, weekly, daily, and hourly basis.

Per-Diem Regulations. Joint Federal Travel Regulations, Vol. 1, and Joint Travel Regulations, Vol. 2, specify allowable per-diem rates for military and civilian personnel, by state and county for CONUS travel, and by country (including Alaska and Hawaii) for overseas travel.

¹⁷ The values for officer grades O-9 and O-10 also include personal money allowances.

¹⁸ RFH (1) also reports budgeted average amounts for officers and enlisted, by type of move, and offers instruction on how to compute PCS costs from tables on cost rates for travel allowances, household goods shipment, and dislocation allowances.
Resource Factor Handbook, Volume 1. At least until 1990, the first volume of the Resource Factor Handbook issued by TRADOC and FORSCOM provided factors for military personnel compensation and PCS costs, civilian pay and benefits, and military and civilian per-diem rates. The handbook was a convenient source for the Comptroller's Composite Standard Rates, the USAFAC drill pay rates, the GS pay schedules, and average Wage Board pay scales and provided a percentage factor for augmenting the Composite Rates to capture medical benefits and quarters costs for active component personnel. Furthermore, the handbook offered a detailed explanation of how to compute civilian PCS costs, including (a) travel to seek residence, (b) expenses related to the sale and purchase of a home, (c) movement of household goods, (d) mileage and per diem (requiring reference to Army Regulation 55-60 for authorized mileage), and (e) miscellaneous expenses incident to relocation.

RFH (1) has been a convenient source of average pay and benefits for military and civilian personnel.

In addition, the handbook provided TRADOC- and FORSCOM-specific pay and benefit factors:

- FORSCOM military compensation rates were estimated salaries of personnel assigned to the U.S. Army Garrison of each FORSCOM installation, and were determined by dividing the total MPA dollar obligations (from the installation's latest AFRM-54 report) by total man-years, with adjustment for authorized pay raises. Amounts were shown by installation and program element, including base operating support.

- FORSCOM civilian rates were average civilian salaries and funded benefits for GS and Wage Grade employees. These data cover base operations personnel only (excluding other TDA units such as FORSCOM headquarters on the installation). Estimates are from the same source and method as military salaries. Averages are shown separately for subaccounts within base operations and real property maintenance.

- TRADOC developed its average military salaries by multiplying the Composite Standard Rates by the TDA authorized pay grades specific to an installation and training activity. Separate averages applied to training courses, training base operations, and real property maintenance.

- TRADOC civilian salaries and funded benefits for GS and Wage Grade workers were averages taken from installation ATRM-2

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19 The rates provided for this purpose in fiscal year 1988 were 6 percent of the composite rate for officers and 18 percent for enlisted.

20 RFH (1) also provided moving cost factors for both personnel and property. Those factors are discussed in Sec. VIII.

21 The warrant officer values assume an average grade of CW102.
reports and are reported by the same categories as military salaries.

As we indicate in Appendix A, however, Army regulations do not permit the continued joint publication of RHF (1), and its future is clouded by TRADOC's recent decision to discontinue its own publication.

**USAREUR Circular 37-11.** The personnel factors in USAREUR Circular 37-11 are similar to the FORSCOM-unique factors in RHF (1). The circular reports Composite Standard Rates for military personnel and civilian pay and benefits factors. The principal difference (aside from the values for civilian pay and benefits) is that the circular covers categories of civilian personnel (indirect hires and U.S. Forces Family Member Employees) and labor conditions not relevant to the FORSCOM estimates. This leads to the following special considerations:

- The Fair Labor Standards Act does not apply overseas. The USAREUR circular indicates that overtime should be valued at 1-1/2 times base pay.
- Tables of fringe benefits are provided, but the circular says that specific local rates should be used for budgeting. The fringe table shows percentages of annual pay to be added for retirement, health/life insurance, Medicare, other, and "overseas-unique costs."
- Tables show "additional costs for U.S. hires" such as transportation and a foreign transfer allowance.
- Although civilian pay factors are salaries by grade and wage scale for direct hire civilians, the factors for local nationals are by type of position.

**AMCOS Factors.** As detailed in Appendix C, AMCOS models estimate pay and benefits costs for active, Reserve/Guard, and civilian Army personnel. Military compensation includes basic pay, housing costs, subsistence, the retirement pay accrual, Selective Reenlistment Bonuses, and special pays; civilian compensation includes basic salary, premium pays, retirement benefits, insurance plans, and other benefits. In addition to an average cost factor, AMCOS also produces a "marginal" cost estimate. It assumes, for example, that all base housing is filled and so additional military personnel would require VHA payments at the maximum rate over all locations.

**TAFCS Exportable Database.** The TAFCS database contains a combination of AMCOS and other factors for active component
personnel pay and benefits. The principal source for the non-AMCOS factors is the Army budget justification book for the MPA appropriation, though the database developer, MAI, may manipulate or supplement these data in ways that are not yet documented. Table 6.2 lists the active component factors in the Version 3.1 database and indicates which are from AMCOS and which are developed by MAI. The factors are presented by grade as well as the overall averages indicated in the table.

At present, the TAFCS exportable database does not use AMCOS factors for Reserve or Guard personnel. Instead, factors are developed by MAI from the DD-RA(M) 1147/1148 A8 financial accounting report, and from the NGPA and RPA budget justification books. The factors for drilling personnel are presented separately by grade and component and also presented are overall averages for the Guard, Reserve, and combined components. In addition, the table indicates that some factors are presented separately for AGR personnel in each component.

Acquisition Costs

<table>
<thead>
<tr>
<th>Personnel</th>
<th>Pay and benefits</th>
<th>√ Acquisition (incl. training)</th>
<th>Medical support</th>
<th>Other (misc.)</th>
</tr>
</thead>
</table>

Although personnel procurement and training activities are separately managed and funded, the two activities are often considered together as “acquisition”—the overall process of obtaining productive personnel. In practice, there are acquisition costs for both military and civilian personnel, but most efforts to estimate the costs focus heavily on military personnel acquisition.

Personnel Procurement

Army military personnel procurement is managed through separate programs for officers and enlisted personnel. The U.S. Army Recruiting Command (USAREC) recruits enlists and warrant officers, and separate programs procure officer candidates through West Point, Officer Candidate School (OCS), and the Reserve Officer Training Corps (ROTC).22

22Personnel procurement for the Air National Guard is conducted through special state solicitations.
<table>
<thead>
<tr>
<th>Source</th>
<th>Element</th>
<th>Source</th>
<th>Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMCOS</td>
<td>Base pay</td>
<td>MAI</td>
<td>Language proficiency pay</td>
</tr>
<tr>
<td>AMCOS</td>
<td>Basic allowance for subsistence</td>
<td>MAI</td>
<td>Physician pay</td>
</tr>
<tr>
<td>MAI</td>
<td>Enlisted subsistence</td>
<td>MAI</td>
<td>Dentist pay</td>
</tr>
<tr>
<td>MAI</td>
<td>Basic allowance for quarters</td>
<td>MAI</td>
<td>Optometrist pay</td>
</tr>
<tr>
<td>MAI</td>
<td>VHA</td>
<td>MAI</td>
<td>Veterinarian pay</td>
</tr>
<tr>
<td>AMCOS</td>
<td>BAQ w/in-kind</td>
<td>MAI</td>
<td>Anesthetist pay</td>
</tr>
<tr>
<td>AMCOS</td>
<td>VHA w/in-kind</td>
<td>MAI</td>
<td>Special duty pay</td>
</tr>
<tr>
<td>MAI</td>
<td>CONUS housing allowance</td>
<td>MAI</td>
<td>Per-capita spec./inc. pay</td>
</tr>
<tr>
<td>MAI</td>
<td>Cost of living allowance</td>
<td>MAI</td>
<td>Enlistment bonus</td>
</tr>
<tr>
<td>MAI</td>
<td>Overseas housing allowance</td>
<td>AM COS</td>
<td>Reenlistment bonus</td>
</tr>
<tr>
<td>MAI</td>
<td>Overseas station allowance</td>
<td>MAI</td>
<td>Permanent change of station: accession</td>
</tr>
<tr>
<td>MAI</td>
<td>Per-capita living allowance</td>
<td>MAI</td>
<td>Permanent change of station: unit</td>
</tr>
<tr>
<td>AMCOS</td>
<td>Retired pay accrual</td>
<td>MAI</td>
<td>Permanent change of station: training</td>
</tr>
<tr>
<td>MAI</td>
<td>Survivor benefits</td>
<td>MAI</td>
<td>Permanent change of station: operational</td>
</tr>
<tr>
<td>MAI</td>
<td>Miscellaneous</td>
<td>MAI</td>
<td>Permanent change of station: rotation</td>
</tr>
<tr>
<td>MAI</td>
<td>Clothing allowance</td>
<td>AM COS</td>
<td>Av. permanent change of station accession</td>
</tr>
<tr>
<td>AMCOS</td>
<td>FICA</td>
<td>AM COS</td>
<td>Av. permanent change of station training</td>
</tr>
<tr>
<td>MAI</td>
<td>Family separation allowance</td>
<td>AM COS</td>
<td>Av. permanent change of station opera tional</td>
</tr>
<tr>
<td>MAI</td>
<td>Per-capita separation (less permanent change of station)</td>
<td>AM COS</td>
<td>Av. permanent change of station rot ation</td>
</tr>
<tr>
<td>MAI</td>
<td>Flight pay</td>
<td>AM COS</td>
<td>Av. permanent change of station separation</td>
</tr>
<tr>
<td>MAI</td>
<td>Jump pay</td>
<td>AM COS</td>
<td>Av. Permanent change of station</td>
</tr>
<tr>
<td>MAI</td>
<td>Demolition pay</td>
<td>AM COS/MAI</td>
<td>Base rates: CONUS</td>
</tr>
<tr>
<td>MAI</td>
<td>High altitude jump pay</td>
<td>AM COS</td>
<td>Base rates: OCONUS</td>
</tr>
<tr>
<td>MAI</td>
<td>Diving pay</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Army participates in joint-Service advertising, marketing research, and other activities that have generalized effects on military personnel procurement; provides recruiters and recruiting stations; and incurs procurement expenses for examinations, accession travel, and processing operations. In addition, the Army offers enlistment bonuses and education benefits to induce enlistments.

**Training**

The Army training system provides schoolhouse training as well as operational training with force units. The latter was treated in Sec. III, under the rubric of operating costs. The training covered in this section is conducted in training institutions operated primarily by TRADOC or occasionally in civilian institutions. Like operational training, this training is conducted under ODCSOPS oversight.

The Army provides the following kinds of training and educational programs:

- **Recruit training.** An eight-week introductory and combat survival skill training course given to newly enlisted personnel. This category also includes refresher training for prior-service personnel reentering the military.

- **Initial skill training.** This formal training for enlisted personnel is normally given immediately after recruit training and leads to the award of a Military Occupational Specialty (MOS).\(^{23}\)

- **One Station Unit Training (OSUT).** This is an alternative to recruit and initial training that combines those topics in a single course for enlisted personnel. Approximately one-third of enlisted recruits receive OSUT.

- **Skill progression training.** This training leads to a higher skill level and includes training for officers and selected civilians as well as enlisted personnel.

- **Flight training.** Undergraduate pilot training (UPT) qualifies commissioned and warrant officer aviation students to become Army pilots. Graduate pilot training includes courses for instructor pilots and instrument flight examiners, for example.

- **Officer Candidate Schools.** TRADOC administers a 14-week course that enables enlistees to become commissioned officers in

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\(^{23}\) An Army model used to program occupational training is the MOS Level System (MOLS). It compares spaces (from PMAD), inventory (from the Enlisted Master File, EMF), and the aggregate requirement (from ELM-COMPLI) to produce requirements by grade. The results are inputs to the Army Training Requirements and Resource System (ATRRS).
the active and Reserve components. States also operate commissioning schools for Guardsmen.\textsuperscript{24}

- Academies and Senior Reserve Officer Training Corps (ROTC). West Point is the Army's four-year collegiate program for officers. ROTC prepares civilian college students to serve as commissioned officers in the active or Reserve components.

- Professional training, such as the Chaplain Candidate Program and Medical Acquisition Programs.

The Reserve Component provides considerably less individual training for their personnel than does the active component.\textsuperscript{25} This is commonly attributed to the reserves' heavy reliance on prior-service personnel (accounting for 40 percent of ARNG enlisted accessions, for example). However, recent research\textsuperscript{26} notes that the Guard and Reserves rely heavily on training within units and that about 16 percent of E-3 to E-9 personnel in the Guard and 25 percent in the Reserves are not fully skill qualified.\textsuperscript{27} Hence, cost estimates based on actual manning tend to overstate the capability of Guard and USAR units and understate the cost of the training they would require to reach the same skill qualification standard as Active units. Possibly in recognition of this concern, the current POM instructions for the USAR show an objective of attaining and maintaining an 85 percent duty-MOS qualification rate at battalion level.

Costs associated with training appear under several appropriations and cover a wide range of resources. Military Personnel Appropriations provide pay and allowances for military students and instructors. O&M Appropriations fund civilian pay and benefits and operating costs in the schools operated by the three Army components. Procurement funds pay for training ammunition and devices, military construction funds pay for facilities, and the Family Military Housing Appropriation maintains family housing at training installations. Although training is an indirect support activity, costing the resources it uses is analogous to costing combat

\textsuperscript{24} However, the state courses consist of just four weeks of active and nine months of inactive duty (correspondence) training.

\textsuperscript{25} Both Reserve components have their own individual training programs and provide instructional personnel for them. However, these program are very small and the Reserves depend on TRADOC for the bulk of individual instruction.

\textsuperscript{26} In a forthcoming study by Richard Buddin and David Grissmer.

\textsuperscript{27} The same study indicates that changing skills is frequent for Guard and Reserve personnel. Over a 15-month period, about a fifth of Guard personnel and a third of Reserve personnel in grades E-3 to E-9 switched occupations. Retraining times for ARF personnel in combat skills also appear to be much longer than in the active component. Enlisted nonqualification rates appear especially high for prior-service personnel and those in noncombat skills.
arms units in that a wide variety of supporting costs must be associated with the activity.

**Acquisition Factors**

**ATRM-159 Reports.** The traditional source of cost data for Army-operated schools is the TRADOC Resource Management Office. It periodically produces an ATRM-159 Report that displays costs per course for TRADOC schools, including instructor contact hours, student loads, costs of supplies, training ammunition, flying hour program costs, and such indirect costs as medical support, base operations, and family housing maintenance.

Most current references to training cost data refer to an ATRM-159 based on fiscal year 1985 data. Efforts are currently under way to update these data and the methodology underlying their development, but the following description is based on the methods in the existing data:

- OMA costs are actual expenditures per course for instructor's materials and flying hour costs (if any). Overhead, base support, medical support, and OMA-funded housing costs are allocated to courses in proportion to student loads (i.e., training man-weeks).

- Instructor MPA costs are based on the number of instructor contact hours converted to man-years and multiplied by the average military compensation for each paygrade. Student pay and allowances is the average of student input and output, multiplied by course length to obtain student man-years, and multiplied by the average military compensation for the students' modal grade.

- The MPA cost also includes a prorata share of military personnel working in base support and medical support at the training installation. (We do not know the basis of allocation, but it seems likely that it is student loads.)

- Procurement costs per course are estimated by equipment procurement costs amortized over a ten-year period and ammunition costs per course. The ATRM-159 also reports ammunition costs per trainee.

**RFH (2) reports CER parameters for training manpower and nonmanpower resources.**

**Resource Factor Handbook Volume 2.** RFH (2) provides cost factors for TRADOC training schools. One set of estimates refers to the (nontrainee) manpower used in training and provides parameter values from Manpower Estimating Relationships (MERs). Another set refers to nonmanpower costs and provides parameter values from Cost Estimating Relationships (CERs).
The manpower estimates are based on TDA manpower spaces costed at Military Composite Standard Rates, civilian personnel pay averages from the ATRM-2 report, and civilian benefit rates from the USAFAC 218 report.

