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Optimally reorganizing navy shore infrastructure

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by

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August 1998

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The United States has significantly reduced defense spending since the end of the cold war for both its force structure (equipment and manpower) and military support base (infrastructure). However, infrastructure reductions at the conclusion of legislated Base Realignment and Closure (BRAC) continue to lag force structure reductions. Regionalization, outsourcing and homebasing are current United States Navy initiatives to reduce share infrastructure spending without BRAC. While regionalization and outsourcing decrease the number of jobs needed on a shore installation, homebasing generally increases the number of available personnel. To jointly consider these opposing effects, we develop the Regionalization and Outsourcing Optimization Model (ROOM), w integer linear program that suggests an optimal combination of regionalization and outsourcing for a Navy shore installation with personnel numbers altered by homebasing. ROOM is a novel application of optimization modeling. A ROOM test use from the Pearl Harbor Naval Installation has proposed homebasing, regionalization, and outsourcing options for 109 "functions," or shore installation activities. Disregarding homebasing and its opposing effects, regionalization is myopically the lowest cost option for 106 of these functions. ROOM considers homebasing and recommends regionalizing only 21 functions outsourcing 14, and leaving 74 unchanged. ROOM's recommendationsreduce first-year personnel spending by more thw $9.5 million.

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OPTIMALLY REORGANIZING NAVY SHORE INFRASTRUCTURE

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August, 1998

Abstract

The United States has significantly reduced defense spending since the end of the cold war for both its force structure (equipment and manpower) and military support base (infrastructure). However, infrastructure reductions at the conclusion of legislated Base Realignment and Closure (BRAC) continue to lag force structure reductions. Regionalization, outsourcing and homebasing are current United States Navy initiatives to reduce shore infrastructure spending without BRAC. While regionalization and outsourcing decrease the number of jobs needed on a shore installation, homebasing generally increases the number of available personnel. To jointly consider these opposing effects, we develop the Regionalization and Outsourcing Optimization Model (ROOM), an integer linear program that suggests an optimal combination of regionalization and outsourcing for a Navy shore installation with personnel numbers altered by homebasing. ROOM **is** a novel application of optimization modeling. **A** ROOM test case from the Pearl Harbor Naval Installation has proposed homebasing, regionalization, and outsourcing options for 109 "functions," or shore installation activities. Disregarding homebasing and its opposing effects, regionalization is myopically the lowest cost option for 106 of these functions. ROOM considers homebasing and recommends regionalizing only 21 functions, outsourcing **14,** and leaving 74 unchanged. ROOM's recommendations reduce first-year personnel spending by more than $9.5 million.

INTRODUCTION: Reducing Navy Shore Infrastructure

The United States has significantly reduced defense spending since the end of the cold war. Initial reductions have been in force structure (equipment and manpower) since budget cuts in these areas are politically feasible and provide immediate savings. Because fewer forces require less support structure, reductions in the military support base, or infrastructure, have followed. To date, infrastructure reductions are proportionally less than those of force structure: The Defense Department has reduced the size of the military services by 30 percent, but the cumulative reduction in military infrastructure is only about 21 percent [Defense Base Closure and Realignment Commission, 19951.

Military infrastructure can be streamlined via Base Realignment and Closure (BRAC). BRAC reduces infrastructure by reorganizing some military installations, while closing others. After four rounds, a legislative BRAC process concluded in 1995 with the recommendation to close or realign 132 military installations in the United States [Defense Base Closure and Realignment Commission, 19951. BRAC is currently projected to save $2.4 billion annually, but these savings are less than expected due to unforseen costs and expenditures that were transferred rather than eliminated [Struble, 1996].

Now the armed services are seeking means other than closing more bases to reduce infrastructure costs. In particular, the Navy wants to reduce its shore infrastructure. Figure 1 shows major Naval installations in the United States.

In the United States Navy, infrastructure accounts for approximately 37 percent of the budget: 1998 fiscal year (FY98) infrastructure consumes $25.1 billion of the Navy's $68.5 billion Total Obligation Authority (TOA) (Figure 2) [Department of the Navy (N464), 1996]. The Navy is now actively reducing its shore infrastructure with cost reduction initiatives, including "regionalization," "outsourcing," and "homebasing." While regionalization and outsourcing decrease the number of jobs needed on a shore installation, homebasing can increase the number of available personnel. These opposing effects invite careful analysis. We develop the Regionalization and Outsourcing Optimization Model (ROOM), an integer linear program that identifies an optimal combination of regionalization and outsourcing options for a Navy shore installation with personnel numbers altered by homebasing. To clarify the factors involved

in ROOM's recommendations, we first present a brief background of Navy shore infrastructure cost reduction initiatives.

