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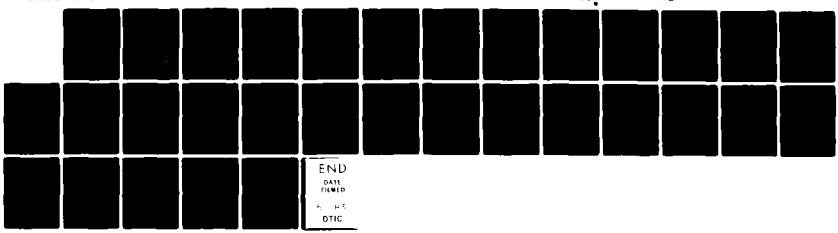

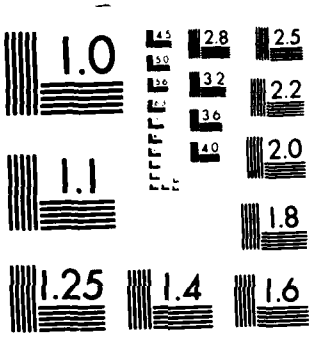

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COST ESTIMATING RELATIONSHIPS FOR REAL PROPERTY MAINTENANCE ACTIVITY AT ARMY INSTALLATIONS

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EXECUTIVE SUMMARY

Real Property Maintenance Activity (RPMA) provides for the utility services, maintenance of real property, minor construction and other engineering services at defense installations. In the Army RPMA is big business with big costs -- $3.2 billion worldwide and $1.8 billion in CONUS in FY81.

RPMA costs are driven mainly by the population served by an installation, with physical size, location, extent to which the population is resident, and primary mission also playing significant roles. Relatively simple cost-estimating relationships based on those factors are capable of explaining most of the variation in RPMA costs.

Pronounced and persistent "economies of scale" exist within Army RPMA costs. Consequently fewer resources and costs are incurred to accomplish RPMA at a large installation than at several smaller facilities serving the same total population. RPMA savings can therefore be expected from realignment of activities from small to large installations, closure of small installations, or consolidation of RPMA among separate nearby installations. The cost impacts of such changes can be estimated using cost-estimating relationships and factors based on the very detailed RPMA cost data which the Army collects at all CONUS installations. The same cost relationships can be used as planning and budgeting tools for estimating RPMA cost impacts of changes to installation populations.

Extension of the method to other DoD components using existing RPMA cost reporting systems appears possible and beneficial.

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1. INTRODUCTION

Base Operating Support (BOS) is a conglomeration of many activities necessary to operate and maintain an installation. Included are activities which are necessary for, but which do not contribute directly to, accomplishment of the mission of military units located at DoD installations. Facility services, called Real Property Maintenance Activities (RPMA), represent about half the total BOS costs. RPMA is comparable to indirect overhead activities such as heating, utility services, building maintenance, and custodial services in the private sector.

This investigation deals with Army RPMA, primarily because the Office of the Chief of Engineers was readily able to supply cost and activity data in the various levels of detail and aggregation needed for the study.

Army's RPMA cost accounts recognize four major activities: operation of utilities; maintenance and repair of real property; minor construction; and engineering support (including fire protection, refuse handling and custodial services).

In FY81, the Army incurred $3.2 billion to accomplish RPMA activities worldwide, $1.83 billion of which was spent by the Army for active installations within CONUS. Table 1-1 shows costs incurred for each of these major RPMA activities.

Managing RPMA within the DoD is difficult because few clear standards or self-correcting mechanisms exist to ensure efficient performance. Market forces present in similar type civilian activities are generally absent within the DoD. An exception occurs for RPMA activities subject to competition through outside contracting. However, measures of performance or productivity

TABLE 1-1. FY81 RPMA COSTS BY ACTIVITY: ARMY-CONUS

Activity	Cost ($ Million)	Percentage of Total
Operation of Utilities	$ 657	36%
Maintenance of Real Property	693	38%
Minor Construction	74	4%
Engineering Support	404	22%
Total RPMA, Active Installations	$1,828	100%

Source: Annual Summary of Operations, Fiscal Year 1981, Facilities Engineering (Office of the Chief of Engineers).

are ambiguous because quality of performance is difficult to measure and because today's performance typically gives rise to impacts measurable only in the future. DoD's installations are geographically, organizationally and functionally diverse, which makes comparison of seemingly similar activities and their associated costs difficult.

To support DoD's efforts to ensure efficient performance of RPMA, this study was undertaken to develop simple macro tools to assist in budgeting, planning and control of RPMA. Analysis was confined to active Army installations located in CONUS. Existing data and information systems were employed. Our principal findings are:

1. Highly aggregated and relatively straightforward relationships can accurately explain actual RPMA costs incurred by Army installations. Explanation of RPMA costs depends principally on total and resident populations served, installation size, primary mission, and location.

2. Additional relationships can explain specific RPMA cost categories (e.g., building maintenance, utility costs) but little, if any, accuracy or reliability is gained as more disaggregated cost categories are considered.

3. Pronounced and persistent "economies of scale" exist for all RPMA functions, no matter what level of detail or aggregation is considered. This implies that fewer resources are used to accomplish RPMA at a large installation than at several smaller facilities serving the same total population. Realignments and

consolidations, where possible, would allow the DoD to take advantage of economies of scale and thus should be expected to offer cost savings.