The nonmanpower estimates are based on data from the USAFAC 218 report on actual expenses, by training installation and AMSCO. TRADOC uses the AMSCOs to identify costs by type of training and uses data from the ATRM-54 report on installation one-time-only and new-item purchases to remove those costs from the USAFAC data. The cost data exclude ammunition costs, since they are not charged to the training center OMA budget.

The estimation process uses two methodologies—one based on statistical analysis of actual experience and one based on resourcing standards.

The method that uses statistical analysis is applied to a multiyear database (in some cases, as much as 16 years). Historical data are "normalized" to account for changes in recent operations; for example, the historical cost values are adjusted to make them comparable to current values when an operation is converted to contract. Factors are estimated from time-series data on each training installation and results are reported in the form of parameters in the equation \( y = A + Bx \), where \( y \) is cost or manning and \( x \) is workload. Parameter \( A \) is interpreted as the training fixed cost (or fixed manpower) and \( B \) is an estimate of the incremental cost of increasing the workload. Under this specification, the incremental cost is constant and hence equals both the marginal and average variable cost per unit of workload.

TRADOC uses statistical analysis for both CERs and MERs for:

- General Skill Training;
- Officer Candidate School (OCS);
- Professional Military Education;
- Undergraduate Pilot Training;
- Other Flight Training;
- General Intelligence Skill Training;
- Cryptological and Related Skill Training;

The CERS are estimated from a time-series of data for individual training installations.

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26 CERS and MERs for activities without sufficient historical data were based on similar activities or the TRADOC composite (described below).

29 Until recently, the methodology involved regression techniques. TRADOC reports, however, that it is moving to an exponential smoothing methodology.
• Reception Stations; and
• Base Operations for training facilities support (from the BASOPS "Z" account, see Sec. VII).

The method is also used for CERs for Recruit Training and Combined Recruit and Skill Training (OSUT).

However, an alternative method is used for MERS for Recruit Training and OSUT. Their manpower costs are predicted by "structure models" that reflect standards rather than actual experience for the level of instructional manpower in these training activities.

Both methods result in a baseline equation that is then adjusted for new missions and programs. Information in the Program Budget Guidance for TRADOC contains manpower and cost estimates for training related to new systems, and TRADOC incorporates that information in the fixed and variable portions of the related CERs and MERS.30

The MER parameters pertain to total authorized manpower. Share factors allow the total to be distributed among the officer, enlisted, warrant officer, and civilian categories. And other factors permit the manpower authorization estimates to be translated into requirements. The translation factors are the ratios of authorizations to requirements in each installation31 and are not broken down by personnel category; they ranged from 0.67 for the Leonard Wood installation to 0.90 for Carlisle Barracks in fiscal year 1988.

The variable cost parameters in RPH (2) are used by TRADOC budget developers to project budget increments or decrements based on projected workload changes. An implication is that installations with unusually high variable costs receive unusually high budget increments for additional workloads. The methodology provides no mechanism for judging whether those high costs are warranted or whether installations with below-normal costs are receiving adequate funds.

_Military Occupational Specialty Training Cost Handbook (MOSB)._ A regression methodology similar to the older RPH (2) method was

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30 In addition to the A and B parameter estimates, the maximum and minimum workload underlying each CER and MER is reported in RPH (2), permitting readers to determine if a prospective workload to be costed is in relevant range. The coefficient of determination is also given for relationships based on historical data; it ranged from 0.64 to 0.87 in the fiscal year 1988 estimates.

31 The ratios are computed from data in TRADOC's Manpower Utilization Management System (MUMS).
previously used by USAFAC to prepare the *Military Occupational Specialty Training Cost Handbook*, a handbook last issued in October 1983. It related training costs, exclusive of major construction and identifiable one-time expenses, to training loads and provided for a fixed cost and a variable cost element. However, it covered not only TRADOC courses but also medical courses provided by the Health Services Command. And the MOSB attributed installation support (base operating) costs to training courses at the installation and accumulated the costs of training courses to develop a total training cost per MOS-qualified graduate. The TRADOC cost factors simply report separate training costs per training load (trainee-man-year-equivalents) and installation support costs per capita for the military and student population.

**Individual Training Predictive Model.** For POM development of OMA Program 8T (Training) costs, ARS, Ltd., has developed an Individual Training Predictive Model (ITPM). It estimates the effect of force strength or structure changes on OMA requirements in PROBE format (by Program Element and MDEP) for the individual training mission during the budget and POM years.

The model first calculates a baseline case for force structure, aggregate and MOS-specific end-strength, and approved 8T funding levels. The user can then enter data for desired changes in MOS strength, aggregate end-strength, aggregate force structure, or particular unit additions or deletions. The model accesses the PMAD database on MTOE unit authorized strength to translate changes in units or overall force structure into effects on MOS strength by year. At present, the ITPM deals only with active component units and those with over 100 authorized military spaces.

A TTHS factor converts overall end-strengths into force structure spaces or conversely. A training load factor converts MOS spaces into training loads, and a cost factor converts training loads into dollar costs. The data sources for these factors are historical costs from the USAFAC 21B report and training resource data from the Army Training Resource Requirements System ATRRS database. However, we lack details on how the factor values are computed.

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32 Training aids, second destination transportation, medical activities, communications, and other support to the training center are also included in the MOSB estimates (though the documentation does not explain how). However, Family Housing, Maintenance Appropriation costs are not included.

33 Nonspecific changes in aggregate force structure are distributed proportionately across units, and changes in aggregate end-strength are distributed proportionately across MOSs.

34 Another feature we are currently unable to document is the manner in which the timing of training loads is related to the desired MOS manning in a particular year. If the user specifies an activation or deactivation of a unit, the model treats the
Factors from the AMCOS and TAFCS databases estimate costs to obtain an MOS graduate, including recruiting costs.

AMCOS and TAFCS Factors. Again, details of the AMCOS treatment of personnel procurement and training costs appear in Appendix C. Noteworthy observations are:

- AMCOS is one of the few factor sources that estimates military personnel procurement costs as well as training costs. AMCOS computes separate recruiting cost factors for low- and high-quality active component recruits and distinguishes between the costs for Reserve/Guard accessions with and without prior military service. Procurement costs are amortized.

- Military training costs for both enlisted and officer personnel are amortized over the years of service in a typical military career. Average and marginal training costs for officers are assumed to differ; the marginal cost estimates are based on costs for Officer Candidate School.

- AMCOS training cost estimates include ammunition costs.

- AMCOS currently does not estimate recruitment or training costs for civilian personnel.

The TAFCS database currently contains AMCOS factors for the cost of obtaining a trained military enlistee within an MOS. These factors combine costs for recruitment and training on a per-graduate basis but report costs separately by appropriation. At present, it appears that only the active component cost estimates are used in TAFCS.

Medical Support

The Medical Support System

Medical services are provided by Military Treatment Facilities and the CHAMPUS insurance program.

Health care benefits are available to active-duty personnel and their dependents, reserve members while on ADT, and military retirees and their dependents. Active duty personnel are served directly by Military Treatment Facilities (MTFs) whenever possible; other beneficiaries may obtain MTF care on a space-available basis. Care that is not obtained from MTFs is supported by the Civilian Health and Medical Program for the Uniformed Services (CHAMPUS), which reimburses beneficiaries for the costs of care supplied by civil-

change in manning requirements as immediate, but it is not clear to us whether that generates changes in training loads for the same year or a prior year.

The Army MTF system consists of seven regional medical centers and 29 station hospitals in the continental U.S. These facilities, as well as Army medical centers and hospitals in Panama, Alaska, and Hawaii, are managed by Health Services Command (HSC). The 7th Medical Command (subordinate to USAREUR) manages ten station hospitals and their clinics in Europe. The 18th Medical Command manages one hospital in Seoul, Korea, and the U.S. Army Japan manages the U.S. Army Health Clinic in Japan.
ian providers. Benefits cover medical, dental, inpatient, and outpatient services.

The MTF system is part of Army Program 8M (Medical), and its mission is to "conserv[e] fighting strength." This mission is viewed as having two elements: preparing medical resources for potential wartime needs (e.g., training medical practitioners) and providing medical services in peacetime to maintain the readiness of Army personnel.

Historically, MTF costs were funded by Service-specific appropriations whereas CHAMPUS was funded by DoD-wide appropriations, but this is no longer the case. Each Service is now charged for both programs for their own beneficiaries. Facilities and other investment costs for MTFs are funded through Military Construction and Procurement Appropriations, and their military manpower (physicians, nurses, and other personnel) are financed by Military Personnel Appropriations. Other MTF operating costs as well as CHAMPUS charges are funded by OMA.

Army Program 8 Medical covers other activities in addition to the MTF system and CHAMPUS. Medical education and training funds education from non-Army federal and civilian institutions. Other medical activities include public health services, military patient personnel administration, and other activities. Care in nondefense facilities covers supplemental health and dental care and sharing arrangements with Veterans Administration and other health facilities.

A number of MDEPs cover resources for Army health care. There are separate MDEPs for types of programs and for programs under different medical commands. CHAMPUS, which pertains primarily to CONUS locations but is also used by the Medical Command in Europe, appears in a separate MDEP under the Health Services Command.

Medical Support Cost-Factor Sources

<table>
<thead>
<tr>
<th>Personnel</th>
<th>Non-Tactical Medical Support Model. To develop the OMA portion of the POM for F8M, the Army uses the Non-Tactical Medical Support Model (NTMSM) developed by ARS, Ltd. The original version (1.0) estimated O&amp;M resource requirements for the</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pay and benefits</td>
<td></td>
</tr>
<tr>
<td>Acquisition (incl. training)</td>
<td></td>
</tr>
<tr>
<td>√ Medical support</td>
<td></td>
</tr>
<tr>
<td>Other (misc.)</td>
<td></td>
</tr>
</tbody>
</table>

HQDA POM developers use the Non-Tactical Medical Support Model to project O&M costs for MTFs and CHAMPUS.
Army Health Services Command. The current version (2.0) replicates that methodology for the entire P8 medical program, including requirements for the Army's worldwide medical commands and for medical education and training, other medical, and nondefense medical care.

The NTSM takes MTF assets as given, and assumes care beyond the MTFs' capacity is provided under CHAMPUS.

Logically, the NTSM assumes that resource limitations in the MTF system determine the amount of beneficiary care provided in that manner, with remaining demand served by CHAMPUS. The primary demand driver is assumed to be projected military end-strength by officer/warrant officer/enlisted status, component, and CONUS or overseas MACOMs. A base case uses end-strength data from PROBE, but the user can enter alternative end-strengths. The size of the total beneficiary population is related to end-strength by means of ratio factors, and the amounts and types of health care demanded are related to the beneficiary population by means of historical usage factors. Projected demands are compared to projected MTF capacities (measured by projected MTF funding or manpower) to determine how much care would be provided through MTFs and what remainder is left for CHAMPUS. Cost rates from actual experience are then applied to the MTF and CHAMPUS services to project OMA costs by type of service and provider.

Notably, the ratio factors used to estimate beneficiary populations from end-strengths are constants in the model, as though the ratio of retirees to end-strengths is constant over time. This assumption is a good approximation for a military force that is in steady state but can be a poor approximation when force sizes change. For example, if active component strength were cut substantially in a given year, the true ratio of current retirees to current strength would rise dramatically, but the NTSM would project a substantial drop in both populations and hence would underestimate total costs for medical care.

The user can alter this assumption by assigning shares of demand to MTFs and CHAMPUS.

MTF military and civilian manning is considered by the model to be a policy decision and is reflected in variables supplied by user input or from PROBE. The model projects nonmanpower OMA costs for MTF operations. The model uses historical average medical services provided per man-year to compute future MTF labor capacities. Capacity determined by funding is projected from historical average medical services provided per funding dollar.

The author is indebted to William T. Mickelson for this observation.
The model also projects medical education and training OMA requirements based on end-strength (for Academy training) and medical command manpower (for all other training requirements). The costs for other medical activities is assumed to be a per-capita value per beneficiary, and care in nondefense facilities is assumed to vary with population served.

All of the model’s cost factors are simple historical averages, such as MTF (nonmanpower) OMA cost per unit of demand in an output category (such as inpatient days). There is no fixed vs. variable cost distinction made for OMA expenditures.

AMCOS. AMCOS attributes Military Treatment Facility costs other than for facilities and medical personnel to active component manpower. AMCOS also attributes all CHAMPUS costs to them (and uses the same estimate for Reserve/Guard medical support). In effect, the AMCOS estimates for active component medical support reflect a methodology very similar to the NTMSM.

TAFCS. The TAFCS database currently contains per-capita cost factors for regional medical care, station medical care, CHAMPUS, and other medical support. These factors are obtained from the NTMSM.

Other Personnel-Related Factors in the TAFCS Database

<table>
<thead>
<tr>
<th>Personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pay and benefits</td>
</tr>
<tr>
<td>Acquisition (incl. training)</td>
</tr>
<tr>
<td>Medical support</td>
</tr>
<tr>
<td>Other (misc.)</td>
</tr>
</tbody>
</table>

The TAFCS factors identified above in this section are summary factors used directly in the TAFCS model (see Sec. IX). In addition, however, the database contains an array of other factors that may be useful in specific costing contexts. The TAFCS database is still in development and will probably continue to vary even after the 1991 version is finalized and documented. However, the following factors have been scheduled for inclusion at various times and suggest the kinds of factors the final database may contain:

- Average annual rotation rates, by MACOM;
- Average clothing allowances, male and female, by component;
• Composite Standard Rates for active component personnel, and daily composite pay and allowances for Reserve/Guard personnel;
• Permanent Change of Station costs for officer and enlisted rotations, by MACOM; and
• Government Social Security contribution and retired pay accrual rates, by component.

**Commentary**

In all military Services, personnel resources are the most difficult to cost properly for studies of force structure or weapon system decisions. The reasons are both technical and conceptual.

Technically, personnel costing is complicated because there are so many forms of compensation and benefits. Cash payments made directly to personnel are both well documented in accounting databases and recognizably associated with particular recipients' paygrades, dependency status, and organizational affiliation. However, costs for a variety of other compensation programs and benefits are difficult to relate to individuals or the functions they perform. Obvious examples are health insurance benefits under CHAMPUS, and G.I. Bill educational benefits. Consequently, considerable effort is needed to accumulate all such entitlements and relate them to the personnel manning particular activities.

Costing is also complicated by the large number of distinct personnel categories to which different compensation programs apply. Special procedures are needed to distinguish, for example, between Military Technicians and other civilian personnel, and between U.S. and foreign direct hire civilians.

In light of these complexities, it is not too surprising that all of the military Services devote most of their attention to developing entitlement cost factors for their largest categories of personnel—active component military, drilling Reserves, and U.S. direct hire General Schedule civilians. The Army provides entitlement factors in all these categories, but factors for other categories of personnel are less readily available.

Another level of complexity arises in connection with indirect personnel support—activities carried out by the DoD to procure, manage, and maintain personnel inventories. The prominent examples are recruiting, training and education, and medical care, but a vast array of other activities (such as morale, welfare, and recreation pro-
grams) also fall in this category. Indirect support results from productive activities that have their own relationships between resource inputs and outputs and (at least in principle) should be analyzed using the same multistep procedures as for force structure or weapon system costing.

Indirect costing is also technically difficult because some indirect services are provided through civilian service contracts that are not attributed to units in contract databases. Aside from the contractor intermediate maintenance cost factors identified in Sec. V, we found no cost factors pertaining to contract services, and contract costs are not included in the personnel-related training or medical support cost estimates.

In addition, there are important conceptual difficulties in relating indirect costs to personnel support. Many supporting activities have large joint or common costs that are conceptually difficult to attribute; for example, it is not clear whether services provided by Military Treatment Facilities are attributable to peacetime health care for military personnel or to training medical personnel for potential wartime contingencies.