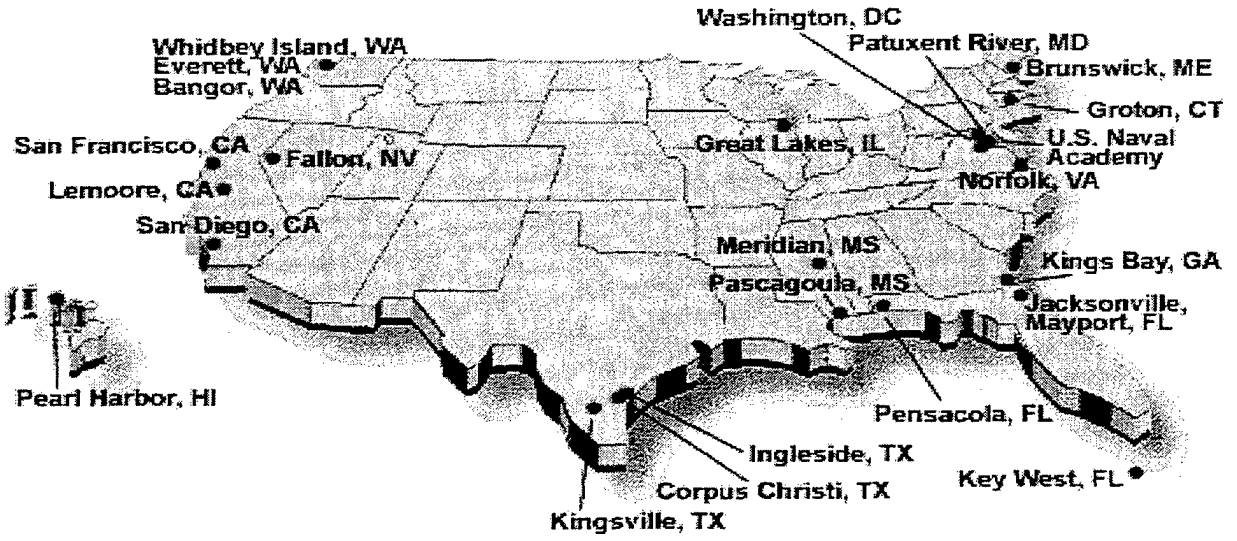

Figure 1. The major U. *S.* Navy installations employ and homeport most of the 385,575 active duty Navy personnel [Department of the Navy (Office of Information), 1998a]. Map from the Department of the Navy (Office of Information) [1998b].

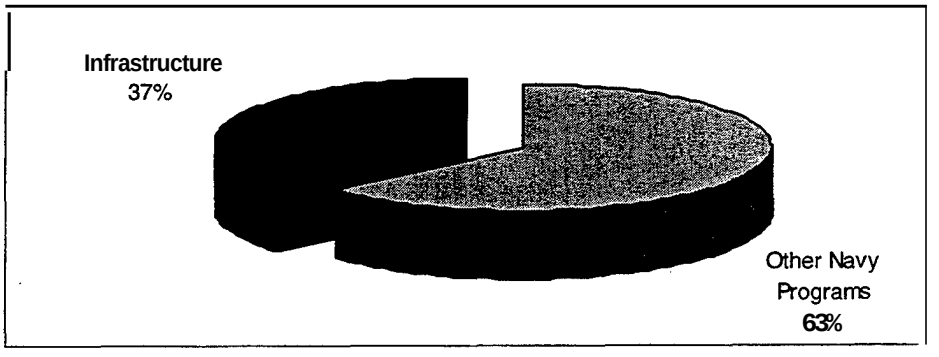

Figure 2. Navy planned infrastructure costs for fiscal year 1998. Infrastructure consumes $25.1 billion of the Navy's $68.5 billion Total Obligation Authority, or approximately 37 percent of the Navy's budget.

In 1994, the Shore Installation Management Division, or N46, was created under the Deputy Chief of Naval Operations (DCNO) for Logistics, "to serve as the principal [Navy] point of contact, resources advocate and coordinating authority for the shore installation chain of

command in all matters affecting Navy Shore Installation programs to support a high level of fleet operational readiness" [Department of the Navy (N46), 1997]. N46 heads several new initiatives to reduce shore infrastructure costs; these fall into three major areas: (1) regionalization;
(2) outsourcing and privatization; and (3) improved operational procedures.

Regionalization

A *function* is any activity performed on a military installation, including those identified in the Office of Management and Budget (OMB) Circular A-76, *Performance of Commercial Activities.* Regionalization is the process of assigning the fiscal and administrative responsibility for similar functions in the same region or area to one command [Struble, 19961. Regionalization consolidates installation management functions and eliminates redundancy, thereby reducing shore infrastructure and costs. For example, the Pearl Harbor Naval Complex maintains three separate Bachelor Officer Quarters (BOQ's) in the same vicinity. The Naval Station BOQ (BOQ 1315), Makalapa BOQ (BOQ 372) on the Commander-in-Chief Pacific Fleet (CINCPACFLT) compound, and Lockwood Hall on the submarine base (Figure 3) are all located within a five-mile radius. Regionalization reduced infrastructure by combining the responsibility for all BOQ's under one command.