4. Cost comparisons for RPMA functions conducted across installations reflect the effects of size, mission, location and, where appropriate, other factors such as the mix of building types and resident population.

5. Potential gross savings from consolidation of RPMA functions can be estimated using incremental cost factors developed in this analysis. Such estimates represent gross savings before consideration of added costs or changes in quality of service which might be specific to each situation.

As a result of these findings, we offer the following recommendations for use of RPMA cost-estimating relationships and data systems to support future analyses.

1. Army aggregate RPMA cost-estimating relationships developed herein should be used to assist command and OSD-level management evaluations of proposed changes in force structure and activity levels.

2. The cost-estimating relationships should be used as management tools to estimate cost impacts of personnel realigments, base closures and RPMA consolidations. (Illustrations are contained in Chapter 3.)

3. Performance evaluations of installations should be conducted using cost-estimating relationships that adjust costs for mission, location and scale effects. Caution is advised since quality aspects of service provided is not captured in cost figures.

4. Reporting of RPMA data for purposes of developing management tools should be confined to aggregated cost categories. Current RPMA reporting in Army is far too detailed for use by top-level management.

5. Analysis similar to that performed in this study should be extended to other DoD components.

The balance of this report describes the data, methods, and results found for a sample of 96 Army installations in FY81 (Chapter 2) and presents illustrative applications of the findings to management of RPMA (Chapter 3). Appendix A describes the data used, and Appendix B lists incremental cost

factors that can be used to assess cost impacts of installation realignments, closures, and consolidations.

2. METHODOLOGY AND RESULTS

DATA EMPLOYED

RPMA costs are incurred in support of mission functions and population served. What was not known is how RPMA costs are impacted as mission, population, location and installation physical characteristics change. Specifically, we sought to identify factors which drive RPMA costs and, as a consequence, determine whether costs respond more, less, or in proportion to changes in these factors. If such analysis is successful, total costs can be predicted with reasonable accuracy and the potential for gains in efficiency through population realignments and consolidations can be estimated.

With this in mind, RPMA cost data for each of 96 active Army installations in CONUS for FY81 were analyzed.[1] Specifically, RPMA costs were subdivided into 15 detailed cost categories based on the nature of the activity involved and the importance of the category in overall RPMA cost. Table 2-1 lists the most detailed level of disaggregated costs categories considered.[2]

Analysis of the RPMA cost categories listed in Table 2-1 was conducted in terms of factors anticipated to explain observed differences among the 96 CONUS installations. Factors representing installation location, command, primary mission, and activity drivers (such as total and resident population, building space and base acreage) were identified as potential explanatory variables. Location, command and mission were introduced as discrete "dummy"

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[1] Cost and activity data were taken from Annual Summary of Operations, Fiscal Year 1981 Facilities Engineering, Department of the Army, Office of the Chief of Engineers, Washington, D.C.

[2] Eventually it proved possible to combine subcategories of costs into more aggregated categories without loss of accuracy, statistical significance or consistency of results.

TABLE 2-1. RPMA COST CATEGORIES CONSIDERED

J. Operation of Utilities:

- Water Services
- Sewer Services
- Other
- Electric Services
- Heating

K. Maintenance of Real Property:

- Water System
- Sewer System
- Other Utility Systems
- Electric System
- Heating System
- Buildings
- Other Maintenance

L. Minor Construction

M. Engineering Support:

- Management and Engineering Support
- Other Engineering Support

Note: Letter designations refer to Army cost accounting codes.

variables. Continuous explanatory variables such as total population and resident population were used in such a way as to avoid obvious statistical intercorrelation -- large installations have high values for both total and resident population and small installations have low values for both. Intercorrelation was avoided by introducing, for example, total population and the percentage of the total that are resident. Similar constructs were used for other interrelated variables such as population and square footage of buildings. Table 2-2 lists the explanatory factors examined in developing RPMA cost relationships for Army installations.

TABLE 2-2. EXPLANATORY FACTORS FOR RPMA COSTS

1. Location (5 climatic zones based on heating and cooling degree days)

2. Command

    a. Forces
    b. Training and Doctrine
    c. Material Development and Readiness
    d. Army Communications
    e. Health Services
    f. Intelligence and Security
    g. Military Traffic Management
    h. All Others

3. Primary Mission

    a. General Purpose
    b. Sealift/Airlift
    c. Communications and Control
    d. Research and Development
    e. Mission Support
    f. Central Support and Maintenance
    g. Training, Medical and Administrative
    h. Guard and Reserve

4. Activity Cost Drivers

    a. Population
    b. Percent Resident
    c. Percent Electricity Purchased
    d. Fuel Used for Heating (Oil, Gas, Coal)
    e. Acres
    f. Building Square Footage
    g. Composition of Buildings
    h. Percent of Water Purchased
    i. Percent of Sewer Services Purchased
    j. Density (Population Per Acre, Per Square Foot)