The attribution of indirect costs varies in Army costing practice. Institutional training and recruiting costs are almost invariably attributed to personnel and, through manning, to force units and weapons systems; however, training costs are usually attributed solely to military personnel, even though a significant number of civilians receive Army training. Costs for military treatment facility operations are commonly attributed to the population served, which does not interpret costs incurred for retirees and their dependents as indicators of future commitments to current military incumbents. At the same time, costs for MTF facilities and professional manning are considered mission costs and not attributed to personnel. And training base operating costs are attributed to the installation’s military population and not to the civilian workforce.

For users of Army cost factors, additional challenges arise from the differences in comprehensiveness among indirect cost factors from different sources. For example, TRADOC training cost estimates exclude ammunition costs, whereas AMCOS captures ammunition as an element of training costs. Furthermore, training and medical support cost measures generally include related base operating support, whereas separate BOS models (see Sec. VII) include Army-wide base operating costs.

For both direct and indirect costs, another methodological issue is the treatment of nonrecurring cost elements. In Army POM and
budget development, where the timing of costs is critical, nonrecurring costs are directly associated with their triggering inventory flow events—recruitments, training at acquisition, separations, and the like. This is possible because the POM and budget develop aggregate costs separately for entire personnel inventories and overall supporting activities in each year. In contrast, force-unit and weapon system costing attempts to allocate personnel costs to selected spaces that will be filled by a steady flow-through of personnel acquired and trained at different times.

The AMCOS model explicitly resolves this issue by “amortizing” nonrecurring indirect costs—spreading them over the grades and man-years generated by discrete events. The shortcoming of this general approach—which is widely used in defense manpower costing—is that it is insensitive to the means that would be used to acquire personnel Manning. For example, it attributes a share of initial training costs to personnel who might be acquired by inducing them to reenlist (perhaps by means of a bonus). Furthermore, cost amortization is problematic whenever force structure decisions lead to substantial changes in personnel inventory management, especially large changes in accession, separation, or retirement rates.

Although changes in personnel management policies are likely to pose important costing issues in the future, another type of issue has been raised by historical personnel policy: The Army has maintained a fairly constant target for overall active military and civilian manpower strengths. Consequently, decisions to activate (or deactivate) a unit or to procure (or not procure) a modernization system have primarily involved reallocating available manpower and have had relatively little effect on overall MPA or civilian personnel budgets. That raises the question of whether personnel costs should be attributed to the decisions in question.

With respect to weapons acquisition decisions, the DoD Cost Analysis Improvement Group has taken an explicit position on this issue:

Use of existing assets or assets being procured for another purpose must not be treated as a free good. The “opportunity cost” of these assets should be estimated, where appropriate, and considered as part of the program costs.39

AMCOS developers, as well as CEAC managers, have explicitly interpreted this to mean that BCE/ICE studies should “include the costs of manpower and other resources even though they may not

39 See enclosure 1 of DoD Instruction 5000.4.
change in the aggregate as a result of a weapon system decision, but are simply reallocated within the Army.40 And many analysts apply the same standard to studies estimating the costs (or savings) from unit activations (or deactivations).

However, two caveats should be noted in this context. One is that personnel costs are crude indicators of opportunity costs. The opportunity cost theory assumes that production is efficient—so the marginal productive values of all assets in all activities equal their marginal costs—and that asset changes under consideration are small enough for marginal conditions to apply. If these conditions are not met, the dollar cost of workers used in an activity may be a very poor indicator of their true opportunity cost—i.e., the cost of replacing them with other assets to maintain capability elsewhere in the force. Second, and perhaps more important, studies that include opportunity costs do not project a decision’s effects on the Army (or other DoD) budget or POM.

Finally, yet another conceptual issue results from the fact that marginal costs are not symmetric with respect to increases and decreases in force strength. In practice, all attempts to measure Army personnel marginal costs address cost increases associated with adding personnel to the force; this generally implies increased costs for pay, other benefits, training, support, etc. Reductions in force may generate corresponding savings assuming the reductions are achieved by reversing force-increasing actions—by eliminating new accessions, in particular. However, force reductions frequently take the form of involuntary separations and trigger civilian and enlisted severance pay, unemployment benefits, and unusual relocation costs that are not reflected in standard marginal cost rates. Accounting for these specialized force reduction costs is a major task in base realignment studies.

40See Davis et al. (1999a), p. 18.
VII. Installation Support

Army installation support is covered by the Army Real Property Management System.

In the terminology of this report, installation support includes all the activities covered by the Army Real Property Management System (RPMS). It encompasses development of requirements for additional installations or facilities, programming for real property development, acquisition of property, and operations and maintenance.

This section discusses these topics under three headings:

- Military facilities construction (including property acquisition and facility improvement):
• Family housing construction, improvement, and operations; and
• Base operations and real property maintenance.

Each discussion covers both general background on Army management of the activity in question and information on pertinent factor sources. The section concludes with commentary on the factors available for installation support costs.

Military Facilities Construction and Property Acquisition

Determining Requirements

The following discussion pertains to projects financed by the Military Construction (MCA, MCAR, and MCNG) Appropriations, which include all major property acquisition, facilities construction, and improvements other than Army Family Housing (discussed separately below) and medical and health facilities.¹

The HQDA office responsible for facilities acquisition, including installations, buildings, railroads, surfaced areas, and electric/water/sewer lines, is the Chief of Engineers (COE). However, requirements for facility construction generally originate with the MACOM engineer, who consolidates and prioritizes installation requirements for inclusion in the command’s POM submission.

Requirements are based on a comparison of projected facility needs and availability. Needs assessment reflects projected population and equipment by installation. For CONUS installations, for example, the Army Stationing and Installation Plan (ASIP) projects equipment and active component populations by installation for the POM period, taken from the FAS. Current and projected availability is recorded in the Integrated Facilities System (IFS).

Once the need for a new facility has been determined, the next step is to prepare a cost estimate. The active component and USAR use one method and the ARNG uses another. Both are described below.

¹All military construction for planning, design, and construction of health facilities has been transferred to the Assistant Secretary of Defense for Health Affairs.
**Construction Factor Sources**

For the active and reserve components, the Facilities Planning System (FPS) uses personnel and equipment as the basis for determining primary facilities square footage requirements. The Army Corps of Engineers annually computes dollars-per-square-foot factors by primary facility category, based on contract bid experience. These factors were previously presented in Army Regulation 415-17 but are currently supplied via an automated newsletter (usually number 19) issued by the Engineering Division of Headquarters, U.S. Army Corps of Engineers (USACE). The dollar value for each type of facility is shown as a mean factor and supplemented by a regional index for adjusting the factor; for example, if the Alaska index is 2.0, then the dollar factor should be multiplied by two for construction in Alaska.

Although the cost factors are presented on a square footage basis, Army Regulation 415-17 provided a separate figure indicating how to adjust the cost estimate for buildings of sizes different from the ones assumed in the factor table. The cost relationship is logarithmic in shape, suggesting that costs per square foot decline as facility sizes increase. We do not know if the USACE newsletter includes a similar cost adjustment procedure.

To account for secondary facilities costs—e.g., for demolition, parking, landscaping—the newsletter also provides secondary cost factors. They are derived from the DD 1391 database of actual facilities construction costs and are computed by a "processor" that compares the primary facilities costs with the total project costs.

For MCA, MCAR, and MCNG costing in the POM, MACOM planners usually add about 6 percent to total estimated project costs for supervision and administration and about 5.5 percent for contingencies.

In the future, many of these calculations and costing for real property maintenance will be done by the Real Property Planning and Analysis System (R-PLANS). It already exists in an HQDA version for comparing existing assets with projected needs and is being distributed to MACOMs for their planning purposes.

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2 Examples of primary facilities are communications centers, flight control towers, TOE vehicle maintenance shops, administration buildings, and barracks.

3 The newsletter also reports construction inflation factors obtained from OSD.
Once the user has tabulated desired facilities, R-PLANS compares those targets with existing facility availability and computes the new project requirements. It then costs the construction plan using factors from the DD 1391 database. R-PLANS can also do what-if drills for moving a unit into an installation or for taking units away. And R-PLANS can compute Real Property Maintenance OMA cost projections based on historical cost experience reflected in the Integrated Facilities System.

The costing methods described above apply to permanent military construction for active and Reserve components—not the ARNG. Historically, the ARNG used lease factors (the cost of leasing an armory that would serve about 200 troops) for estimating facilities costs for new force structure. More recently, however, the ARNG has used specific engineering estimates for construction, reflecting the fact that regulations prohibit initiating construction until new force units have reached half of their authorized strength and hence construction plans are relatively firm.

At present, there are no military construction factors in The Army Force Cost System (TAFCS), but there are plans to include them. A recent proposal was to use R-PLANS to develop cost factors for specified force-unit activations and deactivations.

**Family Housing Construction and Operations**

The Army Family Housing (AFH) budget is unique in that it funds both construction and operations. The appropriation is administered by HQDA and only the operation, maintenance, and leasing portions are managed by installation commanders. The funds are allotted to installations by MACOMs, just like O&M funds.

The only factors for AFH costs we encountered were MACOM factors for the operations\(^4\) portion of the AFH budget. USAREUR Circular 37-11 reports factors for family housing, with separate values for recurring costs (operations and maintenance for on-post and leased housing) and nonrecurring costs (furniture and minor

\(^4\)As in the case of base operating costs, AFH operating costs are defined to include low-cost construction and improvements.
improvements); table notes indicate, however, that actual amounts vary considerably among USEUR communities. In addition, FORSCOM Pam 11-1 includes factors for AFH operating costs in tables pertaining to base operating costs, as described below.

A potential source of AFH maintenance cost factors might be the Base Operations Predictive Model (BOPM) developed by ARS, Ltd., for use in Army POM development. This model, which is described more fully under the next topic, is designed to project future resource requirements by applying historical cost rates to projected workloads. The model is being enhanced to relate AFH operating costs to the numbers of dwelling units on the installation rather than to population as in previous versions.

Base Operations and Real Property Maintenance

General Background

The Army Base Operations Subprogram (Army Program 12, see Vol. 1) consists of "BASOPS (-)" and the Real Property Maintenance Activity (RPMA). Both are broken down into "alpha" accounts (or activities) as listed in Table 7.1.

**BASOPS accounts cover DS/GS maintenance as well as other base operations.**

Note that BASOPS.C covers DS/GS materiel maintenance, the installation-based intermediate maintenance discussed in Sec. V. This activity is clearly driven by materiel and unit operations at the installation rather than by its population base as is generally assumed for other BASOPS activities.

**The RPMA account covers minor construction as well as property maintenance.**

Note also that RPMA account L covers construction. Installations are required to pay all minor construction costs and a portion—at least 10 percent—of major construction. Minor construction is financed by O&M funds, up to amounts limited by law.

The execution of budgets for both base operations and real property maintenance is decentralized and is managed by installations. Execution of the OMAR budget for Reserve Centers is frequently managed by the Directors of Engineering and Housing (DEHs) at active component installations.
Table 7.1
BASE OPERATIONS ACCOUNTS

<table>
<thead>
<tr>
<th>BASOPS(−)</th>
<th>Base Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Real estate leases</td>
</tr>
<tr>
<td>B.</td>
<td>Supply operations</td>
</tr>
<tr>
<td>C.</td>
<td>DS/CS maintenance of material</td>
</tr>
<tr>
<td>D.</td>
<td>Transportation services</td>
</tr>
<tr>
<td>E.</td>
<td>Laundry and dry cleaning services</td>
</tr>
<tr>
<td>F.</td>
<td>The Army Food Service Program</td>
</tr>
<tr>
<td>G.</td>
<td>Personnel support</td>
</tr>
</tbody>
</table>
| H.        | Unaccompanied personnel housing operation, administra-
|           | tion, and furnishings                               |
| N.        | Command element, special staff, HQ Commandant       |
| P.        | Automation activities                                |
| Q.        | Reserve component support                            |
| R.        | Unapplied program adjustments                        |
| S.        | Community and morale support activities              |
| T.        | Preservation of order                                |
| U.        | Resource management operations                       |
| V.        | Plans, training, and mobilization                   |
| W.        | Contracting operations                               |
| X.        | Security and counterintelligence operations          |
| Y.        | Records management, publications                     |

<table>
<thead>
<tr>
<th>RPMA(−)</th>
<th>Real Property Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>J.</td>
<td>Operation of utilities</td>
</tr>
<tr>
<td>K.</td>
<td>Repair and maintenance of real property</td>
</tr>
<tr>
<td>L.</td>
<td>Minor construction</td>
</tr>
<tr>
<td>M.</td>
<td>Engineer support</td>
</tr>
</tbody>
</table>

RPMA needs are reported in an Unconstrained Requirements Report (UKR) submitted through MACOMs to the Office of the Chief of Engineers. Based on approved maintenance resourcing, the installation DEH prepares the Annual Work Plan (AWP) as the basic building block for OMA budget execution.

Maintenance of real property facilities is subject to a floor imposed by Congress. If less is spent, amounts cannot be reprogrammed for other purposes. The Backlog of Maintenance and Repair (BMAR) is a formal measurement of approved work that could not be done because of inadequate resources. There are special Army MDEPs for the Army components’ BMAR accounts.

There are special Army MDEPs for approved maintenance that has not been funded.

Most manpower for installation BASOPS and RPMA is civilian. Installations also regularly use civilian contractor support, not only for intermediate maintenance activities but also for grounds and
facilities maintenance, food service, and other local services. Army military manning for these activities has been declining.

However, this does not mean that military personnel play little or no role in the functions generically considered to be base operations and maintenance. Unlike Air Force units, Army battalions have personnel authorized for support functions, such as food service, utilities, and personnel support activities. This manpower is simply not covered by the BASOPS and RPMA subprogram.

In the National Guard, additional BASOPS and RPMA support is provided by states without appearing in the Army budget. Many ARNG facilities are partially owned by the state, which maintains the facilities and acquires property rights to them after 25 years. States often own local training areas, and states hire and pay some employees, such as adjutants general, who provide services to the ARNG.

**BASOPS and RPMA Factor Sources**

**USAREUR Factors.** OMA and (as noted above) AFH funding in USAREUR Circular 37-11 provides a methodology for estimating installation and manpower changes associated with military end-strength changes. These estimates are intended for use in MACOM POM submissions and are described in the circular as "appropriate for both increases and decrements" in end-strength. The methodology is automated as part of HQ USAREUR software, which provides more detailed costing than the hardcopy circular.

The methodology provides support manning factors (separately for civilian and military workers) to be multiplied by the number of new military personnel (additions to end-strength) to obtain support manning increments. The civilian increment is multiplied by civilian personnel cost factors. The military increment is not costed since the MPA effect does not appear in the installation budget. However, the circular notes that 13 percent of the military increment can be assumed to be officers and the remaining 87 percent enlisted.

The circular also provides nonpersonnel expense factors (for supplies, equipment, and contracts) that are also to be multiplied by the change in installation end-strength.

The preceding calculations are for recurring costs, and apply (as costs) if end-strength increases or (as savings) if end-strength decreases. To account for lags in civilian hiring, the circular recommends using only half the civilian costs in the first year of a change.
In the case of end-strength increases (but not decreases), the circular also notes that there can be nonrecurring costs. If (minor) military construction will occur, the automated model can also identify related BASOPS costs for items like office furniture and bachelor furnishings. A table in the circular shows how those costs would be distributed over time for construction occurring in a hypothetical year.

**FORSCOM Factors.** FORSCOM Pam 11-1 has nonpersonnel base operations CERs for its active component installations. According to the pamphlet, "Nonpersonnel recurring dollars and military man-years supported are used with linear regression techniques to create a fixed cost (a) and a variable cost (b) for each installation at the base operations (-) and RPMA levels." This is essentially the same methodology TRADOC uses for training installation costing, as described in Sec. VI.

The military man-year (MMY) measures are taken from the FORSCOM RCS AFRM-94 report ("Analysis of Operational Costs"), which also supplies data for the FORSCOM operating costs discussed in Sec. III. The reports are submitted annually by FORSCOM installations that have an active component division or separate combat brigade/regiment and operated under TUFMIS (see Vol. 1). Thus, the data pertain to the Army’s ten largest CONUS installations.