Figure 3. Lockwood Hall is one example of Bachelor Officer Quarters (BOQ). It is located on the submarine base in Pearl Harbor, Hawaii. Lockwood Hall, the Naval Station BOQ (BOQ 1315), and Makalapa BOQ (BOQ 372) on the Commander-in-Chief Pacific Fleet (CINCPACFLT) compound are all located within a five mile radius. Regionalization reduced infrastructure by combining the responsibility for all BOQ's under one command. [U. S. Navy photos]

N464, the Plans and Policy Branch of N46, is responsible for gathering the necessary data and making regionalization recommendations for Navy shore installations. N464 first conducted regionalization studies and proposed regionalization alternatives for the San Diego Naval District [Department of the Navy (N464), 1996]. N464 also conducted regionalization studies in Pearl Harbor, Hawaii; Bangor, Washington; and Naval District Washington.

Outsourcing and Privatization

Outsourcing and privatization both achieve cost savings by contracting private companies to provide goods and services that are less expensive than those the government can provide for itself. Although outsourcing and privatization are different methods for achieving the same goal, the terms are often confused or their differences disregarded [Struble, 19961. Table 1 contrasts the two methods.

	Outsourcing	Privatization
Ownership of Facilities	Government	Private Industry
Provides Workforce	Private Industry	Private Industry
Monitors Quality of Output	Government	Government

Table 1. Outsourcing and privatization are two methods to reduce operating costs. Outsourcing "contracts out" just the labor force, whereas privatization relinquishes complete control of the supply of a good or service to private providers.

Outsourcing, also referred to as "contracting out" [Tighe, et al., 19961, refers to the government's purchase of inputs from private providers. In this case, traditionally in-house functions are shifted to the private sector. The workload shifts, but no government facilities are transferred to private industry. The government retains ownership of the facilities and a significant amount of control over operations. Facility maintenance is an example of a function that may be outsourced.

Unlike outsourcing, privatization occurs when a governmental body gives private providers complete control over the supply of a good or service. "More specifically, it can be defined as shifting the production of government goods and services, or the ownership of assets, into the private sector" [Nuskey, 19921. The government only monitors the quality of the output and has no involvement in the daily operations. For instance, if the Navy relied solely upon private providers of child care services while monitoring their performance on a regular basis, then child care services would be privatized.

Outsourcing (henceforth used to encompass both outsourcing and privatization), by no means a new idea, has been used for many years by the private sector to reduce costs. The federal government is now following private industry trends and emphasizes outsourcing. In the past, administrative and legislative constraints limited government outsourcing efforts. However, continuing budget and personnel reductions, the need to fund weapons and modernization, and the elimination of key legislative constraints now allow the Department of Defense (DOD) to further outsource support functions. Outsourcing for commercial services is now a growing practice within the government to achieve cost savings, management efficiencies, and operating flexibility [United States General Accounting Office, 19971.

Tighe, et al. [1996] report that competition, not outsourcing, is the key to savings since winners of competitions usually use fewer workers; the United States General Accounting Office [1997] reports that the government and private industry each won half of the competitions. Outsourcing induces savings, usually through personnel reductions, regardless of whether competitions are won by the government or the private sector. Furthermore, DOD data on cost comparisons for fiscal years 1978 through 1994 confirm that savings from competed functions follow regardless of whether the government or private industry is awarded the work.

The Defense Science Board Task Force on Outsourcing and Privatization [1996] concluded that the DOD could realize savings between 20 and 40 percent by outsourcing support functions, thus saving billions of dollars. Several other studies, including Tighe, et al. [19961, suggest similar figures.

Outsourcing is endorsed by high-level leadership; the Secretary of the Navy's guidance is to "maximize outsourcing and privatization to the extent allowed under current law" [Department of the Navy (Office of the Chief of Naval Operations), 19961. The Outsourcing Programs Division, or N47, was formed to act as the Navy's lead for outsourcing and privatization issues, providing a liaison with the Office of the Secretary of Defense, Office of Management and Budget, and Congress [Department of the Navy (N47), 19971.

Improved Operational Procedures

Improving operational procedures also reduce shore infrastructure. Better business practices include implementing commercial performance standards and measures, utilizing state-of-the-art technology, and reviewing military product specifications in order to use commercially available products to satisfy military requirements when applicable [Department of the Navy (N464), 19961.

The specific better business practice of homebasing is mentioned in the N47 charter. The idea behind homebasing is simple (Figure 4). Navy shore installations, by nature, have a certain number of personnel who alternate between sea and shore duty called "sea-shore rotation." Frequently, when an individual rotates from sea to shore (or vice versa), he is not stationed at the same shore installation. In order to reduce costs, the Navy wants to maintain the majority of its personnel in one location or at one "home" base throughout these rotations. Such "homebasing" ". . . helps Sailors improve their quality of life by increasing geographic stability for them and their families, and it helps the Navy to reduce costs associated with Permanent Change of Station (PCS) moves" [United States Navy Wire Service, 19971.