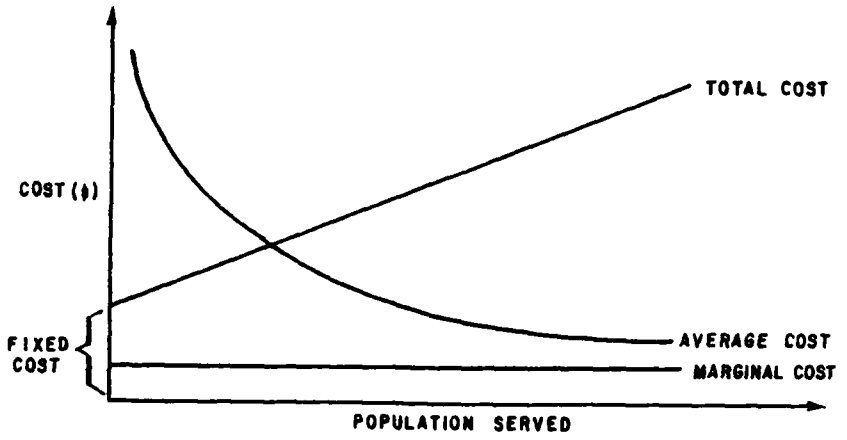
RELATIONSHIPS SPECIFIED

Relating RPMA costs to installation characteristics and activity factors requires the specification of an explicit functional relationship. Two general forms are possible: linear and logarithmic-linear. Although the criterion for selection of the preferred form depends on statistical results, each form nevertheless has certain advantageous properties.

The simple linear form has a fixed and variable cost component. Thus it displays decreasing average cost as the fixed costs are spread over a larger population served. Incremental (marginal) costs, those varying with activity, are constant and less than average cost. Estimated marginal cost is a uniform level that does not change with the characteristics of an installation. The relationships that are implicit with linear forms are summarized in Figure 2-1 below.

FIGURE 2-1. LINEAR RELATIONSHIP OF TOTAL, AVERAGE AND MARGINAL COST

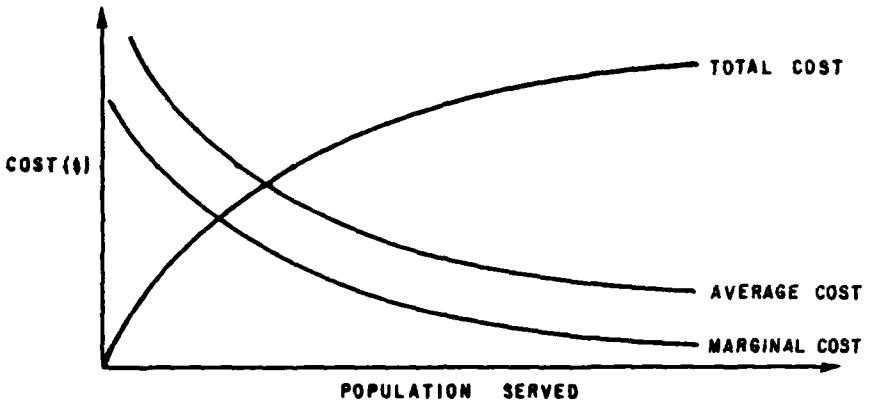
(COST = a+b POPULATION)



In contrast, a logarithmic-linear form has variable average and marginal costs that are sensitive to each installation's activity level (e.g., population served). Total cost can increase more than, less than, or in proportion to increases in activity. Declining average costs imply declining marginal costs that are below the average costs. These relationships are summarized in Figure 2-2.

FIGURE 2-2. LOGARITHMIC - LINEAR RELATIONSHIP OF TOTAL, AVERAGE AND MARGINAL COST

(LOG COST = a+b LOG POPULATION)



RESULTS

Cost-estimating relationships were developed by multiple regression techniques for total RPMA costs, the four major activity categories, and for each of the more detailed subcategories listed in Table 2-1. We first developed linear estimating relationships because, if the observed differences in RPMA costs could be effectively explained by the use of simple linear relationships, there would be little need to investigate the logarithmic form. We found, however, that the actual costs could be better explained by the logarithmic form. Our findings are all presented in the logarithmic-linear specification.

For each relationship we have provided the cost function as specified by: 1) activity variables which proved to be statistically significant cost drivers and the associated "t" values; 2) estimated coefficient (exponents) indicating, for the logarithmic-linear form, the percentage change in cost for a given percentage change in the activity level; 3) the overall goodness of fit (R^2) indicating the percentage of actual variation in costs for the sample

of installations that is explained by the estimated relationship and; 4) adjustment factors which proved statistically significant for primary mission and/or location of installation. These findings and interpretations are illustrated with the following relationship for total RPMA costs:

$$\text{(1) Total RPMA costs} = \$72900 \times (\text{Population})^{0.544}_{t=19.83} \times (\text{Acres})^{0.052}_{t=2.76}; \; R^2 = .86$$

$$\text{With Adjustments} = \begin{cases} 0.72 \text{ for General Purpose} \\ 0.67 \text{ for Guard and Reserve} \\ 1.91 \text{ for Cold Zone} \end{cases}$$

Total installation RPMA costs thus depend on the population served at the installation and its physical size as measured by acreage. Other variables considered (such as resident population, density and the like) were not statistically significant explainers of total RPMA cost. The coefficients estimated to define the impact of population and acreage on cost indicate "economies of scale" -- each 10 percent increase in population raises costs by 5.44 percent. Similarly, installations which are otherwise identical except for acreage will evidence 0.52 percent higher cost for each 10 percent increase of acreage.