Tables in the FORSCOM pamphlet show the a and b values for each of 20 installations and in total. Separate totals break down the base operations variable cost factor (parameter b) among the BASOPS "alpha accounts." Similarly, tables break down the variable factor for RPMA into its activities.

Corresponding regression results relate the BASOPS workforce (civilians and "borrowed" military manpower) to military man-years (MMY) supported. Additional tables show BASOPS military as a percentage of total military at each installation and BASOPS civilians as a percentage of total civilians. And another table shows average civilian salaries by installation at alpha account, BASOPS, RPMA, and total BASOPS levels; these salaries include funded benefits and overtime.

For all equations, MMY comprises MTOE and TDA tenants, U.S. Army Reserve personnel on annual duty training (measured in full-man-year equivalents), and students.
The BOPM Model. At HQDA, the BOPM model (mentioned above in this section) is an automated system for developing POM projections for BASOPS, RPMA, and AFM. The model uses historical obligations from the USAFAC 218 report and workload measures from various sources (including PROBE, IPS, the Resource Analysis Planning System, the Standard Installation Division Personnel System, and FAS) to develop cost rates. In model version 3.0, the workload measures were based on the population served (e.g., military personnel, personnel with dependents), but version 4.0 is being designed to use a variety of workload measures—and to allow the user not only to consider alternative workloads but also alternative measures of levels of service provided and resource productivity. Examples of workload measures that might be used for various BASOPS, RPMA, and AFH activities in the BOPM are numbers of pieces of mail processed, numbers of service workorders, numbers of inspections/surveys, square footage of facilities, and numbers of dwelling units.

The Guard, unlike other Army components, does not use population served as the basis for projecting installation support costs.

ARNG Factors. Unlike the active component and USAR, the ARNG does not use military population supported for BASOPS and RPMA cost estimation. ARNG maintenance costs are estimated by past execution for existing programs, measured as overall averages; for a new project, the rule of thumb is to use 10 percent of investment cost as the maintenance and utilities estimate. Base operating costs are estimated on a per-facility basis; the reasoning is that base operating costs rise if the same manpower is spread among more locations. The exception is for the "head tax" of $3 per day for the use of federal facilities, which appears in the OMNG miscellaneous account.

The TAFCS Database. The TAFCS exportable database Version 3.1 includes MACOM-developed BASOPS and RPMA factors. Presumably, these factors are like those found in the USAREUR circular and FORSCOM pamphlet described above.

Commentary

One difficulty analysts frequently encounter in costing the implications of defense output decisions is in identifying effects on military construction costs. Historical evidence provides a basis for computing typical construction costs for facilities of various kinds, but cost studies frequently lack information on the facility changes that might accompany changes in force size, structure, or materiel outfitting. The Army's R-PLANS model represents a vehicle for identifying relationships between facilities requirements and force-unit decisions and hence might prove useful in a variety of costing exercises as well as in its intended application in Army facilities planning.
For weapon system costing, the Army generally does not use factors for construction costs. Both BCE/ICEs and the Army Cost Position on modernization equipment normally show zeros in the "MILCON" cost cells. The reason: Facilities are not normally considered system-specific (though there have been exceptions, such as modifications to maintenance bay doors to accommodate the M64 tank). Similarly, Army Family Housing costs are not considered to be materiel-specific and are not reflected in BCE/ICE costing exercises.

BCEs and ICEs also lack line items for base operations and real property maintenance.\(^5\) Costs for intermediate maintenance are explicitly taken into account, and some BASOPS and RPMA costs enter BCEs and ICEs through the AMCOS model for personnel costing (see Sec. VI), because medical and training cost estimates include related installation operating costs. However, even though most Army analyses assume that BASOPS and RPMA costs are driven by the size of an installation's population, BCEs and ICEs do not attempt to associate installation operating costs with the manpower used to support modernization systems.

Costing undertaken from the force-unit perspective may be subject to double-counting hazards. Readily available OSMIS factors for materiel operating costs include the costs of replenishment items for intermediate maintenance, and other OSMIS factors account for civilian intermediate maintenance labor. Meanwhile, overall BASOPS cost rates (generally given as per-capita factors) also include DS/GS maintenance costs. Consequently, when intermediate maintenance is treated as part of equipment support costs for a force unit, installation support costing for the unit's personnel should not use an overall BASOPS factor.

\(^5\) However, such costs might be included in the "other OMA" line item if a materiel system were expected to have significant effects on installation operating costs.
This section covers factors that did not fit conveniently under other topics in this report. The three factor categories considered here are:

- Transportation.
- Inflation/escalation.
- Miscellaneous.
Transportation

Transportation costs fall into three principal categories: (a) transport of personnel, their families, and household goods, (b) “first destination” transport of equipment and supplies for their point of origin to a government delivery point, and (c) “second destination” transport of equipment and supplies, including both movement from a government delivery point to a warehouse or unit and movement between units and depot maintenance stations. Changes in force structure impose costs in categories (a) and (c).

The bulk of military personnel transportation is in connection with Permanent Changes of Station, is funded by military personnel appropriations, and is covered by the factors discussed in Sec. VII. Civilians who are relocated in connection with their government employment are also eligible for PCS reimbursement but the costs are covered by the O&M appropriations and are not as easy to observe in military accounting systems. And military and civilian personnel are occasionally sent on temporary duty (TDY) assignments away from their regular duty location, and the resulting transportation and per-diem costs are reimbursed by O&M funds.

Based on an OSD Program Budget Decision, first destination transport should be covered by procurement appropriations and appear in the fielding category of Army weapons acquisition cost studies. In costing for established equipment, first destination transport is often included in the procurement prices reported in the AMDF database, as noted in Sec. IV.

As we noted in Sec. VI, we encountered no data sources that report transport distances for movements to and from depots, but these costs will often be included in stock-fund prices in the future. Army Regulation 55-60 reportedly contains mileage factors for other specific moves, and the TAFCS database should eventually contain some distance factors, as described below.

The first volume of the Resource Factor Handbook has contained typical transport cost rates (average costs per ton-mile, by air, motor, and rail) for ammunition and explosives; military baggage; vehicles and parts; and household goods (motor transport only). RFIH (1) also showed average costs per passenger-mile and for packing and crating for unit moves. The handbook recommended using the

Changes in force structure inevitably require transportation of people and things.
Computerized Movement Planning and Status System (COMPASS) to obtain TOE unit data on weights of materials and equipment.

USAREUR Circular 37-11 is a particularly useful source for transport costs overseas. The circular includes Military Airlift Command air rates per passenger or cargo-pounds for moves to and from locations in Germany.

The USAREUR circular also provides factors for unit relocation costs (per USAREUR Regulation 220-5). These factors cover personnel and family relocation; moving military administration and tactical vehicles (on a per-mile basis); commercial truck line-haul cargo; and rail costs for armored vehicles moved 200 km. All of the estimates are based on data received from units but are not updated annually.¹

Finally, the circular contains a “Rail Transportation Model.” The model shows how to compute costs based on distance, cost per M60A1 tank per kilometer, factors for measuring other items in M60A1-equivalents, and the numbers of rail cars/passenger coaches required.

Plans call for the TAFCS database to contain a wide variety of transport factors:

- Second-destination transportation per ton-mile for moves between CONUS and USAREUR or the Eighth U.S. Army and for moves within those command regions.
- USAREUR distances from home stations to major training areas.
- USAREUR rail cost factors and distances and other factors similar to those in the USAREUR circular.
- FORSCOM typical transportation costs to national training centers, by SRC.

### Inflation and Escalation Factors

<table>
<thead>
<tr>
<th>Other Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
</tr>
<tr>
<td>√ Inflation/escalation</td>
</tr>
<tr>
<td>Miscellaneous</td>
</tr>
</tbody>
</table>

Escalation and inflation are not synonyms. In principle, escalation includes not only inflation (i.e., changes in the value of the dollar) but also real cost growth that might reflect changes in a product’s design, quantity, or schedule. In practice, however, escalation

¹For example, the estimates in the cost table for 1989 were from 1984 experience.
rates often reflect only general price trends for particular categories of items, whether or not there have been changes in product design or production schedules.

In defense program development, it is traditional to use the next fiscal year as the base year for escalation adjustments. For example, the base year for an exercise done on October 1, 1990 (the start of fiscal year 1991), is fiscal year 1992. When resources are costed in constant dollars, they are costed as though they would be delivered in the base year and all payments would be obligated and outlaid in that year.

The phrase "constant budget dollars" refers to partially escalated costs. Such measures treat costs as though they will be obligated in the base year but outlaid according to historical outlay patterns. Thus additional dollars to cover escalation during the outlay period are included.

The phrase "FYDP dollars"—also known as "then-year dollars"—refers to fully escalated costs for the period between the base year and the first year of program execution as well as the timing of outlays over the execution period.

Escalation factors are normally presented in terms of converting FYDP dollars to base year constant budget dollars separately for the following categories of funding:

- Military personnel (weighted).
- Reserve personnel (weighted).
- O&M.
- O&M reserve.
- Stock fund.
- Procurement.
- MILCON active.
- MILCON reserve.
- Family housing (weighted).
- RDT&E (weighted).
- Other procurement.

Properly measured, costs in constant budget dollars include escalation for the outlay period following initial obligations.

OSD requires that annual System Acquisition Review (SAR) updates use OSD deflators unless a system-specific exception is approved. System-peculiar indexes have been approved for the Black Hawk and Chinook (CH-47) systems, and they are developed and updated

AMC Headquarters distributes escalation guidance in memo form, including escalation procedures and the following rates:

- Composite rates for major items, initial provisioning, and replenishment spares. Department of the Army guidance requires the use of these factors for budget estimates.

- A consolidated MPA rate for use in manpower lifecycle estimates for weapon system costing only. (The methodology in that application—but not for budget submissions—is approved by CEAC and the Army Budget Office.) The rate represents an averaging of pay and nonpay escalation. In budgeting applications, HQDA adjusts the pay portion of MPA for expected pay rates, and a nonpay MPA rate is used for escalating other elements.

- OMA indexes for life cycle costing only. They pertain to the portion of OMA not covered by specific guidance on pay raises, the Army Industrial Fund/Army Stock Fund, POL prices, and utilities. For budgeting, HQDA escalates the OMA portion of the AMC budget submission.

- Military construction indices.

- Indices for commercial activities studies.

FORSCOM Pamphlet 11-1 also has inflation factors for nonpay Army Family Housing costs, OMA/OMAR nonpay costs, and MPA/RPA costs. There are also OMA/OMAR/AFH Civilian Pay Raise Factors.

The TAFCS exportable database also includes official inflation factors, by appropriation and by type of procurement subcategory (aircraft, missiles, tracked combat vehicles, ammunition, and other).

## Miscellaneous

<table>
<thead>
<tr>
<th>Other Factors</th>
<th>Transportation</th>
<th>Inflation/escalation</th>
<th>Miscellaneous</th>
</tr>
</thead>
</table>

For realignment actions, RFH (1) provides a rule of thumb for computing the portion of total PCS costs chargeable to the realignment. The rule is to assume that about a third of the unit's military personnel would turn over each year in any case, leaving two-thirds of the moves attributable to the unit move.
Although rarely found in force-unit costing studies, software support costs are commonly included in BCE/ICE studies. Both AMC and CEAC have models that relate software support to lines of software code or numbers of man-years in software support centers. Commonly referenced models are named PRICE, COCOMO, CECOMO, SEER, and CEAC-SIZE. CEAC-SIZE is based on actual cost experience and has been shared with other Services.

In BCE/ICE costing for large missiles, there may be estimates for recertification costs. Recertification is done at supply or ammunition depots, and the Missile Logistics Center in Huntsville provides factors based on actual experience.

BCE/ICE studies also have a line item for System Project Management. This is computed as the number of people in the program manager's office, multiplied by composite rates for military officers, or by the grade 12 step 5 GS rate for civilians. An alternative source is simply the PM's budget for preceding three years.

BCE/ICE factors for communications costs draw from the Defense Communication Agency Factors Handbook, which was not reviewed in our study.

There is no standard factor or rule of thumb for engineering change orders (i.e., an allowance for engineering changes not anticipated in the production contract). AMC asks program managers to examine the history of similar systems. Values that are frequently used for these costs range from 2 to 4 percent of system production costs.

Finally, BCE/ICE costs for testing draw from specific test costs reported by the Operational Test and Evaluation Agency (OTEA).
IX. Army Costing Models

This section describes the way Army cost factors are combined to generate overall cost results. We illustrate the features of models used for:

- Force-unit costing;
- Weapon system costing; and
- Base realignment costing.

These three types of models differ in their basic units of analysis; it is usually a battalion or company in force-unit models, the total fleet of a particular system in Army weapon system models, and one or more installations in base realignment studies. The result is a set of costing approaches that differ in their scope and line-item structure, even though they frequently use the same cost-factor sources.

Force-Unit Costing

The old AFFC/ (noted in Sec. 1) included a model for approximating resource requirements (both OMA and MPA) arising from proposed Army force changes during peacetime. Cost estimates provided by AFFCH, therefore, were illustrative of peacetime operations, reflecting the average costs associated with fielding a typical force unit; in particular, the model used factors for notional TOE units in CONUS locations and manned at ALO 1. The AFFC/ established a basic modeling structure that remains widely used as the starting point for force-unit costing models, but newer models vastly expand the scope and detail found in the old AFFC/ model.

One illustration of a newer force-unit model is provided by the UNITCOST model developed at RAND. It is a personal-computer-based LOTUS 1-2-3 spreadsheet model that estimates the total non-recurring and annual recurring costs for a unit (or units), given the cost and weight of the unit's equipment and manpower requirements. UNITCOST supports excursions from a base case and can calculate detailed cost estimates for one excursion case at a time. In its basic structure, however, UNITCOST parallels the AFFC/ design.
UNITCOST’s two major cost categories are: investment (procurement-funded costs, including systems for operational and maintenance float, ammunition, and spares), and Operations and Support (OMA and MPA costs). These two categories are each subdivided into direct costs (that are directly attributable to the unit) and indirect costs (that are incurred on behalf of the unit by another element). In many force-unit models, the indirect costs pertain solely to MOS training activities. However, UNITCOST also shows base operating support, central supply, depot maintenance, and other Program 8 costs in the indirect category.

Variations on the UNITCOST model appear in the ARROYO Lifecycle Cost Estimator (ALICE) model used at RAND and in the Logistics Net Assessment System model used by the Army Logistics Evaluation Agency. ALICE was originally developed to perform life cycle cost analysis for active duty Army helicopter battalions and produces output in both the AFPCH-based format of UNITCOST and a format that resembles the Air Force CORE model. The model used by LEA was designed to provide a costing capability in the Performance Oriented Logistic Assessment (POLA) system, which evaluates combat service support unit wartime capacities and estimates the costs of increasing capacity by adding or replacing equipment. Thus, the same basic modeling structure has been applied to both combat and supporting units.

The factor values for the foregoing models were developed by analysts from old AFPCH and OMA/MPA handbooks, BCE cost studies, informed judgment, and miscellaneous supplementary sources. This reflects the recent state of Army cost factors but is being rectified as the TAFCS database becomes more complete and widely accessible.

The TAFCS project has also generated a model that produces cost estimates for (1) acquiring materiel and personnel for a force unit, (2) activating a force unit, and (3) operating a force unit.1 The model has been developed in the “C” language using commercially available software, and functions in a desktop environment. As of winter 1991, the model was in a user testing phase.

1 However, several of the line items for the nonrecurring cost of activating or deactivating a division currently show zero values because of a lack of suitable factors in the TAFCS database.