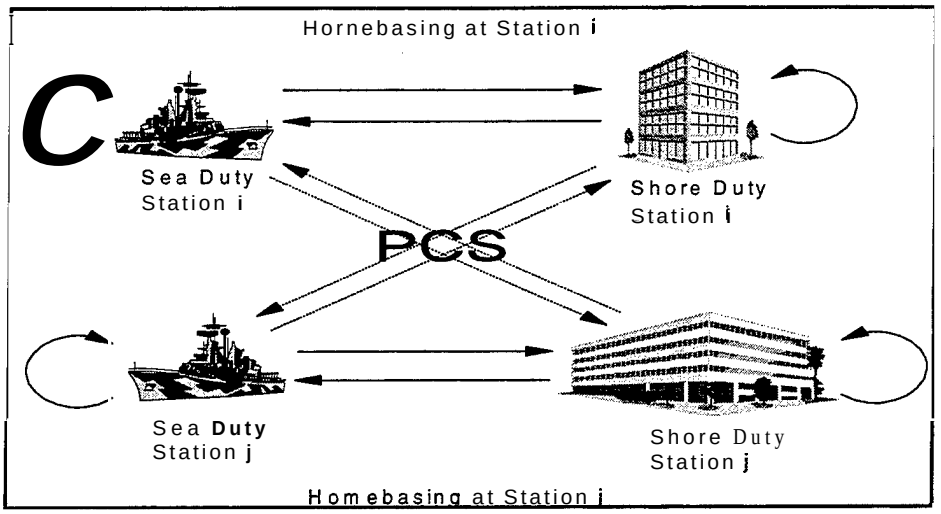

Figure 4. The goal of homebasing is to maintain personnel at the same station throughout their sea-shore rotations or to limit transfer of personnel between stations i and j (along a dotted line). Personnel transfer or Permanent Change of Station (PCS) between shore locations is expensive.

THE OPTIMIZATION PROBLEM

Regionalization, outsourcing, and homebasing all sound like effective, cost-saving initiatives. However, they must work together and still meet the Navy's personnel and job, or "billet," requirements. Currently, N464 gathers manpower data and provides several regionalization options for each function on a Navy shore installation. Then, N47 considers regionalization, manpower, and homebasing when making outsourcing recommendations for the shore installations.

We develop the Regionalization and Outsourcing Optimization Model (ROOM) to identify the optimal combination of regionalization and outsourcing options that can be supported by personnel available after making homebasing adjustments at a Navy shore installation.

RELATED MODELS

ROOM reduces planned infrastructure costs using a personnel assignment model with additional side constraints.

Several other military infrastructure cost reduction models have been developed. The Cost of Base Realignment Actions (COBRA) [Brown, 1989] evaluates BRAC actions by

estimating the cost associated with the disposition of assets at closed bases and the transfer of activities to other bases. The Optimally Stationing Units to Bases (OSUB) model [Dell, et al., 19941 is an elastic bi-criterion integer linear programming model that develops realignment and closure recommendations for Army maneuver and training bases by maximizing military value while minimizing operating cost. Free [19941 develops another BRAC optimization model to schedule Army base realignment and closure actions. Dell [1998] reports on the later evolution and use of such a model for BRAC 95. All of these models share ROOM's goal to decrease military infrastructure costs, but none of them provides regionalization and outsourcing recommendations for functions on a Navy installation.

Several personnel assignment models have been developed to accommodate military requirements. Like ROOM, these models assign personnel to jobs at the minimum possible cost, and many have additional side constraints. Klingman and Phillips [1984] present a linear model and solution approach for the Marine Corps enlisted personnel assignment problem, a complex multicriteria assignment problem. Gaimon and Thompson [1984] derive a cohort (longitudinal) personnel planning model solved using distributed parameter optimal control theory that requires cross-sectional data. Personnel are considered in cohort groups sharing the same organizational age, and this model finds the optimal hiring, promotion, separation, and retirement policies of an organization as functions of time and an employee's organizational age and grade. Ali, Kennington, and Liang [19931, in addressing the issue of billet assignment with en-route training of Navy personnel, develop a new resource-directive decomposition and Lagrangean relaxation method to solve this integer network problem.

Additionally, there are numerous non-military models and decision support systems for personnel assignment. Constantopoulos [1989] designs a decision support system for assigning large numbers of personnel to jobs according to multiple criteria. Feiring [1993] develops a model that assigns individuals to jobs by generating model values that reflect management's job assignment policy and a general risk-assessment of an individual's success in a particular job.

THE REGIONALIZATION AND OUTSOURCING OPTIMIZATION MODEL (ROOM)

N464 collects data from an installation for regionalization studies and groups these data by what it calls its Installation Management Function Code (IMFC). Each Navy installation has

a specific number of billets for each IMFC and a group of personnel available to fill these billets. Additionally, each installation has Function Activity Code General (FACG) billets, or billets into which certain designator and rank combinations may be substituted with no associated training cost. So, ROOM naturally groups personnel by designator and rank combination.

Model Assumptions

ROOM makes several simplifying assumptions:

- The cost to perform a function using a specific regionalization and outsourcing option can be estimated by the personnel costs for the function and option combination.
- Personnel can be substituted into billets according to a set of allowable substitutions for personnel designator and rank combinations. These substitutions have associated training costs.
- A specific number of FACG billets is available for each designator and rank combination.
- Sufficient personnel of each designator and rank combination are available outside the installation.
- **Any** military personnel not needed at the installation are moved to other installations.
- The cost to move military personnel to or from the installation is based upon the maximum permanent change of station (PCS) shipping weight allowances for personnel of the specific rank and the average cost per hundred pounds of goods shipped to or from the installation. Costs to move civilian personnel are not considered.
- Monthly salaries for military personnel are based upon the average salary for the specific rank and include benefits, such as Variable Housing Allowances (VHA) and Cost of Living Allowances (COLA). Monthly salaries for civilian personnel are based upon the average salary for the specific ''government service ***(GS)*** level."
- Monthly pay for part-time workers is estimated as 50 percent of the monthly salaries of their full-time counterparts. The part-time workforce can be grouped into one civilian ***"GS*** level and series" with a monthly salary equivalent to the average monthly pay of all part-time workers.