The overall explanatory power of the relationship, as measured by R^2, is 86 percent. This means that the estimated regression relationship explains 86 percent of the variation in total RPMA observed across the sample of installations. This number represents the improvement in explanatory power of the estimated relationship over that achieved by using the overall average value for RPMA cost from the entire sample.

A number of adjustment factors are also indicated. These factors are, for the case of total RPMA cost, downward adjustments for installations with primary mission of General Purpose and Guard & Reserve, and an upward adjustment for installations located in the coldest climate. The magnitude of the

adjustments implies that, for example, a General Purpose installation incurs 72 percent of the RPMA costs incurred at other installations with otherwise similar characteristics.

Similar interpretations apply to the relationships estimated for the RPMA cost categories listed in Table 2-3. The estimated relationships are presented below (Tables 2-4 and 2-5) in a format indicating significant explanatory variables, associated estimated coefficients, adjustment factors for primary mission and climate, and the overall explanatory power (R^2) of the relationship. Relationships are given in the same order as listed in Table 2-3.

TABLE 2-3. COST-CATEGORIES ESTIMATED

Aggregate

1.0 Total RPMA Costs

1.1 Operation of Utilities (J account)

1.2 Maintenance of Real Property (K account)

1.3 Engineering Support (M account)

1.4 Minor Construction (L account)

1.5 All RPMA except minor construction (1.1, 1.2 and 1.3)

Detailed

1.1 Operation of Utilities (J)

- 1.11 Water, Sewer and Other Utilities
- 1.12 Electric Costs (Electric Use in MKW was also estimated)
- 1.13 Heating Costs

1.2 Maintenance of Real Property (K account)

- 1.21 All Utility Maintenance
  - 1.211 Water, Sewer and Other Utility Maintenance
  - 1.212 Electric System Maintenance
  - 1.213 Heating System Maintenance
- 1.22 Building Maintenance
- 1.23 Other Maintenance

1.3 Engineering Support (same as 1.3)

1.4 Minor Construction (same as 1.4)

TABLE 2-4. AGGREGATE RPMA COST-ESTIMATING RELATIONSHIPS

1.0 Total RPMA Costs = $72,900 x (Population)$^{.544}$ x (Acres)$^{.052}$; R^2 = .86
t = 19.83 t = 2.76

Adjustments =

0.72	General Purpose
0.67	Guard and Reserve
1.91	Cold Zone

1.1 Operation of Utilities = $5,850 x (Population)$^{.723}$; R^2 = .84
t = 21.88

Adjustments =

1.61	Research and Development
1.31	Mild Zone

1.2 Maintenance of Real Property = $35,100 x (Population)$^{.497}$ x (Acres)$^{.048}$ x (% Resident)$^{.583}$; R^2 = .87
t = 18.46 t = 2.49 t = 3.53

Adjustments =

0.60	Communications and Control
0.69	General Purpose
0.62	Guard and Reserve
1.97	Cold Zone

1.3 Engineering Support = $17,300 x (Population)$^{.566}$; R^2 = .74
t = 13.45

Adjustments =

0.44	Sealift/Airlift
1.94	Research and Development
1.62	Mission Support
1.96	Cold Zone

1.4 Minor Construction = $718 x (Population)$^{.738}$; R^2 = .48
t = 9.26

1.5 Total RPMA less Minor Constructon (1. - 1.4) = $68,600 x (Population)$^{.545}$ x (Acres)$^{.048}$; R^2 = .86
t = 19.77 t = 2.5

Adjustments =

0.77	General Purpose
0.70	Guard and Reserve
1.23	Research and Development
1.95	Cold Zone

TABLE 2-5. DETAILED RPMA COST-ESTIMATING RELATIONSHIPS

Operation of Utilities (J):

1.11 Water, Sewer, and Other Utilities = \$2,190 x (Population)$^{.521}$ x (Acres)$^{.122}$; R^2 = .57
t = 6.79 t = 2.2

Adjustments =

0.46	General Purpose
0.07	Airlift/Sealift
0.38	Guard and Reserve

1.12 Electric Cost = \$1,300 x (Population)$^{.789}$; R^2 = .84
t = 20.91

Adjustments =

0.64	Guard and Reserve
1.65	Research and Development

1.12* Electric Use (MKW) = 50.1 (MKW) x (Population)$^{.744}$; R^2 = .84
t = 19.29

Adjustments =

0.40	Airlift/Sealift
0.64	Guard and Reserve
1.42	Research and Development

1.13 Heating Cost = \$247 x (Population)$^{.813}$ x (% Gas Fired)$^{.922}$ x (% Oil Fired)$^{1.37}$; R^2 = .69
t = 10.28 t = 2.01 t = 8.96

Adjustments =

0.06	Airlift/Sealift
3.01	Cold Zone
3.47	Cool Zone
2.98	Mild Zone
2.46	Warm Zone

Maintenance of Real Property (K):