UNITCOST is an example of a force structure costing model based on the traditional AFPCH design but expanded to capture additional costs.
The TAFCs model currently analyzes costs for Army divisions, but CEAC analysts eventually hope to be able to examine costs for the force-unit aggregates used in JCS exercises. The model computes costs for any type of Army division, including standard divisions, by SRC. (A standard division is defined by a particular set of SRCs on the TOE Master File maintained at TRADOC.) The user can specify that the division is in a particular MACOM and at a particular installation or can generate costs for a MACOM composite or installation composite. Input variables can also be tailored to ALO, Training Readiness Rating, and alternative constant-dollar base years, and the user can choose whether the personnel for the unit are “within end-strength” or will “increase end-strength”; the former means all personnel are already in the force (adding no personnel costs), and the latter means all E-3 and below personnel will have to be recruited. The user can display the cost estimate, equipment cost drivers, OPTEMPO data, personnel, and costs by appropriation, and the data can be downloaded in a text (ASCII) file for use in other applications. Previous sessions (i.e., results from previous runs of the model) can be accessed as a starting point for additional analysis.

The grouping of units into larger force elements has not been resolved. CEAC would like to be able to combine SRCs that correspond to a Division Force Increment, Tactical Support Increment, and Nondivisional Increment, because the Joint Chiefs of Staff rarely deal with units below the division or corps level and larger aggregates would be useful for force structure planning. However, the design of larger aggregates remains to be determined.

Table 9.1 lists the format for operating cost estimates in the TAFCs model. The user can also list the LINs used to estimate the costs of replenishment repair parts, replenishment spares, and POL.

With respect to nonrecurring costs, Army costing distinguishes between changes in force structure and changes in basing, so that the TAFCs model is explicitly designed to deal only with the former.

2The Training Readiness Rating "relates to the number of days of training required to overcome a unit's training shortfall, assuming all available personnel can participate in training, and train the unit to standards in the unit's Mission Essential Task List (METL)." (Force Cost Model Users Guide; 1990, pp. 3-12)

3There is no plan in the TAFCs to do a breakdown by budget activity, but it is not too difficult to show costs by Program Element.

4Based on current factors, the model includes depot overhaul cost in the cost of replenishment spares and treats the source of funding as OMA; input data file changes are currently required to treat depot overhaul. However, when separate factors for the depot overhaul costs become available (see Sec. V), the model will be modified to account for the costs separately.
<table>
<thead>
<tr>
<th>Cost Element</th>
<th>Cost ($ Million)</th>
<th>Appropriation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations</td>
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<tr>
<td>Materiel</td>
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<td>Aircraft operations</td>
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</tr>
<tr>
<td>Replenishment spares</td>
<td>31.935</td>
<td>OMA</td>
</tr>
<tr>
<td>Replenishment repair parts</td>
<td>5.743</td>
<td>OMA</td>
</tr>
<tr>
<td>POL</td>
<td>2.277</td>
<td>OMA</td>
</tr>
<tr>
<td>Ground/afloat operations</td>
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<td></td>
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<td>Replenishment spares</td>
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<td>OMA</td>
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<tr>
<td>Replenishment repair parts</td>
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<td>OMA</td>
</tr>
<tr>
<td>POL</td>
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<td>OMA</td>
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<td>Training ammunition and missiles</td>
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<td>OMA</td>
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<tr>
<td>Depot overhaul of secondary items</td>
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<td>OMA</td>
</tr>
<tr>
<td>Other materiel-related costs</td>
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<td>OMA</td>
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<td>Personnel</td>
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<tr>
<td>Replacement personnel</td>
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<td>Training through initial MOS</td>
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</tr>
<tr>
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<td>PCS travel for military and dependents</td>
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<td>MPA</td>
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<tr>
<td>Military personnel</td>
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<td>Basic pay and allowances</td>
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<tr>
<td>Special/incentive/hazardous duty pay</td>
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<td>Non-OPTEMPO</td>
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<td>Mission/support-related TDY</td>
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<tr>
<td>BASOPS (-)</td>
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<td>OMA</td>
</tr>
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<td>RPMA</td>
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</tr>
<tr>
<td>Base communications</td>
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<td>OMA</td>
</tr>
<tr>
<td>Central supply</td>
<td>0.000</td>
<td>OMA</td>
</tr>
<tr>
<td>Transportation</td>
<td>0.000</td>
<td>OMA</td>
</tr>
<tr>
<td>Depot overhaul of end items</td>
<td>0.000</td>
<td>OMA</td>
</tr>
<tr>
<td>Medical support below general hospitals</td>
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<td>OMA</td>
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<tr>
<td>TDA augmentation</td>
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<td>Family housing O&amp;M</td>
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<td>AFHO</td>
</tr>
<tr>
<td>Army family housing leases</td>
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<td>AFHO</td>
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<tr>
<td>Other support</td>
<td>0.000</td>
<td>OMA</td>
</tr>
</tbody>
</table>

SOURCE: Printout of a sample screen.

NOTE: "0.000" indicates that the line item cannot be computed from currently available factors in the TAFCS database.
Specifically associated with closing the base itself. By separating the two analyses, the Army aims to prevent double-counting for the two separate (force restructure and basing restructure) initiatives.

In effect, however, the TAFCS model is capable of estimating base closure effects. The inactivation module can be used to treat the elimination of all the TOE units, then a separate “unit” can be constructed for all the TDA resources at the base and it can be deactivated too. If caretaker costs were added, the results should be the same as in a corresponding BRAC analysis.

Table 9.2 shows the screen line items for the unit-activation module. It treats nonrecurring costs for accessing and training people and acquiring equipment. Equipment is represented by LIN, and the costs for between 5 and 25 cost drivers, items that together account for 95 percent of the unit’s acquisition cost value, can be listed separately. There are no cost estimates for military construction because that is considered part of rebasing rather than force restructuring.

The TAFCS acquisition cost module computes the current cost of procuring all unit equipment—unless the user specifies that some equipment is “inherited.”

Note that the acquisition cost is designed to yield the total procurement costs for all equipment in the unit, regardless of when it is purchased. However, the user can specify that the unit has “inherited assets” so that not all the TOE requirements have to be filled by new acquisitions. The supporting database does not contain data on assets on-hand in actual units, but the model allows the user to alter the unit’s asset requirements read in from the database. If some cost-driver assets are treated as inherited, the model automatically assumes all non-cost-driver assets are also inherited.

The TAFCS model is supported by factors in the TAFCS Exportable Force Cost Database (EFCDDB), which (as noted in previous sections) contains factors from OSMIS, BLTM, AMCOS, logistics data files, Army Cost Positions for major weapons systems, and budget justifications books. Notably, however, CEAC also tried to develop CERs for operating and support cost items covered by the OMA appropriation. Initially, the analysts regressed dollars per person (actual expenditures for past years) on time, later on force size (average strength). These equations gave an excellent fit until 1991, when the relationships “fell apart” for transport costs, depot maintenance, central supply, and training costs. It appears that there was a significant change in Army funding actions for these activities.

CEAC has attempted to estimate CERs for some support costs but found that Army funding patterns changed radically in 1991.

Continuing TAFCS modeling work will develop a capability to modify the manning or equipping in an SRC and to operate in a batch mode that computes and summarizes costs over all SRCs in a task group. (This capability was found to be desirable in the context
<table>
<thead>
<tr>
<th>Cost Element</th>
<th>Cost ($ Million)</th>
<th>Appropriation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition of resources</td>
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<tr>
<td>Material acquisition</td>
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<tr>
<td>Equipment</td>
<td>163.666</td>
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<td>Aircraft</td>
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<tr>
<td>Missiles</td>
<td>0.775</td>
<td>MSLS</td>
</tr>
<tr>
<td>Weapons and tracked combat vehicles</td>
<td>1.189</td>
<td>WTCV</td>
</tr>
<tr>
<td>Other procurement</td>
<td>7.602</td>
<td></td>
</tr>
<tr>
<td>Tactical and nontactical vehicles</td>
<td>4.688</td>
<td>OPA1</td>
</tr>
<tr>
<td>Telecommunications and other communications</td>
<td>1.757</td>
<td>OPA2</td>
</tr>
<tr>
<td>Other support equipment</td>
<td>1.157</td>
<td>OPA3</td>
</tr>
<tr>
<td>Ammunition items and special weapons</td>
<td>0.000</td>
<td>AMMO</td>
</tr>
<tr>
<td>OMA major end items</td>
<td>0.931</td>
<td>OMA</td>
</tr>
<tr>
<td>Ammunition initial issue</td>
<td>3.449</td>
<td>AMMO</td>
</tr>
<tr>
<td>Organizational CIE</td>
<td>0.626</td>
<td>OMA</td>
</tr>
<tr>
<td>CTA field equipment and medical items</td>
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</tr>
<tr>
<td>PLL/ASL</td>
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</tr>
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<td>PLL</td>
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</tr>
<tr>
<td>OMA funded</td>
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<td>PROC funded</td>
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<td>Class 1, 2, 3, basic load</td>
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<tr>
<td>Replenishment repair parts (wholesale)</td>
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<td>OMA</td>
</tr>
<tr>
<td>Publications</td>
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<td>OMA</td>
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<tr>
<td>Personal acquisition</td>
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</tr>
<tr>
<td>Recruiting</td>
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<td></td>
</tr>
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<td>MPA funded</td>
<td>0.555</td>
<td>MPA</td>
</tr>
<tr>
<td>OMA funded</td>
<td>0.398</td>
<td>OMA</td>
</tr>
<tr>
<td>Training through initial MOS</td>
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<td></td>
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<td>MPA funded</td>
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</tr>
<tr>
<td>OMA funded</td>
<td>0.365</td>
<td>OMA</td>
</tr>
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<td>OMA funded</td>
<td>0.024</td>
<td>AMMO</td>
</tr>
<tr>
<td>Clothing initial issue</td>
<td>0.129</td>
<td>MPA</td>
</tr>
</tbody>
</table>

of costing for Operation Desert Storm.) A transportation module is also under development to compute costs for equipment relocations; the module will require the user to specify the distances involved but will compute costs based on default assumptions about the mode of transport and weight and other relevant data concerning Army equipment.

The TAFCS models represent a major improvement in the ease with which analysts can approximate force-unit costs using current factors. Future enhancements, including some that will prove desirable when the model has been in regular use, will surely make the model more valuable for force-structure costing. However, it should be recognized that the model is designed to estimate cost effects of changes in Army combat force structure, without projecting major changes in supporting system organization or significant changes in personnel management policies. Changes of that kind remain difficult to cost in the Army, as in the other Services.

**Weapon System Costing**

A second category of Army cost models is based upon weapon system costing, which usually costs the entire procured inventory of a specific weapon system and all of its associated costs. We use the recently developed Operational Baseline Cost Estimate (OBCE) System, which provides a comprehensive format for BCE costing, as a representative of the Army's weapon system costing approach.

In addition, we also describe the Modernization, Sustainment, Developmental and Operational Model (MSDOM), which provides resourcing information for POM development pertaining to modernization systems. Unlike the OBCE, this model operates at the level of the individual MACOM and deals only with selected O&M costs. It is of interest here as a potential source of information on potentially authorized, as contrasted with required, resourcing.

**Operational Baseline Cost Estimate System**

OBCE is an automated system developed by Calibre for AMC and is scheduled to support 40 user sites in performing cost analysis for weapons acquisition. The system's objective is to provide AMC headquarters, the major subordinate commands, and program management offices with up-to-date life cycle cost estimates for major weapon systems via personal computers networked through a minicomputer. For our purposes, however, the important features of the
OBCE are its use and formatting of cost data for weapons acquisition studies.

Volume 1 of this report explained the Army's organization of RDA costs into five principal categories: development, production, military construction, fielding, and sustainment. The OBCE can present data in terms of these five categories, an older "Big 3" categorization that fit OSD Cost Analysis Improvement Group (CAIG) guidelines, and certain other formats that are particularly useful for program management activities. However, the most widely used format in acquisition review activities is the "B Matrix" format shown in Table 9.3. The B Matrix organizes costs according to the "Big 5" cost categories listed in the table and the modernization system's Work Breakdown Structure (main components, listed as column headings).

The factor sources and basis of estimation used in BCE/ICE development were cited in the several preceding sections of this report. For present purposes, the following comments are useful for interpreting the information supplied by the B Matrix format:

- The OBCE includes a set of background tables that detail the specific sources and methodologies used to develop all cost elements in the matrix.
- The production category includes items that are supplied as part of the production contract, such as initial repair parts and peculiar or common support equipment, regardless of the appropriation that would fund the same items later in the system's life cycle.
- Costs are included if they are "system-specific." Since military construction is rarely system-specific, BCE/ICE estimates are often zero.
- The distinction between fielding and sustainment costs is virtually the same as a distinction between nonrecurring and recurring operating costs. However, fielding does not include a unit's activation-phase operating costs. Moreover, fielding does not include costs of equipment realignment for displaced equipment in a modernized unit.
- Sustainment includes direct MPA costs, even if the modernization system will be fielded by an existing unit without any changes in

The most widely used OBCE costing format is the "B Matrix" with its Big 5 cost categories: development, production, military construction, fielding, and sustainment.

The distinction between fielding and sustainment is a distinction between nonrecurring and recurring costs—but force-unit activation costs are excluded.

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5Recall (from Secs. V and VI) that the Army is currently revising the appropriations sources for replenishment spare parts (from Procurement to O&M) and modifications installation (from O&M to Procurement). In addition, the Total Package Fielding (TPF, see Sec. V) for a modernization system that has one will also be entirely funded by the Procurement Appropriation. These changes will result in some slight modifications to the Big 5 line items that are not yet reflected in the OBCE format shown here.
<table>
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<th>Development</th>
<th>Sunk (no detail)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development engineering</td>
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</tr>
<tr>
<td>Engineering</td>
<td></td>
</tr>
<tr>
<td>Product engineering and planning (PEP)</td>
<td></td>
</tr>
<tr>
<td>Tooling</td>
<td></td>
</tr>
<tr>
<td>Prototype manufacturing</td>
<td></td>
</tr>
<tr>
<td>Data</td>
<td></td>
</tr>
<tr>
<td>System test and evaluation</td>
<td></td>
</tr>
<tr>
<td>System/project management</td>
<td></td>
</tr>
<tr>
<td>Training, service, and equipping</td>
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<tr>
<td>Facilities</td>
<td></td>
</tr>
<tr>
<td>Other RDT&amp;E fund development</td>
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<td>Sunk (no detail)</td>
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<td>Production</td>
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<td>Nonrecurring production</td>
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<td>Intermediate production facility (IPF)</td>
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<tr>
<td>Production base superintendent (PBS)</td>
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<td>Other nonrecurring production</td>
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<td>Recurring production</td>
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<td>Manufacturing</td>
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<td>System manufacturing/ASB</td>
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<td>warranty</td>
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<td>Recurring engineering</td>
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<tr>
<td>Sustaining tooling</td>
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<td>Quality control</td>
<td></td>
</tr>
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<td>Engineering changes</td>
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<td>Data</td>
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<td>System test and evaluation</td>
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<td>Training, service, and equipping</td>
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<td>Initial spares</td>
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<td>Operating/site activity</td>
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<td>Other procurement fund production</td>
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<td>STS</td>
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<td>Special tools</td>
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<td>ASICE</td>
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<td>Other procurement fund production</td>
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<td>Sunk (no detail)</td>
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<tr>
<td>Military construction</td>
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<td>Test construction</td>
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<td>Production construction</td>
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<td>Oper/site activity construction</td>
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<td>Other Military Construction Army fund construction</td>
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military manpower. For ICEs in particular, the source of the MPA estimates is the AMCOS model.6

- Military manpower for the MPA computation is based on the TOEs for units that will field the modernization system. The analysis allows for the fact that end items procured for maintenance float and war reserves (including POMCUS) will not be fielded in TOE units.

- Since the BCE/ICE approach is TOE-based, it makes no distinctions among Army components, other than with respect to peacetime manning.

Note that the BCE/ICE costing approach excludes force-unit-related costs even if a weapon system is expected to be fielded by a newly activated unit. For example, the military manpower reflected in the BCE/ICE accounts only for the manning related to the system (i.e., for crews and incremental maintenance), not for other unit manpower. The weapon system analysis treats the modernization decision as though it were independent of the unit activation decision. However, the force-unit costs would be recognized in the Army program.