- The contracted or outsourced labor cost for a specific function and option combination can be derived from the current outsourced labor cost and the additional number of personnel outsourced.
- ROOM allows planned personnel additions, removals, and substitutions to be fractional.

- The number of available personnel for each designator and rank combination is non-negative after adjusting for homebasing. ROOM, therefore, does not consider homebasing initiatives that would result in eliminating more billets of a designator and rank combination than are currently available at an installation.

- Billet reductions do not exceed the number of available billets for each function, designator, and rank combination.

Essential Elements of the Model

Indices

d, d'	Civilian series, enlisted rating, or officer designator;
f	Installation Management Function Code (IMFC);
o	Regionalization, outsourcing, and "no change" option; and
r, r'	Civilian GS level, enlisted rate, or officer rank.

Input Data

$ALLOW_{dr}$	Set of all designator d', rank r' allowed to substitute for designator d, rank r;
$ALLOWF_{dr}$	Set of all designator d', rank r' allowed to substitute for designator d, rank r as a FACG substitution;
$FACG_{dr}$	Number of FACG billets for personnel of designator d and rank r [personnel type (d, r)];
$HOMEBASE_{dr}$	Number of personnel type (d, r) eliminated or added by homebasing;
$MOVEIN_r$	Cost to move personnel of rank r to the installation;
$MOVEOUT_r$	Cost to move personnel of rank r from the installation;
$MSAL_r$	Monthly salary for personnel of rank r (base pay only);
$OUTCOST_{fo}$	Yearly contracted or outsourced labor cost for function fusing option o;
$PERS_{fdr}$	Number of personnel type (d, r) in function f;
$REDUCE_{fdro}$	Billet reductions for personnel type (d, r) in function f under option o; and
$TRAIN_{d'dr'r}$	Training cost for designator and rank substitutions of designator d', rank r' for designator d, rank r.

Derived Data

$PAVAIL_{dr}$	Personnel of type (d, r) available $PAVAIL_{dr} = MAX(0, \sum_f PERS_{fdr} + HOMEBASE_{dr})$ if d, r;
$PNEED_{fdro}$	Personnel of type (d, r) needed in function fusing option o $PNEED_{fdro} = PERS_{fdr} - REDUCE_{fdro}$ $\forall$ f, d, r, o;
$YSAL_r$	Yearly salary for personnel of rank r (base pay only) $YSAL_r = 12 \cdot MSAL_r$ if r; and
$COSTTODO_{fo}$	Cost to perform function fusing option o $COSTTODO_{fo} = \sum_{d,r}(PNEED_{fdro} \cdot YSAL_r) + OUTCOST_{fo}$ $\forall$ f, o.

Binary Decision Variable

$perform_{fo}$	Equals one if function f is performed using option o. The value is zero otherwise.

Continuous Non-negative Decision Variables

$facgsub_{d'dr'r}$	FACG substitutions from designator d', rank r′ into designator d, rank r;
$pmovein_{dr}$	Number of personnel type (d, r) to move to the installation from other locations;
$pmoveout_{dr}$	Number of personnel type (d, r) to move from the installation to other locations; and
$sub_{d'dr'r}$	Non-FACG substitutions from designator d', rank r′ into designator d, rank r.

Formulation

MINIMIZE Total Cost

$$\sum_{f,o} (COSTTODO_{fo} \cdot perform_{fo})$$

$$+ \sum_{d,r} [MOVEIN_r \cdot pmovein_{dr} + MOVEOUT_r \cdot pmoveout_{dr}]$$

$$+ \sum_{d,r} \sum_{d',\, r' \in ALLOWFdr} (YSAL_{r'} - YSAL_r) \cdot facgsub_{d'dr'r}$$

$$+ \sum_{d,r} \sum_{d',\, r' \in ALLOWdr} (YSAL_{r'} - YSAL_r + TRAIN_{d'dr'r}) \cdot sub_{d'dr'r}$$

SUBJECT TO CONSTRAINTS:

$$\sum_{f,o} (PNEED_{fdro} \cdot perform_{fo}) = PAVAIL_{dr} + pmovein_{dr} - pmoveout_{dr} + \sum_{d',r' \in ALLOWFdr} facgsub_{d'dr'r} - \sum_{d',r':\, d,r \in ALLOWFd'r'} facgsub_{dd'rr'} + \sum_{d',r' \in ALLOWdr} sub_{d'dr'r} - \sum_{d',r':\, d,r \in ALLOWd'r'} sub_{dd'rr'} \quad \forall\, d, r \quad (1)$$

$$\sum_{o} perform_{fo} = 1 \quad \forall\, f \quad (2)$$

$$\sum_{d',r' \in ALLOWFdr} facgsub_{d'dr'r} \le FACG_{dr} \quad \forall\, d, r \quad (3)$$

$$perform_{fo} \in \{0, 1\} \quad \forall\, f, o \quad (4)$$

$$pmovein_{dr} \ge 0, \quad pmoveout_{dr} \ge 0 \quad \forall\, d, r$$
$$facgsub_{d'dr'r} \ge 0, \quad sub_{d'dr'r} \ge 0 \quad \forall\, d', d, r', r \quad (5)$$