1.21 Total Utility Maintenance = \$3,010 x (Population)$^{.565}$ x (Acres)$^{.103}$; R^2 = .54
t = 6.93 t = 1.73

Adjustments =

0.49	General Purpose
0.05	Airlift/Sealift

1.211 Water, Sewer, and Other Utility Maintenance = \$2,372 x (Population)$^{.745}$; R^2 = .84
t = 21.49

Adjustments =

0.70	Guard and Reserve
1.52	Research and Development

1.212 Electric System Maintenance = \$213 x (Population)$^{.642}$ x (Acres)$^{.010}$; R^2 = .58
t = 8.18 t = 1.75

Adjustments =

0.48	General Purpose
0.48	Airlift/Sealift

1.213 Heating System Maintenance = \$1.34 x (Population)$^{.943}$ x (Acres)$^{.249}$; R^2 = .53
t = 8.13 t = 3.03

Adjustments =

0.11	General Purpose
54.73	Cold Zone
10.66	Cool Zone
10.07	Mild Zone
7.66	Warm Zone

1.22 Building Maintenance = \$944 x (Sq. Ft. of Bldgs.)$^{.926}$ x (% of hi-cost Bldgs.)$^{1.135}$; R^2 = .89
t = 19.68 t = 3.24

Adjustments =

0.65	Communications and Intelligence
0.61	Airlift/Sealift
0.77	Research and Development
0.43	Mission Support
1.60	Cold Zone

1.23 Other Maintenance = \$2,370 x (Population)$^{.476}$ x (Acres)$^{.187}$; R^2 = .69
t = 9.96 t = 3.95

Adjustments =

0.69	General Purpose
1.99	Airlift/Sealift
1.35	Mission Support

3. POTENTIAL APPLICATIONS

INTRODUCTION

The statistical results presented in the previous chapter indicate substantial "economies of scale" for RPMA costs in total and by subactivity. This means that total RPMA costs increase with population served, but the increase is substantially less than the percentage increase in population. Consequently, average cost per person served declines with installation size. Marginal costs incurred to serve an additional person are less than average cost and also decline with increased population.

These findings have implications for policy and in the application of the RPMA cost relationship to budgeting, planning and management control. Potential applications are described below.

BASE REALIGNMENTS AND CLOSURES

Total RPMA costs are estimated to behave in response to changes in population served with, for example, a 10 percent change in population affecting total RPMA costs by 5.44 percent. Consequently, realignments from small to large installations can be expected to reduce total RPMA costs. The magnitude of gross cost impacts from realignments can be estimated from the relationships found. Base closures are a special case of realignments with the total population served on the closed base reassigned to one or more recipient installations. The logic for estimating savings from closure is essentially the same as that used for realignments with the proviso that total RPMA costs are avoided for the closed installation.

To illustrate the use of the estimated RPMA cost-relationship, consider a hypothetical realignment of activities causing the shift of 324 people from

Ft. Monroe to Ft. Hamilton. This change in population would not change the location, mission, or acreage at either location. The estimating relationship (equation 1 in Chapter 2) indicates an exponent of 0.544 for population. This exponent implies the relationship between rate of change in population and rate of change in total RPMA cost. The specific estimate for this realignment using actual RPMA costs would be made as follows:

1. Ft. Monroe's 1981 population was 3,240. The proposed realignment thus represents a 10 percent reduction in population and should lead to a 5.44 percent reduction in RPMA.

2. The expected cost reduction at Ft. Monroe, based on FY81 RPMA costs of $9,741,887, would be $529,735 (0.544 x 0.10 x $9,741,877).

3. An increase of 324 persons at Ft. Hamilton, which had a population of 13,320, would be a 2.43 percent increase.

4. The expected RPMA cost increase at Ft. Hamilton, based on FY81 RPMA cost of $15,979,718, would be $211,286 (0.544 x 0.0243 x $15,979,718).

5. The expected net savings from the realignment would be $318,448 ($529,735 minus $211,286).

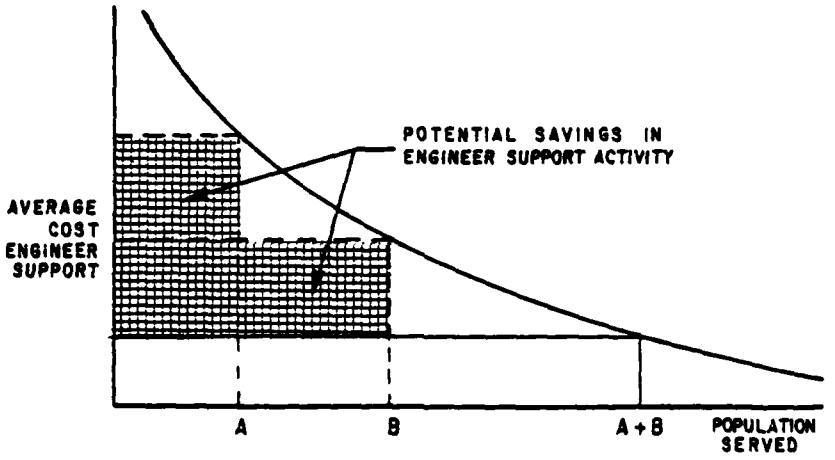
As a convenience, we have prepared cost planning factors for the calculations in steps 1-5 above for active CONUS Army installations. The cost factors give the RPMA cost increase (or decrease) for a one person addition (or reduction) to the current installation population. These cost planning factors are presented in Appendix B.