**MSDOM/MRIS Modeling**

As Vol. 1 explained, the Modernization Resource Information Submission (MRIS) is the mechanism by which MACOMs provide HQDA with estimated O&M requirements in connection with major modernization systems to be fielded during the POM years. Initially, MACOMs were required to estimate all such requirements. However, HQDA has now established a “top-down” MRIS model, also known as the Modernization, Sustainment, Developmental and Operational Model (MSDOM).

MSDOM directly estimates selected O&M costs for intensively managed systems. For the fiscal years 1990-94 POM, the “top-down” cost rates covered recurring requirements for repair parts and POL, and one-time transportation and port-handling charges. The model was not used, however, to calculate resource estimates for the flying hour, training development, combat development, or depot maintenance programs.

Functionally, the system calculates O&M requirements at the UIC (Unit Identification Code) and MACOM levels based on equipment

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6The MPA costs from AMCOS exclude O&M expenses for training, base, and medical support operations.
distribution data extracted from the TAEDP. Operating rates are
taken from the AMIM and the Army Guidance and costed (currently) at 94 percent of the stated requirement. CEAC supplies
OSMIS factors for replenishment repair parts and POL; these are
"P2-related sustainment" factors, meaning that they will appear as
sustainment line items in the system MDEP but will appear in the
combat unit’s P2 mission accounts when the system is fielded. Other
factors are supplied by the HQDA Comptroller’s Office.

Other costs for modernization systems are estimated by MACOMs
and described as "MACOM-unique" requirements. Examples are
site activation, military construction, and new-equipment training
support. Costs from MACOM-unique submissions are combined
with TAEDP distribution data, converted to average annual
requirements per system, and included in the MSDOM database.
Since MACOM-unique cost submissions include all modernization
systems, the model’s database includes factors for all AMIM systems,
including systems that are not intensively managed. These factors
can then be used at HQDA to do quick turnaround estimates for
changes in equipment distribution or optempo.

Base Realignment Modeling

Models for costing base realignments received major attention for the
Base Closure Commission and continue to be analyzed by the BRAC
Office. Since closures and realignments came under scrutiny for all
Services simultaneously, the Services now share a basic perspective
on the cost elements to be considered. This is summarized in Table
9.4.

In addition to the listed items, the Army also considers a major real-
alignment’s potential “environmental” effects, including costs for
cleaning up abandoned training sites and programs for communities
adversely affected by the loss of defense jobs.

Of the cost items considered in base realignment studies, several el-
ements were not traditionally subject to regular cost factor develop-
ment: potential costs to non-DoD agencies, homeowner assistance
costs for relocated civilians, environmental costs, costs of caretaker
forces, and the resale value of government property. However, fac-

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7 The 1988 version, however, included only MACOM-level distribution data.
8 These include Standard, Displaced, and Abbreviated Form Systems, and Terminated Systems. Requirements for these systems account for only about 10 percent of the total requirements and are not calculated individually by system.
tors have been developed recently to support analyses by the BRAC office.

<table>
<thead>
<tr>
<th>Cost Sources</th>
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<tbody>
<tr>
<td>Personnel relocation</td>
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<tr>
<td>Military PCS costs</td>
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<td>Civilian PCS costs</td>
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<td>Homeowner compensation</td>
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<td>Equipment transfer</td>
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<td>Freight costs</td>
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<td>Capital investment</td>
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<td>New facilities</td>
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<td>Remodeled facilities</td>
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<td>New equipment suites</td>
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<td>Retirements and compensation</td>
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<td>Military severance pay</td>
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<td>Civilian adjustment allowances</td>
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<td>Early retirement projections</td>
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<td>Caretaker costs</td>
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<td>Increases in non-DoD spending for displaced employees</td>
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<th>Savings Sources</th>
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<tr>
<td>Eliminated positions</td>
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<tr>
<td>Mission and support cost efficiencies (other than manpower)</td>
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<td>Proceeds from sales of excess property</td>
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<tr>
<td>Cost avoidances (cancellations of previously programmed expenditures)</td>
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X. Conclusion

The Army has undertaken a massive revitalization of its costing capabilities. If adequate investment continues, analysts should soon see major improvements in costing capabilities.

Conceptual and methodological issues remain unresolved in all Services. Questions remain about whether cost estimates should be based on requirements or other resource measures, how indirect support should be costed, and how to measure military personnel cost effects when management policies change.

The Army is obviously in the midst of a massive revitalization of its costing capabilities. It is developing supporting databases and models for use by all organizations that participate in all aspects of PPBES and RDA decisionmaking, from HQDA to MACOMs and installations, from POM and budget development to weapons acquisition studies. Although many factors are not yet available, we found no major category of Army expense that is not planned for inclusion in some factor database or model that is expected to become widely available to cost analysts within the next few years. Provided the Army continues its investments in factor development despite overall defense budget cuts, cost analysts should soon observe a marked improvement in Army factor accessibility.

Accordingly, the issue that remains to be addressed is whether the factors under development are of appropriate design and quality for the purposes for which they are intended—or for other purposes for which they might be used. Judgments in this dimension require criteria that remain to be fully articulated in defense costing methodology.

In our analysis to date, we have identified a number of conceptual and methodological issues that remain to be resolved, not only in the Army but in all Services and in OSD. As Sec. IV discussed, the appropriate choice among requirements, authorizations, and actual experience is a matter on which costing policies differ, not only among organizations but among types of decision issues. The linkages between indirect activities (e.g., central supply, training, medical support, base operations) and primary defense outputs are commonly based on assumed relationships that have not been evaluated empirically—and that might change markedly as the Services reorient their force sizes and structure over the next decade. The costing of manpower spaces (in force units or in support of weapon systems) commonly reflects assumptions about personnel accession, promotion, and retention rates that may be violated by changes in personnel management. Even the appropriate definition of the unit of analysis—a force unit or a weapon system, for example—varies from one type of costing exercise to another. Resolving these and other basic costing issues is an essential first step before fundamental judgments can be made about factors in the Army or any other Service.
However, we highlight some considerations that analysts, working in the current costing environment and using familiar methods, should keep in mind when using Army factors:

- Unit modernization is clearly an important aspect of Army capability improvement and has received much attention in cost analyses. However, many cost models do not treat modernization as part of a larger process of equipment realignment and hence may neglect relevant costs, particularly those associated with resource redistribution and disposal.

- Army requirements data are particularly easy to access and use but may differ considerably from typically authorized or actual resourcing and hence may produce misleading cost estimates in some decision contexts.

- There are likely to be differences among Army components with regard to factors that are commonly reported for the Total Army, such as depot maintenance costs. Particular examples are operating rates per weapon system or force unit and fuel usage per mile or hour.

- Army data sources make it very difficult to associate command overhead and supporting unit costs with combat arms units. In some applications, both command and functional linkages are needed to assure that unit changes are fully costed.

- Some important changes in Army accounting procedures are currently under way: Replenishment secondary items that have been funded by procurement appropriations will now be financed through the Army Stock Fund, and depot modification labor will be charged to procurement accounts. These changes will affect cost factor development and interpretation for the next several years, until there is a base of historical data accumulated under the new funding rules.

- Factors for central supply operations (other than the stock fund) are in an especially limited state of development.

- As in all Services, the proper treatment of stock-fund and depot system overhead is questionable. To the extent that such overhead is insensitive to workloads, it is a fixed cost that should not be associated at the margin with force units or weapon systems. However, the costs charged to units for stock-funded items and depot services automatically include overhead costs.

- As in the other Services, the Army attributes many indirect costs solely to military manpower. This is questionable practice because some training and base operating services are provided to civilians, and some medical support is provided to retirees from previous military personnel cohorts. These distinctions are likely
to become more important as changes in Army force size and structure affect the size and mix of personnel inventories.

- The Army Manpower Cost System (AMCOS) for estimating the "life cycle" costs associated with manpower spaces is exceptional in its coverage of personnel-related costs, including recruitment, institutional training, and medical support. The system is also exceptional in that it computes both average and marginal cost rates. However, the system "amortizes" nonrecurring costs by allocating them to man-years based on current retention and separation rates. Consequently, the model is not tailored to evaluating incremental (or decremental) costs if there are substantial changes in personnel management policies.

- The Army has made an important advance in construction costing by developing a database and model (R-PLANS) that relate facility needs to force-unit manning and equipping.
Appendix A
Army Cost Factor Sources

Until the mid-1980s, the Army published general-purpose factor handbooks that became widely known among cost analysts. Cost estimates for selected Tables of Organization and Equipment (TOEs, see Vol. 1) and Division Force Equivalents (DFEs, see Vol. 1) were reported in the U.S. Army Force Planning Cost Handbook (AFPCH), along with per-capita cost factors for estimating Army Military Personnel (MPA) and Operations and Maintenance (OMA) expenditures, and selected factors for weapon system life cycle costing. When the AFPCH was discontinued in 1982, the OMA and MPA factors (but not the life cycle, DFE, or unit costs) were published in the two volumes of the U.S. Army OMA and MPA Cost Factors Handbook. But those volumes have not been updated since 1984. Because these older handbooks are so dated, this report does not examine their factors or methodologies in much detail. However, because the AFPCH is familiar to many cost analysts, this report sometimes uses short descriptions of its contents as points of departure for discussing newer factors and methods.

In contrast, this report provides considerable detail about factor sources that are in current use or development. They include four of the handbooks Major Commands (MACOMs) regularly publish for their own programming/budgeting uses and two major Army initiatives designed to expand the scope and accessibility of general-purpose cost factors. This appendix provides brief overviews of those six general factor sources.

MACOM Factor Handbooks

Among the factor handbooks prepared by Army MACOMs, we examined four that have been commonly used even for centralized costing activities:

- The Resource Factor Handbook (RFH), traditionally produced in two volumes by the Army Forces Command (FORSCOM) and Training and Doctrine Command (TRADOC);
- FORSCOM Pamphlet 11-1, “Base Operation and Unit Cost Factors”;
- FORSCOM Pamphlet 37-1, “Equipment Operating Cost and Usage Factors”;

Resource Factor Handbooks

During the 1980s, Volume 1 of the RFH, “Cost Planning Factors,” was published jointly by TRADOC and FORSCOM. In the April 1988 edition reviewed for this study, the fac-
tors covered military and civilian pay, both forcewide and for FORSCOM and TRADOC specifically. The volume incorporated factors for nonrecurring personnel costs resulting from reduction and realignment actions, such as base closures. In addition, RFH (1) included cost rates for moving passengers and freight, not just for personnel and their households but for such other commodities as explosives.

In March 1989, however, it was determined that RFH (1) was in violation of a regulation requiring a command's publications to be distributed only within the command. The alternatives were to issue the document as an Army pamphlet or to separate the TRADOC and FORSCOM publications and publish only MACOM-specific factors. The latter option was selected initially, and TRADOC published its own version of RFH (1) in September 1989 and July 1990. But in 1990, a general review of TRADOC publications targeted RFH (1) for elimination. TRADOC has proposed that CEAC assume propensity for RFH (1), and that option is currently in review.

The handbook's second volume, RFH (2), is the TRADOC Resource Factor Handbook.¹ That document provides CERs for manpower and nonpersonnel OMA costs for school-based training activities.

**Other MACOM Sources**

The FORSCOM Pamphlet 11-1 referenced in this report is dated 15 September 1989. It presents factors measured in fiscal year 1990 dollars that estimate "recurring costs which vary with changes in workload" based on the actual experience of FORSCOM active component installations. The factors cover:

- Annual direct recurring obligations for TOE divisions and nondivisional units;
- CER parameters, average workloads, and summary factors for nonpersonnel OMA costs of base operations, by installation; and
- Average civilian salaries for base operations personnel, by installation.

An appendix also lists inflation factors.

The FORSCOM Pamphlet 37-1 referenced in this report is dated 1 October 1988 and reports average OMA costs for petroleum, oils, and lubricants (POL) and repair parts at active component installations over a two-year or more period ending in 1988. Equipment is identified by WESDC (Weapons/Equipment System Designator Code), but since those codes are being replaced by End Item Codes (EICs), the pamphlet includes an appendix showing known code crosswalks.

The USAREUR Circular 37-11 referenced in this report applied to fiscal year 1987. It presents general factors and data sources for exchange rates, inflation rates, and present

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¹The point of contact for this volume is Commander, U.S. Army Training and Doctrine Command (ATTN: ATRM-MR (Mr. West), Fort Monroe, VA 23651-5000).
value discounting factors; civilian pay and allowances for overseas hires of U.S. and local nationals; military pay and allowances; engineering and family housing cost factors; logistics costs factors (including direct costs per flying hour, rail cost factors, and POL); and factors for nonpersonnel costs associated with changes in end-strength.

Although the MACOM factor documents cited above include measures of unit and equipment operating costs, those measures will not receive detailed attention in this report. In the past, the major commands have developed operating cost factors using various (and sometimes poorly documented) methods, and the results could not always be reconciled with the “official” operating and support cost factors developed under the OSMIS project described below. The Army is currently trying to coordinate all operations cost sources, so that eventually only the OSMIS factors will be reported. This report will focus on the MACOM cost estimates for elements other than operating costs.

The OSMIS Project

The Army Comptroller’s Office initiated the Operations and Support Cost Management Information System (OSMIS) in 1979. Oversight of the project later passed to the Army Cost and Economic Analysis Center (CEAC), initially working through a contract with Management Consulting and Research, Inc. (MCR). For the last several years, the project has continued under a contract with Calibre Systems, Inc. (a spin-off of MCR), located in Falls Church, Virginia.

One purpose of the project is to satisfy the DoD VAMOSC (Visibility and Management of Operating and Support Costs) Initiative of 1974 (per DoD Directive 7220.33). That initiative called for the Services to use existing databases to accumulate information on the actual operating and support cost experience of individual weapon systems.

In addition, however, the project provides factors for a wide variety of internal Army costing activities. OSMIS factors for fuel and repair and spare parts are used to program and budget the OMA accounts for operations of existing systems, to build the Army flying hour program, to develop cost-per-hour reimbursement rates for Army aircraft, and as a data source for predicting operating costs for new weapon systems.

Since the Army manages items rather than complete systems (see Vol. 1, Sec. II), a major effort in the OSMIS project is the creation of a “definition” for each system. This entails specifying all the parts, components, and system-specific Associated Secondary Items of Equipment (ASI/EOE) necessary to form a complete system configured for combat use. In addition, Calibre has had to create crosswalk tables for the many coding systems used to identify these items in existing Army databases.

Furthermore, the O&5 factors found in the USAEUR circulars are reportedly derived from the FORSCOM estimates from a prior year. Consequently, the USAEUR estimates do not appear to represent an independent data source, nor are they specific to USAEUR operations.
Because these time-consuming efforts must be carried out system by system, the project has expanded its coverage gradually. The first OSMIS report in September 1983 covered just 24 major systems; today, however, the data cover more than 100 aircraft, ground combat, missile, and electronic systems.3

The OSMIS project produces two distinct types of cost measures: annual costs and cost factors. The annual measures are published by CEAC in the OSMIS annual report. Cost factors for programming and budgeting uses are submitted to CEAC in memo format by the OSMIS contractor. Some of the factors, along with special measures developed from the OSMIS database, also appear in the TAPCS database, described below.

**OSMIS Annual Reports.** The OSMIS annual reports are organized by weapon system and each section begins with a set of system identifiers; for example, the identifiers for the M1A1 Abrams tank are:

- Nomenclature: Tank, Main Battle, 120MM;
- Standard Study Number (SSN): G82915;
- Line Item Number (LIN): T13168;
- National Stock Number (NSN): 2350-01-087-1095;
- AMIM4 number: 1518;
- Equipment Identification Code (EIC): AAB; and
- Fuel type: diesel.

This information is followed by a text description of the weapon system. Additional tables list the system's major components by LIN and NSN and the 25 spares and repair parts (by NSN) that have the highest ranking in terms of Army-wide recurring expenditures to support the system. The table of the top 25 spares and repair parts shows their unit prices and their total Army-wide usage in both quantities and costs.