The objective function expresses the total expense of meeting the billet and personnel requirements. The first summation represents the cost to perform all functions. The second summation represents the costs incurred due to moving personnel into or out of the installation. The third summation is the cost or'savings due to FACG personnel designator and rank substitutions. The final summation accumulates the cost or savings due to non-FACG personnel substitutions plus the associated personnel training costs.

Constraint set (1) balances billets and personnel. This constraint set guarantees that all billets are filled by personnel of the appropriate designator and rank combination or an allowable substitute. Constraint set (2) ensures that only one option is chosen for each function. Constraint set **(3)** guarantees that the number of FACG substitutions does not exceed the number of FACG billets available for each personnel type. Constraint sets (4) and (5) specify variables as binary and non-negative, respectively.

IMPLEMENTATION AND COMPUTATIONAL EXPERIENCE

The prototypic model is expressed in the General Algebraic Modeling System (GAMS) [Brooke, Kendrick, and Meeraus, 19881, which generates it and solves it with the Optimization Subroutine Library (OSL) [e.g., Wilson and Rudin, 1992]. ROOM contains approximately 20,000 continuous variables, 300 binary variables, and 1,400 constraints. Each excursion reached an optimal solution within one minute on a Pentium-100 based personal computer.

N464 considers a subset of the Pearl Harbor functions eligible for outsourcing (hereafter called the "N464 subset"). N464 identified functions in this subset as offering the greatest potential for savings. Kerman [1997] provides a complete list of all 109 functions in the Pearl Harbor data set and the 23 functions in the N464 subset. ROOM also considers all functions for outsourcing to see what further savings are possible by expanding the "N464 subset." The data set contains 341 personnel designators and 41 specific ranks. Note that we use the generic term "designator" to refer to civilian series, enlisted rating, or officer designator. Similarly, the term "rank" encompasses civilian level, enlisted rate, and officer rank. We form two primary test cases by considering either the N464 subset or all functions eligible for outsourcing.

Most of the Pearl Harbor data set comes from N464. Homebasing information has been provided by the total force programming and manpower office for the Department of the Chief of

Naval Operations. Homebasing data are based upon a 70 percent homebasing policy, meaning that 70 percent of rotating personnel should remain in the same location for their next assignment. We estimate training costs based upon a subjective relative desirability of personnel substitutions into specific billets.

Regionalization, outsourcing, and "no change" options are available for each function. When examining the functions individually (function by function), the best myopic option is that with the lowest cost. To demonstrate the advantage of using ROOM, we first find this best myopic option for each function. ROOM would make these same recommendations if it did not consider homebasing adjustments or allow personnel substitutions. Table 2 shows the number of functions myopically selected for each option and compares these results to ROOM's optimal recommendations for the cases where the N464 subset and all functions are eligible for outsourcing. This table shows a significant difference in recommendations. Clearly, not all of the lowest-cost options can be supported under homebasing in both cases. Kerman [1997] details results at the function level.

Functions eligible for outsourcing		N464 subset			All	
Recommendation	Regionalize	Outsource	No Change	Regionalize	Outsource	No Change
ROOM total	21	14	74	13	59	37
Myopic total	106	0	3	***55***	47	7
Difference	85	14	71	42	12	30

"Summary functions" are aggregate function categories and descriptions formed from multiple IMFCs. The 109 Pearl Harbor functions data set are combined into 36 summary functions. Table 3 shows ROOM's recommendations by summary functions. Out of all 109 functions, ROOM recommends 21 for regionalization, 14 for outsourcing, and 74 to remain the same when the N464 subset is eligible for outsourcing. When all functions are eligible for outsourcing, ROOM proposes 13 for regionalization, 59 for outsourcing, and 37 to remain the same. In this case, eight functions previously recommended for regionalization and 37 functions previously recommended to remain the same are now recommended for outsourcing. Many of

the facilities-and-realestate, base operations, and personnel and professional support functions shift. Due to the personnel availability and substitutability constraints, opposing shifts occur in family housing, freight transportation, printing and publications services, and other personal and family services summary functions.