REAL PROPERTY MAINTENANCE ACTIVITY CONSOLIDATIONS

An indication of "gross" savings from consolidating real property maintenance activities within a regional area can similarly be estimated using the cost functions in Chapter 2. Savings can be expected because "economies of scale" were found to prevail for detailed RPMA activities, (e.g., the building maintenance component of real property maintenance). Thus, savings can be expected when, for example, an RPMA function performed independently at two installations is consolidated under a single manager at one installation.

The analysis for estimating such gross savings is essentially similar to that illustrated for realignments. Here, however, the cost impact is estimated from the cost coefficient found for the activity under consideration, and population changes refer to the total populations served by both installations. The concept is illustrated in Figure 3-1 below for engineering support activities. Separate populations of A and B are served under a consolidation as a combined population (A+B) yielding gross savings indicated by the cross hatched area of Figure 3-1.

FIGURE 3-1. ENGINEERING SUPPORT ACTIVITIES



Obviously, "gross" RPMA savings found in this manner would have to be reduced by any added costs of implementing the consolidation to arrive at "net" savings. Such costs are unique to each potential consolidation since they depend on local circumstances (such as proximity, cross-service differences, or absolute size of populations served). Intangible costs, including possible reduction in the quality of service, must also be considered.

PERFORMANCE EVALUATIONS

No one would attempt to "evaluate" RPMA performance on the basis of the total costs incurred because an installation with a large population would

be expected to incur high costs. Performance evaluations, at least in a gross sense, might be attempted on the basis of average costs per person served. Our findings suggest, however, that such average or unit costs are not suitable for comparing installations because the costs per person are expected to decline as the size of the population served increases.

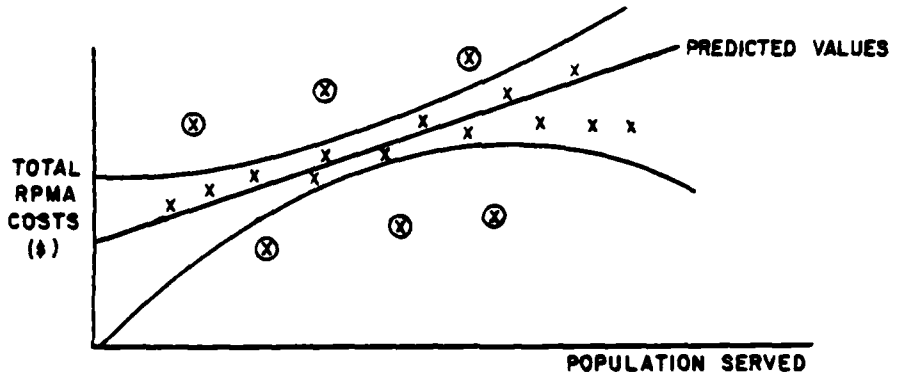
The RPMA cost relationships represent predictors of cost, based on installation characteristics and the relation of costs to scale effects. Nevertheless, factors that can not be measured and, in particular, quality aspects of RPMA services rendered are not accounted for in the cost-estimating relationships. With this reservation in mind, we can arrange installations in terms of the ratio of total RPMA costs actually incurred to the total RPMA costs predicted by the estimating equation.

Installations with a high ratio of actual to predicted costs are high-cost installations after adjustment for population and acreage scale effects, primary mission and location. Those with a low ratio of actual to predicted costs are low-cost installations. These installations are either efficient or are providing low quality service. The next step is to examine subcategories of RPMA costs in the same manner to investigate the RPMA functions causing higher than predicted costs.

In essence, this process represents use of cost-estimating relationships to predict what costs should be and then to determine those installations with actual costs far in excess of predicted. This concept can be put in a statistical framework since the expectation of abnormally high or low predicted value is known. In Figure 3-2, the cost-estimating relatonship for predicted cost is given as a function of population served.

A "confidence band" can be constructed around the regression line. Installations deviating from this band (denoted by (X)) are those with extreme costs after accounting for all factors that drive RPMA costs.

FIGURE 3-2. CONFIDENCE BAND FOR EXTREME VALUES



The estimating relationships in Chapter 2 represent significant statistical tendencies present in the 1981 data. If an installation had a higher actual cost (either for total RPMA or for one or more of the specific categories of cost) than indicated by the estimating relationship, there may have been well recognized special circumstances. In planning for changes in activity at such an installation, there may be good reason to plan for continued costs in excess of the amount suggested by the estimating relationship, but the changes might still be planned at marginal costs determined by the statistical relationship.

The important point is that these cost estimating relationships do not substitute for case-by-case management. They do, however, provide a basis for specific attention where installation costs appear to be significantly different from those expected.