Table A.1 lists the cost measures reported in the OSMIS annual report. These are measures of actual cost experience for a given weapon system in a given fiscal year. In the underlying OSMIS database, the weapon system data are recorded by appropriation and Unit Identification Code (UIC, see Vol. 1), and include systems in Table of Distribution and Allowance (TDA) units and at training bases. The annual report rolls the costs per system up to the MACOM level, with the USAR and ARNG identified separately; a separate table shows the cost elements by appropriation. Both tables also report the number of systems (except in unclassified versions of the annual report), total miles or flying hours, and total armament rounds fired from the system's main gun.

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3Accounting for the number of covered systems is complicated because the major end items under consideration are identified by Line Item Number (LIN) and there can be multiple LINS for a given system. The project will eventually cover approximately 160 systems, or 200 major end-item LINS. This will account for essentially all systems that have substantial costs and are programmed at the LIN level by HQDA.

4Army Modernization Information Memorandum.
### Table A.1

**COST ELEMENTS IN THE FISCAL YEAR 1980 OSMIS ANNUAL REPORT**

<table>
<thead>
<tr>
<th>Initial spares (issues)</th>
<th>POL (consumption)</th>
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<tr>
<td>Initial repair parts</td>
<td>Ammunition/missiles (expenditures)</td>
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<tr>
<td>Obligations</td>
<td>Depot maintenance</td>
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<tr>
<td>Repairable</td>
<td>Obligations</td>
</tr>
<tr>
<td>Consumable</td>
<td>Major items</td>
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<tr>
<td>Expenditures</td>
<td>Secondary items</td>
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<td>Second items</td>
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<td>Consumable</td>
<td>Modifications</td>
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<tr>
<td>Replenishment spares (issue)</td>
<td>Obligations</td>
</tr>
<tr>
<td>Replenishment repair parts</td>
<td>Principal major items</td>
</tr>
<tr>
<td>Obligations</td>
<td>Associated major items</td>
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<tr>
<td>Repairable</td>
<td>Expenditures</td>
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<tr>
<td>Consumable</td>
<td>Principal major items</td>
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<td>Expenditures</td>
<td>Associated major items</td>
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<td>Repairable</td>
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<td>Consumable</td>
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An additional table presents a summary of depot maintenance and modification costs for the system. For each of these costs, the table shows OMA obligations and quantity completed, as well as expenditures for civilian labor, military labor, OMA materiel, procurement-funded materiel, transportation, other, and contract costs.

**OSMIS Factors.** The OSMIS measures annually submitted to CEAC are specifically identified as “factors.” When possible, the factors are developed from detailed analysis of a system’s actual experience over a three-year period. However, for newer systems that lack adequate field histories, the project develops factors based on more traditional methods, such as using engineering estimates to predict fuel usage. And, for systems maintained under Contractor Logistics Support (CLS) contracts, the estimates are actual contract costs.

**OSMIS factors estimate five sustainment cost elements:**

- Replenishment repair parts;
- Replenishment spares;
- Petroleum, oil, and lubricants (POL);
- Ammunition; and
- Depot maintenance.
The first three of these are used in PPBES activities, and the first four are used in life cycle costing. Separate depot factors are prepared for special-purpose analyses and for use in the TAFCS database.

The Army Force Cost System Project

The Force Cost and Economic Analysis Division of CEAC is responsible for maintaining data sources and methodologies for estimating the costs associated with force units. Until recently, the process for costing force units used a wide variety of sources, including the old OMA/MPA handbooks (to estimate the fraction of costs that is variable), budget justifications, MACOM publications (noted above), TOE files from TRADOC, and a CEAC database on procurement costs. The system was only partially automated.

The TAFCS project was undertaken to replace the former system with one that is fully automated, standardized, supported by current data, and more comprehensive in its coverage of force-unit costs. The project is currently being performed by Management Analysis Inc. (MAI) under contract to CEAC.

The Total Army Force Cost System consists of both an "exportable" database and a set of models. The database covers a much wider set of measures than are directly used in the TAFCS models and has been widely available in partial form since its development began. Users include HQDA staff, Army major commands, Army analysis centers and activities, AMC and its major subordinate commands, and program executive offices. A technical manual and data requirements dictionary for the database should become available when the database development is completed in spring 1991.

A portion of the intended family of TAFCS models is currently in user testing. Eventually, the models should estimate the recurring and nonrecurring cost of all TOEs for Army active, Reserve, and Guard units; develop force cost estimates at the brigade, division, and corps levels in support of Army PPBES activities; estimate costs for changes in unit composition (manning and equipping), activations/inactivations, and conversions/movements; and compute and display force costs in various formats, including data by Standard Requirements Code (SRC), force cost element, and appropriation and budget subprogram.

The TAFCS modeling system currently being tested computes the cost of activating, operating, or deactivating a division. However, several of the line items for the nonrecurring costs of activating or deactivating a division currently show zero values because of lack of suitable factors in the TAFCS database. We provide additional information on the current TAFCS modeling capabilities in sec. X.

5The database is in the form of dBase files, compiled using Clipper. At present, the database is distributed by CEAC on high-density diskettes.
Further work on the TAFCS models will develop a capability to modify the manning or equipping in an SRC and to operate in a batch mode that computes and summarizes costs over all SRCS in a task group. (This capability was found to be desirable in the context of costing for Operation Desert Storm.) A transportation module is also under development to compute costs for equipment relocations; the module will require that the user specify the distances involved but will compute costs based on default assumptions about the mode of transport and weight and other relevant data concerning Army equipment.
Appendix B
Army Coding Systems

CODES RELATING TO END ITEMS AND SUPPLIES
(EQUIPMENT, PARTS, COMPONENTS, AMMUNITION,
POL, ETC.)

ABA ( Appropriation and Budget Activity Account Code)—a one-character code assigned to NSNs (see below) to indicate whether an item is funded by OMA or procurement funds, whether it is stock-funded, etc. (See DA Supply Bulletin 700-20.)

BLIN. (See SSN.)

DODAC (DoD Ammunition Code)—an eight-character alphanumeric code that identifies a category of ammunition sufficiently similar in physical characteristics and functional capabilities “to warrant issuance to satisfy the same operational requirements and to be treated collectively in supply operations.” (See DA Supply Bulletin 710-1-1, p. 1-2.)

DODIC (DoD Identification Code)—the first four positions of the DODAC (DoD Ammunition Code) identifying a type of ammunition.

ECC (Equipment Category Code)—a two-position descriptor of a broad materiel family.

EIC (End Item Code)—a three-position code with a unique crosswalk to NSNs. The first position identifies a commodity group (e.g., aircraft, combat vehicles), the second position identifies the equipment family, and the third position completes the reference to a specific NSN.

EOR (Element of Resource)—a code that classifies a type of service or goods according to the type of resource dollars, manpower, or materiel.

FAC (Facility Code)—a two-position alphanumeric code used in DESCOM’s Master File Maintenance (MFM) to identify individual depot maintenance installations/activities.

FIA (Financial Inventory Accounting) code—a code used in the Army Provisioning Master Record files maintained by Major Subordinate Commands of AMC. (See MATCAT.)

LCC (Logistics Control Code)—a one-position alpha code used for making logistics support decisions (e.g., overhaul, distribution) for an item.

LIN (Line Item Number)—a six-character alphanumeric code used to identify equipment of interest in Army property books and authorization documents; LINs represent items sufficiently similar “to warrant issuance to satisfy the same operational requirements and to be treated collectively in supply operations.” (See DA Supply Bulletin 710-1-1, p. 1-2.) (See also PLIN, ZLIN.)

LOCCD (Location Identifier)—a 12-position alphanumeric code used to identify equipment of interest—and its location—in Army property books and authorization documents. In general LINs are assigned to pieces of equipment that appear in authorization tables. The first two positions in the LOCCD code uniquely identify the major installation at which the LIN-coded item is located.
MATCAT (Material Category Code or Materiel Category Structure Code)—a five-digit code found in the Army Master Data File (AMDF). The first digit indicates the major subordinate command responsible for the item. The second indicates the appropriation or budget activity account (which distinguishes, for example, between procurement and stock-funded items). The third digit is for inventory management. The remaining two digits associate the item with a major end item. NOTE: The MATCAT is also known as the FIA or Financial Inventory Accounting code in Provisioning Master Record (PMR) files.

MDS (Mission Design Series)—a ten-character alphanumeric code that identifies weapon/material systems by model/series within mission type (e.g., UH-60A, M60A3 tank).

NIIN (National Item Identification Number). (See NSN.)

NSN (National Stock Number)—a unique 13-position numeric code, consisting of the four-digit federal supply classification code and nine-digit serial number, that identifies end items at the type/model/series level. Also referred to as the National Item Identification Number (NIIN).

PCC (Provisioning Control Code). (See Use On Code.)

PCCN (Provisioning Contract Control Number)—a six-position code that originally indicated a specific contract but now designates a group of end items (e.g., all Blackhaws). The first place identifies the MSC (AMCCOM, TACOM, MICOM, CECOM, AVSCOM, or TROSCOM) having responsibility for the contract items. The second position is usually year of contract award. The remaining four positions are alphanumeric and can be structured in whatever manner the MSC deems appropriate.

PID (Part Identifier)—a 15-position alphanumeric code. The part may be identified by an NSN (so the last two PID positions are blank) or by a part number (P/N) having 6 to 15 characters.

PLIN (Primary Line Item Number)—a particular LIN designated to identify a major end item.

PLISN (Provisioning Line Item Sequence Number)—a four- to six-position alphanumeric code that, within a PCCN, indicates different model configurations.

PNSN (Primary National Stock Number)—a particular NSN designated to identify a major end item.

RICC (Reportable Item Control Code)—a one-digit numeric code assigned to items for which asset reporting is required by AR 710-3 and AR 220-1.

RC (Resource Code)—Army codes corresponding to the OSD Resource Identification Codes (RICs), used to identify appropriations, forces, and types of manpower.

Supply Category of Material code. (See Sec. III.)

SSN (Standard Study Number)—an 11-character code used to indicate either a single LIN or DODAC or a group of LIN/DODACs. SSN provides a means of grouping related equipment and ammunition at various levels of aggregation for analysis purposes. For example, the first six positions are known as the BLIN, which is used in ASA (RDA) management, and the full element positions are associated with a specific LIN. The SSN file system contains cross-reference data (SSN to LIN, LIN to SSN, etc.) and factors such as maintenance float, replacement, pipeline, and ammunition rates per AR 710-60.

Use On Code (or Usable On Code)—identifies the model or end item within a PCCN group on which a particular part and application appears (i.e., to which a particular PLISN applies).
W/ESDC (Weapon/Equipment System Designator Code)—a code now largely replaced by the EIC.

W/SS (Weapon/Support System) Identification Code—a three-digit code used in depot maintenance reporting for the type of end item. For example, the codes for aircraft indicate fighters, bombers, cargo/transport, trainers, utility. Other major categories are automotive equipment, combat vehicles, construction equipment, electronics and communication equipment, missile systems, ships, munitions armament, weapons armament, rail equipment, general equipment, and "commodity groups." (See also WBS, below.)

ZLIN—a provisional LIN established for new items of equipment that are not yet type-classified. A ZLIN has an associated SSN.

CODES RELATING TO UNITS OF ORGANIZATION, LOCATIONS, ASSOCIATED AUTHORIZATION DOCUMENTS, ETC.

APE (Army Program Element)—a six-character code identifying organizational entities and resources needed to perform assigned missions within an Army Program. The APE comprises the first six positions of the Army Management Structure Code (AMSCO). (In the PROBE database, there are ten positions available for this code, but only the first six are currently used.)

AMSCO (Army Management Structure Code). (See APE.)

CCNUM (Command Control Number) identifies an MTOE document.

CMD (Command Code)—a two-character code in the PROBE database that designates the operating agency that expends the resources for a particular mission and /or acquisition.

LOCCD (Location Identifier). (See the preceding subsection.)

MTDA Number—an eight-position alphanumeric code used to identify the specific document under which a TDA unit is organized. The MTDA number comprises the command code, which identifies the subcommand to which the TDA unit is assigned, followed by the UIC organized according to that MTDA document. Only TDA units have a numeric character in the second position of the UIC.

MTOE Number—a 14-position alphanumeric code used to identify the specific authorization document pertaining to a given unit. Multiple units organized by the same MTOE document will have identical MTOE numbers.

SRC (Standard Requirements Code)—a six-position (five numbers and a letter) code used to identify a TOE.

TPSN (Troop Program Sequence Number)—A five-position code in the Green Book (Troop List) used to identify units in a division, separate brigade, or regiment. These codes can help identify command linkages among units.

UIC (Unit Identification Code)—a six-position alphanumeric code used to identify an Army unit. Generally based at the battalion level of organization, no two unique Army units have the same UIC. (The Force Accounting System Handbook contains instructions on how to interpret UIC codes. A particular code can, for example, refer to POMCUS.)
OTHER CODES

BA (Budget Activity)—a three-character code representing the first major subdivision of an appropriation in the President's Budget. In MPA and OMA appropriations, budget activities are the same as FYDP programs.

WBS (Work Breakdown Structure)—identifies major category and component of equipment, used in depot maintenance job coding and in BCE formats. (See Sec. IX.)
Appendix C
Army Manpower Cost System (AMCOS) Models

This appendix provides additional details about the models in the Army Manpower Cost System described in Sec. VII.

The AMCOS Active Component Model

The active component model has a policy module for each of the following cost elements:

- Military compensation (basic pay and allowances);
- Special pays;
- Enlisted recruiting;
- Training;
- Officer acquisition;
- Reenlistment bonuses;
- Retirement costs;
- Miscellaneous costs and benefits; and
- Educational benefits.

In addition to the Army costs listed above, AMCOS estimates costs of the New GI Bill educational benefit that are paid by the Veterans Administration.

Some of the Army costs appear in the underlying database as annual cost rates but others appear as daily rates, pertain only to selected personnel, or are nonrecurring costs. The policy modules convert daily rates to annual values, selective amounts to expected values per man-year, and nonrecurring costs to amortized rates. Cost output is reported by officer, warrant officer, and enlisted grade; occupation (Military Occupational Specialty for enlisted personnel); and appropriation.

Principal data sources for the active component model include the latest issue of the Department of Defense Manpower Requirements Report, Joint Uniform Military Pay System (JUMPS) files, DoD actuary tables, Military Personnel Center Force Management Books, President's Budget Justification Books, the TRADOC ATRM-159 report, and special information requests from the Army Office of the Surgeon General. In the policy modules, personnel data are broken down whenever possible by years of service (YOS) as well as grade and occupation.

*Military compensation* is an MPA cost, and includes:
• Basic pay. Marginal cost equals average cost.

• Housing cost. The average is computed as the sum of average BAQ and average VHA (weighted over locations); in this calculation, the BAQ rate is used as a surrogate for the costs of quarters-in-kind recipients. Marginal costs use the maximum VHA rate; the model assumes that all base housing is filled and marginal personnel would require VHA and uses the maximum VHA rate rather than an expected value over locations.

• Subsistence, computed as the average BAS rate, where the BAS rate is used as a surrogate for the costs of subsistence-in-kind. Values are computed first on a YOS-specific basis within each grade, then the grade factor is the weighted average of the YOS values. Marginal costs equal average costs.

• Retirement pay accrual, a fixed percentage of basic pay. The percentage is obtained from the DoD Actuary. Logically, the marginal cost is assumed to equal the average.

Selective Reenlistment Bonuses (SRBs) differ among enlisted occupations but are usually paid as a lump sum at time of reenlistment plus annual installment. The model calculates a discounted present value of the payments for each bonus level and weights by the probabilities individuals in various grades and MOSs will receive the bonuses. The average cost is the expected bonus present value, but the marginal cost is designed to include "inframarginal rents"—i.e., the total amount of additional bonus costs incurred when bonuses must be raised to obtain the marginal reenlistment.¹ Since SRB expected present values are "one-time" costs, the model amortizes them, but the methodology is not clear from the model documentation.²

Special pay includes all special and hazardous duty pay, overseas pay, and family separation allowances. The estimates are expected values, based on average amounts paid per recipient and the percentage of total Army personnel who are recipients; however, hazardous duty pay is calculated on an MOS-specific basis. Marginal costs are assumed to equal average costs, except the AMCOS user can apply zero to special pay known to be irrelevant to a case under consideration.