Functions eligible for outsourcing	N464 subset			All		
Function Description	Regionalize	Outsource	No Change	Regionalize	Outsource	No Change
Facilities & Real Estate						
Property Management and Utilities	1	2	0	1	2	0
Utilities Operations and Maintenance	0	1	1	0	1	1
Family Housing	0	2	0	0	1	1
Bachelor Quarters	0	0	4	0	2	2
Environmental Services	1	0	4	0	4	1
Base Operations						
Security	2	0	6	2	4	2
Communications	0	0	3	0	3	0
Command and Staff	0	0	3	0	3	0
Administrative Support Functions	2	0	1	2	1	0
Safety Services	2	0	1	0	3	0
Emergency Services	0	0	3	0	1	2
Port Operations	0	0	5	0	1	4
Air Operations	0	0	3	0	2	1
Weapons Handling Operations	0	0	3	0	2	1
Logistics Support						
Procurement	2	0	1	1	2	0
Passenger Transportation	2	1	1	2	1	1
Freight Transportation	0	1	3	0	0	4
Retail Supply Services	3	0	5	2	2	4
Fuel Services	0	0	3	0	0	3
Personnel & Professional Support						
Legal Services	0	0	5	0	4	1
Public Affairs Support	2	0	2	0	4	0
Military Personnel Services	0	0	4	0	4	0
Civilian Personnel Management	0	0	1	0	1	0
Resource Management	1	0	2	0	3	0
Printing and Publications Services	0	2	0	0	0	2
Data Processing and Audio Visual Services	0	3	0	0	3	0
Services Provided to Individuals						
Food Services	1	0	1	1	0	1
Laundry Services	0	0	1	0	1	0
Educational Services	0	0	1	0	0	1
Religious Programs	0	0	1	0	1	0
Family Services	0	0	1	0	1	0
Child Care Services	0	0	1	0	0	1
Other Personal and Family Services	0	2	0	0	1	1
Morale, Welfare, and Recreation Services	2	0	2	2	0	2
Training						
Training	0	0	1	0	1	0
Non Installation Management						
Non-Installation Management Functions	0	0	1	0	0	1
TOTALS	21	14	74	13	59	37

Table 3. ROOM recommendations for the Pearl Harbor Naval Installation by summary functions. For example, ROOM suggests regionalizing one environmental service function and leaving four unchanged when the N464 subset **is** eligible for outsourcing. When all functions are eligible for outsourcing, ROOM recommends outsourcing four environmental service functions and leaving one the same.

ROOM quantifies the total costs and savings of the optimal combination of regionalization and outsourcing options. We use the term "savings" for the reduction in personnel cost less training costs; this includes the salary difference allowed by personnel substitutions but does not include any moving costs or savings from the 70 percent homebasing policy. ROOM first determines the original cost of meeting all billet requirements without regionalizing or outsourcing personnel. This original cost is the sum of the yearly salaries of all personnel in the installation's current personnel complement. For Pearl Harbor, the original cost is about $681.8 million. By myopically selecting the best option for each function, the lowest possible cost is $620.1 million, a savings of $61.7 million. ROOM computes the minimum total planned cost of implementing the optimal combination of regionalization and outsourcing options. The one-year savings is the optimal cost subtracted from the original cost. The one-year savings is $9.5 million (15 percent of the myopic savings) when the N464 subset is eligible for outsourcing; $3.7 million of this savings is from personnel substitutions and $5.8 million is due to outsourcing. The one-year savings increases to $29.2 million (47 percent of the myopic savings) when all functions are eligible for outsourcing; ***$2.2*** million of this savings comes from personnel substitutions and outsourcing accounts for the other $27 million in savings. The $19.7 million difference in savings between having the N464 subset and all functions eligible for outsourcing is motivation to expand the N464 subset.

ROOM allows personnel additions, removals, and substitutions to be fractional. However, all Pearl Harbor results were intrinsically integer. This is not guaranteed for all cases.

ROOM recommends only one option for each function, but the LP relaxation of ROOM can provide fractional recommendations. When the N464 subset is eligible for outsourcing, both ROOM and the LP relaxation of ROOM yield the same results. With all functions eligible for outsourcing, however, ROOM's LP relaxation recommends fractional outsourcing of four summary functions. Kerman [1997] provides further details.

Sensitivity Analysis

A sensitivity analysis of ROOM's recommendations is performed by varying both the training costs and FACG substitutions allowed. Table 4 summarizes the results of varying the training costs when the N464 subset is eligible for outsourcing. The training costs are varied **as** a

percentage (fraction) of the absolute value of the difference between the salaries of the person required to fill the billet and the person substituted into the billet. Notice that the model recommends only one change as the training cost fraction increases from 0.2 to 0.3. The changed function shifts from an outsourcing to a "no change" recommendation. Also, note that the total training costs increase about a half million dollars for each 0.1 increase in the training cost fraction. This trend continues until the training cost fraction is above 0.5. At this point, ROOM is substituting fewer personnel of different ranks and assigning more personnel of the required rank. The total training costs decrease at a 0.7 training cost fraction, slightly increase at 0.8, and then continue on a downward trend after 0.8. Ultimately, ROOM outsourcing or regionalizing decisions are insensitive to changes in the training costs when the N464 subset is eligible for outsourcing.