APPENDIX A

DATA FILES FOR EACH INSTALLATION

Physical Factors

Water Service, Total Gallons + Gallons Purchased
Sewer Service, Total Gallons + Gallons Purchased
Electric Service, Total Watt-Hours + Watt-Hours Purchased
Heat Service, Hi-Pressure Boilers, Total Btus + Btus gas, oil and coal fired
Heat Service, Over 3.5 MBtu/h., Total Btus + Btu's gas, oil, and coal fired
Heat Service, 0.75 - 3.5 MBtu/h., Total Btus + Btus gas, oil, and coal fired
Heat Service, Under 0.75 MBtu/h., Total Btus + Btus gas, oil, and coal fired
Steam + Hot Water Purchased, Total Btus
Buildings, Sq. ft. in each of 13 bldg. types and total sq. ft.
Grounds, Total Acres
Population, Total, Resident and Non-Resident

Installation Descriptors

Command Identification:

Forces Command
Training and Doctrine Command
Materiel Development and Readiness Command
Army Communications Command
Health Services Command
Intelligence and Security Command
Military Traffic Management Command
All Others

Mission Identifiers: (3-Digit IDPP Category Classification)

General Purpose (202)
Airlift/Sealift (204)
Communications plus Control (103 & 303)
Research and Development (106 & 306)
Mission Support (401 & 402)
Central Support and Maintenance (507)
Training, Medical, and Adminstration (508)
Guard and Reserve (205)

Location Designators, Based on U.S. Weather Zone Map of Heating Degree Days and Cooling Degree Days, prepared by Census Bureau:

Cold
Cool
Mild
Warm
Hot

RPMA Costs

Water Service
Sewage Service
Electric Service
Heat Service-Hi Pressure
Heat Service-Over 3.5 MBtu/h.
Heat Service 0.75-3.5 MBtu/h.
Heat Service Under 0.75 MBtu/h.
Steam & Hot Water Purchased
Air Conditioning + Cold Storage
Base Closures/RIF Actions
Other Utilities Actions
Total Utilities Operations
Maintenance of Water Systems
Maintenance of Sewer Systems
Maintenance of Electric Systems
Maintenance of Heating-Hi Pressure
Maintenance of Heating -Over 3.5
Maintenance of Heating - 0.75 to 3.5
Maintenance of Heating - Under 0.75
Maintenance of Steam + Hot Water Systems
Maintenance of Gas Distrib. Systems
Maintenance of Gas Storage + Generating
Maintenance of Air Condition + Refrigeration
Maintenance of Other Utilities
Maintenance of Buildings
Maintenance of Grounds
Maintenance of Railroads
Maintenance of Surfaced Areas
Maintenance of Bridges
Miscellaneous Maintenance
Base Closure/RIF Maintenance Actions
Total Maintenance Costs
Minor Construction
Management and Engineering (Master Planning)
Total Other Engineering Support
Total RPMA Costs

Computed Values

Share of High-Cost Buildings[1]
Share of Population which is Resident
Share of Water Service Purchased
Share of Sewage Service Purchased
Share of Electric Service Purchased

[1]This percentage is defined as the ratio of square footage in building types reported to have significantly higher than average maintenance cost per square foot to total building square footage. The building types included as "high cost" are: research, development and test; hospital and medical; administration; community; and utility plant.

Computed Values (continued)

Share of Heat from Gas
Share of Heat from Oil
Share of Heat from Coal
Population per Acre
Population per Square Foot of Building

APPENDIX B

PLANNING COST FACTORS

Table B-1 presents planning cost factors (PCF) for total RPMA costs for Army CONUS installations. The factors represent the estimated RPMA cost increase (or decrease) for each person added to (or substracted from) the population at each installation. The factors have been calculated using the cost coefficient found in the total RPMA cost-estimating relationship, and the actual installation RPMA cost and population as follows:

$$PCF = 0.544 \frac{\text{RPMA Cost}}{\text{Population}}$$

RPMA cost impacts can be estimated using the planning cost factors and population changes as follows:

$$\text{Cost Change} = PCF \times \text{Population Change}$$

The factors presented in this Appendix are valid for estimating cost impacts for relatively small percentage changes (i.e., less than 20 percent) in population. For large changes, RPMA cost impacts can be calculated using the cost-estimating relationships in Chapter 2.