Together, training and officer acquisition include costs for all types of individual training and are based on the ATRM-159 reports³ for TRADOC schools and Army Health Services Command data for medical courses.⁴ These costs are covered by several appropriations: MPA for pay and allowances of students and instructors and for student relocation costs; OMA for costs of training operations; procurement for training ammunition; Family Housing Maintenance, Army (FHMA), for family housing maintenance.

¹The model documentation is very unclear about how this is computed, however, saying both that a supply elasticity "will be" obtained from the literature—and that the marginal cost was set equal to the SRB ceiling of $20,000. Using the ceiling does not follow from the inframarginal rent theory, and no explanation for its use was given.

²According to the documentation on the Reserve model, the first step in amortization is to divide the bonus-expected present value (average or marginal) by the number of man-years expected from the bonus. However, we found the remainder of the discussion concerning how this is allocated to grades confusing.

³Note that the training cost factors include the ATRM-159 estimated shares of base operating, medical, and other support costs at training installations.

⁴Although the AMCOS database does not retain detailed costs for courses that are not directly related to specific MOSes (such as airborne and ranger courses). It appears to allocate an average cost per student in these courses among military paygrades.
Skill training is targeted on particular enlisted skill levels, and AMCOS interprets them in terms of grades: skill level 1 courses are assigned to grades 1 through 3, and courses at skill levels 2 through 5 are assigned to grades 5 through 8, respectively. The model assumes that no skill training occurs after grade 8. Similarly, professional and career training for officers is reflected in grades 5 through 9.

For enlisted training, marginal costs are assumed to equal average costs. For officers, marginal cost is the cost of acquiring an officer from Officer Candidate School, acknowledging the fact that the Army relies primarily on OCS graduates to meet increased officer demands during periods of expansion.

Training and officer acquisition costs are both one-time costs that are amortized in the AMCOS model. The amortization method is not explained in the active component model documentation, and the explanation in the Reserve model documentation is incomplete.

Recruiting includes the costs of: recruiters, enlistment bonuses, and education benefits; the Army’s share of joint-Service advertising, marketing research, etc.; and examining, accession travel, and processing operations. Costs vary by MOS partly because bonuses differ by military occupation and partly because the model assumes that some costs differ between high- and low-quality recruits, the mix of which differs among occupations.

Average cost for low-quality recruits in all MOSs is assumed to equal processing costs (i.e., examining costs, U.S. Army Recruiting Command (USAREC) operations cost, accession travel costs, and the cost of recruiters’ time).

However, other research has shown that recruiter time increases with the number of high-quality recruits, and is four to eight times higher for the marginal high-quality recruit than for a low-quality recruit. Since AMCOS has access only to the total recruiter cost and the numbers of high- and low-quality recruits, some method must be found to estimate the average costs for high-quality recruits.

The model assumes that low-quality recruits and half of all high-quality recruits require the same per-capita amount of recruiter time, and that recruiter time then increases linearly until, for the last high-quality recruit, it is six times the minimum. These assumptions are sufficient to translate the available cost and quantity data into estimates of the average recruiter cost per low-quality recruit (reported as $1,080 in the 1989 documentation) and per high-quality recruit ($2,360).

The marginal values are easily calculated from the average and the foregoing assumptions: The marginal recruiter cost for low-quality recruits is, by assumption, equal to the average ($1,050), and the recruiter cost for the marginal high-quality recruit is, again by assumption, six times that ($6,300).

The recruiter cost is simply added to per-capita examining costs, USAREC recruiter costs, and accession travel costs to obtain the average (and marginal) cost per low-quality recruit. For high-quality recruits, however, the processing cost (which has distinct marginal and average values) captures only part of the recruiting cost; advertising and special incentives costs are added in for them:
• Advertising costs are added at a simple per-capita rate based on the ratio of annual spending to high-quality accessions. This treatment is questionable for two reasons. One is that advertising costs in any one year can influence accessions in other years. The other is that previous research (see Polich et al., 1986) suggests that marginal advertising costs increase with the number of high-quality recruits.

• Enlistment bonuses and educational benefits (based on an expected cost computed by the DoD actuary) are included using a methodology recognizing that both incentives vary by term of service. In this case, the marginal and average costs differ because of the inframarginal rents (computed using the same methodology as for reenlistment bonuses). As in the reenlistment bonus case, no source is cited for the elasticity parameter required by the method.

Since they are one-time costs, recruiting costs are amortized in the model. The amortization method is not described in the active component model documentation, but the Reserve model document indicates that nonprior-service (NPS) recruiting costs are amortized by dividing the average or marginal cost by the weighted average of expected man-years at grades E-1 through E-3; this is done separately for high-quality and low-quality recruits, with and without bonuses. This seems to imply that the costs are allocated only to man-years in grades E-1 through E-3.

Medical support estimates include reimbursement expenditures under the Civilian Health and Medical Program for the Uniformed Services (CHAMPUS) and costs of care provided by the military hospital system.

Total CHAMPUS costs are divided by total beneficiaries to obtain an average cost per user. This is multiplied by the average numbers of dependents per active force member in each paygrade and by the probability a family member will receive CHAMPUS benefits. The probability is estimated by the ratio of total beneficiaries to total active component dependents. The CHAMPUS estimate is reported separately by the model although the costs are covered by the OMA appropriation.

For care provided by the MTF system, costs for facilities and the pay of medical personnel are excluded. This is appropriate under the assumption that the “sizing” of the medical care system is based on wartime needs rather than peacetime demands for services. All other medical support costs are averaged over the total number of active duty personnel and their dependents; this average cost is assumed to equal marginal cost.

None of the military health system costs are attributed to retirees and their dependents. This probably implies an overestimate of medical costs in the AMCOS model.

Permanent Change of Station (PCS) costs are budgeted in five categories of moves: rotational (to and from overseas assignments), operational (moves to entire units and reassignments among units), accession, training (to and from training bases), and separation. AMCOS calculates average cost rates for all types of moves but includes the training rate in the training cost estimates, the accession rate in the recruiting cost estimates, and the separation rate in the “other benefits” estimates. In all cases, marginal costs are assumed to equal average costs.
For accession, training, and separation moves, the model uses a weighted average cost provided by ODCSPIER, and adjusts the averages for differences in freight weight allowances across MOSs and grades.

For the operational and rotational moves, the model performs a complex calculation that takes account of weight allowances. Once the average cost per move is estimated, the model uses numbers of overseas assignments and overseas tour lengths to estimate the average number of rotational moves per year, by MOS. The documentation claims that the number of operational moves is estimated "as a residual, after moves out of CONUS fill the empty overseas positions and separations are accounted for," but we found it difficult to interpret the equations relating to this computation. In any case, the result is an estimate that is not a simple per-capita cost for a particular budget year.

Finally, other benefits are computed as follows.\(^5\)

- The total costs of death gratuities, apprehension of deserters, and unemployment compensation are divided by the total number of soldiers to obtain an average cost applied to all soldiers.
- Terminal leave pay (for unused leave at time of separation) is computed as the product of leave months accrued in each pay grade, base pay in that grade, and the probability of separation. The expected values of severance pay and separation travel costs are estimated by allocating the total costs to grades according to the grade distribution of terminal leave payments and dividing by the grade strengths shown in the President's Budget. Terminal leave pay, severance pay, and separation travel costs are combined in a grade-specific "separation pay" factor.
- Clothing allowances are paid at varying rates throughout each enlistment. The model uses rates from the Army's budget justification books, weighting the values across sex.
- The Social Security tax paid by the DoD is computed as 7.65 percent of base pay for fiscal years 1990 and thereafter.
- Survivors benefits are averaged over all Service members. So are MWR benefits costs from the Army budget justification books. The marginal costs of all "other benefits" are assumed equal to the average cost estimates.

The Reserve Component AMCOS Model

The Reserve component model treats both USAR and ARNG personnel but does not distinguish between their costs. The principal data sources are the Reserve Component Common Personnel Data System (RCCPDS\(^6\)); Reserve Component Budget Justification Books; military pay and al-

\(^5\)Note that the AMCOS documentation lists family separation allowances under both military compensation and other benefits. It is not clear whether this is a misprint or whether the same allowances were counted twice. Moreover, AMCOS documentation indicates that the total Army cost for family separation pay is divided by total grade strength—which should yield an appropriate expected value—and is also multiplied by a probability of separation. Since the latter multiplication is inappropriate, either the estimate or the documentation may be in error.

\(^6\)The RCCPDS is a DoD-wide data file maintained by the Defense Manpower Data Center in Monterey, California. Users of this file, including the authors, have found that it contains numerous missing values and apparent data errors (because of the poor quality of data submitted by the Services). Although data quality has improved over time, certain
lowance tables and Reserve component bonus data; and the active component AMCOS model for data common across components (such as training costs).

The Reserve model is similar in structure and estimation methodology to the active component model. The salient differences are:

- Although Reserve personnel receive the same basic pay rates as active component personnel, Reservists do not work full-time throughout the year. The AMCOS model transforms the basic pay table into pay per drill or training day, by YOS and grade, then computes annual compensation based on drills and training days.
- Reserve military compensation does not include VHA because Reserves are eligible for it only if on duty over 140 days.
- In estimating the marginal costs for reenlistment bonuses, the model uses a supply elasticity of 0.2, reportedly taken from published (but uncited) literature. Although the model includes Reserve reenlistment bonuses, it does not deal with bonuses some states pay to Guardsmen.
- Reserves receive special pay only when on Active Duty Training (ADT) and at a daily rate (1/360 of the active rate).
- The Reserve model handles recruiting costs for nonprior-service (NPS) recruits analogously to the active component model but also deals with recruiting-related costs for prior-service (PS) recruits. AMCOS assumes that PS recruits with a remaining military obligation generate no processing costs but must be attracted by bonuses, advertising, and recruiter activities; however, the model assumes that those without a remaining obligation are not actively sought out but do generate recruiter and processing costs. In addition, the model includes the expected present value of costs for the PS "affiliation" bonus (for individuals who enter the Reserves with an unexpired obligation). Finally, the Reserve model adjusts the average cost of recruiting for first-year attrition, which differs by recruit quality.\(^7\)
- Officer acquisition costs are calculated the same way as in the active component model, except the costs are assumed to be zero for PS officer accessions. This reduces the overall average cost per officer accession. The marginal cost, which assumes the marginal officer is obtained through OCS, is unaffected by PS acquisition.
- The training costs for Reserve personnel include only costs incurred during Reserve service, not any training obtained during prior active component service. The training courses pertinent to the Reserves are initial active duty training (OSUT) (or a combination of basic military and initial skill courses), career training (advanced skill training), prior-service (refresher and new skill) training, undergraduate and graduate flight training, and professional training. Average costs per course are taken from the active component AMCOS model but are multiplied by the Reserve probability of taking the course to obtain an expected value. Marginal costs equal average costs, except OSUT is assumed not to be available to the marginal recruit.
- The Reserve model allows users to change training days requirements.

\(^7\)The Reserve model amortizes recruiting costs for both NPS and PS personnel. The documentation is unclear about precisely how the costs are distributed across grades, but it appears that the distribution varies by MOS.
• CHAMPUS costs per man-year are taken directly from the active component model. (AMCOS developers argue that the small size of these costs does not warrant a separate estimate for the Reserves.)

• The G.I. Bill cost estimates include the expected present value of costs for the “2x4” program that applies to active component members who complete their obligations in the Reserves.

• The Reserve model also treats specialized costs not covered by the active component model—Student Loan Repayment Program, Health Professions Stipend, etc.

AMCOS Civilian Model

The AMCOS civilian model functions like the active and Reserve component models but differs because of substantial differences between military and civilian personnel management. The description given below is based on documentation prepared in advance of the model that has actually been distributed; although it may differ from that model in some respects, it indicates the intentions of the model's designers.

Among the explicit purposes of the civilian model is to support costing for “A-76” studies. The title refers to Office of Management and Budget Circular A-76, which specifies procedures for evaluating choices between commercial services and civil service performance of functions. The Army has used the Commercial Activities System (CAS) to generate civilian personnel costs for A-76 studies, but AMCOS provides cost estimates by occupation and grade that are aggregated in the CAS.

The initial civilian model is limited to U.S. direct hire civilians. Other civilians (foreign nationals, indirect hires, NAFI employees, and Military Technicians) might be addressed “as resources permit.” The initial model also is limited to the principal pay schedules—GS-GM, SESAME, and wage board workers—that account for 98 percent of the direct hires population.\(^8\) Permanent and temporary and part-time and full-time workers are included.

GS workers are disaggregated by 155 occupations as well as grade. This acknowledges the concentration of special pay and allowances in specific occupations and differences in their distributions of personnel among pay steps. This initial model assumes that the step distributions reflect an underlying occupational characteristic (i.e., are not the result of transitory phenomena) and remain constant over time. This implies that expansion in a grade’s workforce takes place through hiring at all steps in proportion to their current distribution, rather than promotions from lower steps (or grades), and hence affects estimation of marginal civilian costs. However, the model designers proposed to test this assumption.

Blue-collar workers are not disaggregated by occupation but by location—the 155 wage areas used in wage board schedules. Years of service, which are highly correlated with grade in the civilian workforce, are not used in the model.

\(^8\)Over 70 percent of all direct hires are GS, and close to 20 percent are WG workers.
As proposed, the initial model would cover just five civilian cost elements: basic salary, premium pay, retirement benefits, insurance plans, and other benefits. Since these are all recurring costs, the current version of the model does not require amortization. However, other costs that might later be added to the model are for training, bonus and incentive pay, relocation (PCS) costs, and recruiting and hiring costs—and some of these are one-time costs that would presumably be amortized.

For GS workers, base pay (by occupation) is computed from a current civilian pay table and historical estimates (based on Defense Manpower Data Center files) of the step distributions within grades. There are no steps in the GM system, but model designers proposed to compute a factor analogous to a step distribution factor that would translate any current GM pay schedule into expected average wages within grades. SES salaries are computed as a weighted average of the six SES pay levels.

For blue-collar workers, the model has a default for the national average wage per grade. Otherwise, the user can select any of 135 wage areas specific to a costing case under consideration.

Premium pay is calculated using the scheduled base pay differential (e.g., white-collar overtime is paid at 150 percent of hourly base pay) and a rate of recipiency. A default value for the recipiency rate is (at least initially) just the per-capita figures for white- or blue-collar workers, estimated from Finance and Accounting Office data. Since A-76 studies allow specific pay to be included only if it is actually used, the AMCOS model allows the user to replace the default values with zero or other values as desired.9 The model also automatically accounts for whether a particular type of premium pay is or is not included in fringe benefit calculations.

Fringes are calculated on administratively controlled overtime, stand-by pay, and pay for hardship/hazardous duty for white-collar workers. Fringes are calculated on night-shift and environment differentials for blue-collar workers.

Average retirement costs are a weighted average of CSRS and FERS (including Social Security) costs, but the proportions of employees under the two systems would be a user-defined parameter (not estimated by the model).10 Marginal costs uses on the FERS figures since new employees are not eligible for CSRS. The model computes both costs to the Army and total cost to the government (including amounts charged to the Office of Personnel Management).

Since life insurance plan participation is reported on Defense Manpower Data Center civilian personnel files, the model can compute occupation- and grade-specific estimates of the Army’s expected cost per employee.11 However, available data permit only a single government-wise average cost for health insurance contributions.

9For example, remote duty pay would not be applicable in CONUS locations.
10Temporary workers are covered solely by Social Security, and the Army contributes 7.51 percent of their salary to cover both retirement and Medicare.
11The cost rate is currently $2.41 per year per thousand dollars of salary.
Other benefits estimated by the model are life and health insurance benefits for personnel who retire with annuities, injury and disability payments, unemployment benefits, and severance pay costs. Estimation methods and data sources were not firm at the time of documentation.
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