TABLE B-1. PLANNING COST FACTORS

Installation	Mission	Cost Factor
Fort Bragg, NC	General Purpose	$ 728
Fort Campbell, KY	General Purpose	446
Fort Carson, CO	General Purpose	403
Fort Devens, MA	Training, Medical, Adm.	558
Fort Drum, NY	National Guard & Res.	1,371
Fort Hood, TX	General Purpose	394
Fort Indiantown Gap, PA	National Guard & Res.	1,042
Fort Sam Houston, TX	Training, Medical, Adm.	506
Fort Lawton, WA	National Guard & Res.	2,927
Fort Lewis, WA	General Purpose	523
Fort McCoy, WI	National Guard & Res.	181
Fort McPherson, GA	Mission Support	898
Fort Meade, MD	Mission Support	477
Fort Riley, KS	General Purpose	386
Fort Sheridan, IL	Training, Medical, Adm.	1,149
Fort Stewart, GA	General Purpose	448
National Training Center, CA	General Purpose	681
Presidio of San Francisco, CA	Mission Support	804
Vancouver Barracks, WA	National Guard & Res.	8,888
Yakima Firing Center, WA	General Purpose	4,429
Fort Greely, AK	General Purpose	2,707
Fort Richardson, AK	General Purpose	640
Fort Wainwright, AK	General Purpose	1,120
193d Infantry Brigade, CZ	General Purpose	1,093
Fort Ord, CA	General Purpose	400
Fort Polk, LA	General Purpose	456
Fort Belvior, VA	Training, Medical Adm.	1,181
Fort Benning, GA	Training, Medical, Adm.	692
Fort Bliss, TX	Training, Medical, Adm.	499
Fort Chaffee, AR	National Guard & Res.	712
Fort Dix, NJ	Training, Medical, Adm.	873
Fort Eustis, VA	Training, Medical, Adm.	926
Fort Gordon, GA	Training, Medical, Adm.	499
Fort Benjamin Harrison, IN	Training, Medical, Adm.	552
Fort A. P. Hill, VA	National Guard & Res.	2,048
Fort Jackson, SC	Training, Medical, Adm.	582
Fort Knox, KY	Training, Medical, Adm.	545
Fort Leavenworth, KS	Training, Medical, Adm.	829
Fort Lee, VA	Training, Medical, Adm.	740
Fort McClellan, AL	Training, Medical, Adm.	471
Fort Monroe, VA	Training, Medical, Adm.	1,634
Fort Hamilton, NY	Training, Medical, Adm.	652
Fort Pickett, VA	National Guard & Res.	1,607
Fort Rucker, AL	Training, Medical, Adm.	629
Fort Sill, OK	Training, Medical, Adm.	553

TABLE B-1 (Continued)

Installation	Mission	Cost Factor
Fort Leonard Wood, MO	Training, Medical, Adm.	646
Carlisle Barracks, PA	Training, Medical, Adm.	1,195
Fort Huachuca, AZ	C.C.C.I.	764
Fort Ritchie, MD	C.C.C.I.	922
Anniston AD, AL	Central Support & Maint.	1,320
Army Materials & Mechanics Research Center, MA	Research & Development	2,304
Harry Diamond Laboratories, MD	Research & Development	2,430
Letter Kenny AD, PA	Central Support & Maint.	1,264
Lexington-Blue Grass AD, KY	Central Support & Maint.	1,510
McAlester AAP, OK	Central Support & Maint.	3,743
Navajo Depot Activity, AZ	Central Support & Maint.	4,679
New Cumberland AD, PA	Central Support & Maint.	716
Picatinny Arsenal, NJ	Research & Development	3,200
Pine Bluff Arsenal, AR	Central Support & Maint.	3,868
Pueblo Depot Activity, CO	Central Support & Maint.	2,894
Red River AD, TX	Central Support & Maint.	1,142
Redstone Arsenal, AL	Research & Development	1,012
Rock Island Arsenal, IL	Central Support & Maint.	1,270
Rocky Mountain Arsenal, CO	Central Support & Maint.	4,841
Sacramento AD, CA	Central Support & Maint.	716
Savanna AD, IL	Central Support & Maint.	2,511
Seneca AD, NY	Central Support & Maint.	2,593
Sharpe AD, CA	Central Support & Maint.	1,290
Sierra AD, CA	Central Support & Maint.	2,417
Tobyhanna AD, PA	Central Support & Maint.	1,163
Tooele AD, UT	Central Support & Maint.	1,815
Umatilla Depot Activity, OR	Central Support & Maint.	4,204
Fort Wingate Depot Activity, NM	Central Support & Maint.	3,283
Watervliet Arsenal, NY	Central Support & Maint.	1,964
Corpus Christi AD, TX	Mission Support	1,569
Detroit Arsenal, MI	Research & Development	1,517
Fort Monmouth, NJ	Research & Development	1,258
Jefferson Proving Grounds, IN	Research & Development	3,698
St. Louis Area Support Center, IL	Mission Support	3,204
Aberdeen Proving Ground, MD	Research & Development	884
Dugway Proving Ground, UT	Research & Development	1,705
Natick Development Center, MA	Research & Development	1,838
White Sands Missile Range, NM	Research & Development	1,230
Yuma Proving Grounds, AZ	Research & Development	1,227
Fort Detrick, MD	Research & Development	2,092
Fitzsimons Army Medical Center, CO	Training, Medical, Adm.	1,297
Water Reed Army Medical Center, DC	Training, Medical, Adm.	1,599
Arlington Hall Station, VA	C.C.C.I.	904

TABLE B-1 (Continued)

Installation	Mission	Cost Factor
Vint Hill Farms, VA	C.C.C.I.	972
Bayonne Military Ocean Terminal, NJ	Airlift/Sealift	1,982
Gulf Outport, LA	Airlift/Sealift	683
Oakland Army Base, CA	Airlift/Sealift	1,258
Sunny Point Military Ocean Terminal, NC	Airlift/Sealift	9,882
Military District of Washington, D.C.	Mission Support	408
U.S. Military Academy, NY	Training, Medical, Adm.	1,199

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—This report describes cost estimating relationships developed for Real Property Maintenance Activities (RPMA) at Army installations. Cost estimating relationships are presented for total RPMA and subcategories of RPMA as functions of variables determined to significantly influence incurred costs. A sample of 96 Army installations within CONUS during FY81 was used to construct the cost estimating relationships. Findings with respect

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to cost determinates, economies of scale and application potential for estimating the cost impacts of realignments, consolidations and base closures are also included.


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