N464 subset eligible for outsourcing					
Training Cost Fraction	Regionalize	Outsource	No Change	Total Training Cost ($M)	One-Year Savings ($M)
0.1	21	14	74	0.5	10.0
0.2	21	14	74	1.1	9.5
0.3	21	13	75	1.5	9.0
0.4	21	13	75	2.0	8.4
0.5	21	13	75	2.5	7.9
0.6	21	13	75	2.9	7.4
0.7	21	13	75	1.8	7.1
0.8	21	13	75	1.8	6.8
0.9	21	13	75	1.3	6.7
1.0	21	13	75	1.2	6.5

Table 4. ROOM recommendations under varying training costs when the **N464** subset of functions is eligible for outsourcing. Training costs are varied from 10 to 100 percent of the absolute value of the difference between the salaries of the person required to fill the billet and the person substituted into the billet. ROOM recommendations are insensitive to changes in the training costs; only one function recommendation changes as total training costs vary between $0.5 million and $2.9 million.

Table 5 summarizes the results of varying the training costs when all functions are eligible for outsourcing. Again, the training costs are varied as a percentage of the absolute value of the difference between the salaries of the person required to fill the billet and the person substituted into the billet. In this case, ROOM recommendations persist for training cost fractions between 0.4 and 0.9. A large change in ROOM prescriptions follows training cost

fraction increases from 0.3 to 0.4. Four functions shift from recommendations to remain the same to outsourcing. Overall, only seven functions out of the 109, or approximately 6.4 percent, shift recommendations as the training cost fraction varies. Again, ROOM is insensitive to changes in training costs when all functions are eligible for outsourcing. The trend in the total training costs is similar to the case in which only the N464 subset is eligible for outsourcing.

All functions eligible for outsourcing					
Training Cost Fraction	Regionalize	Outsource	No Change	Total Training Cost ($M)	One-Year Savings ($M)
0.1	13	57	39	0.3	29.5
0.2	13	58	38	0.6	29.2
0.3	13	57	39	0.9	28.9
0.4	13	61	35	1.1	28.6
0.5	13	61	35	1.2	28.3
0.6	13	61	35	1.1	28.1
0.7	13	61	35	1.1	27.9
0.8	13	61	35	0.5	27.8
0.9	13	61	35	0.3	27.8
1.0	13	62	34	0.2	27.8

Table 5. ROOM recommendations under varying training costs when all functions are eligible for outsourcing. Training costs are varied from 10 to 100 percent of the absolute value of the difference between the salaries of the person required to fill the billet and the person substituted into the billet. ROOM recommendations are insensitive to changes in the training costs; only seven function recommendations change as total training costs vary between $0.2 million and $1.2 million.

A sensitivity analysis is also performed by varying the number of allowed FACG substitutions over multiple model runs. The results of this analysis indicate that ROOM recommendations, optimal costs, total training costs, and total savings are insensitive to changes in the number of allowed FACG substitutions at Pearl Harbor.

A combined model that simultaneously varies training costs and the number of allowed FACG substitutions yields similar results. The optimal costs and recommendations vary slightly with changes in the training cost fractions, but remain constant for changes in the number of allowed FACG substitutions.

Extending the Model Results over Several Years

ROOM computes annualized values for the savings and total training costs. The total training costs apply only to the first year since we assume they are paid up-front when an

individual substitutes into the billet. The savings are recurrent and may apply to several years beyond the first year. To ascertain the approximate amount of money that the Navy will save over several years, we apply a standard discount rate to the annual savings and use a net present value (NPV) analysis.

Three percent is the standard discount rate used for each year [Defense Technical Information Center, 1997]. ROOM with the N464 subset eligible for outsourcing is the base case, yielding savings of approximately $10.5 million and a total training cost of $1.0 million. Therefore, the first-year savings are about $9.5 million, and the gross savings over three years are $30.5 million. Applying NPV analysis over three years, these savings correspond to about $28.8 million in present dollars. This analysis assumes that personnel rotate jobs after three years, which is reasonably accurate for Navy shore billets.

CONCLUSIONS AND STATUS

While regionalization and outsourcing decrease the number of available billets on a shore installation, homebasing generally increases the number of available personnel requiring billets. Disregarding combined effects and homebasing, the least-cost (myopic) option for Pearl Harbor is to regionalize 106 functions, outsource none, and keep three the same, saving $61.7 million in personnel costs annually. ROOM's optimal solution for the N464 subset, accounting for the combined effects and homebasing, recommends regionalizing only 21 functions and outsourcing 14 functions, giving first-year savings of $9.5 million, or 15 percent of the myopic savings. When all functions are available for outsourcing, ROOM recommends regionalizing 13 functions and outsourcing 59 functions, resulting in a first-year savings of $29.2 million, or 47 percent of the myopic savings. Assuming associated training costs occur only in the first year and savings occur over three years, the net present value of expected savings is $28.8 million for the N464 subset.

ROOM was developed at the invitation of N46, but N464 is not using it. N464 projects an annual savings of $18 million under its own regionalization plan for Pearl Harbor [Department of the Navy (N464), 1997]. We do not know the analytic basis for either the plan or its projected savings, whether it is myopic, or even how it would be completed at realistic detail. But, ROOM does show with the same data that these projected savings may be overly optimistic

because N464 does not consider the possible cost associated with homebasing and N464 does not always consider personnel at the level of designator and rank. ROOM's inclusion of homebasing offers the Navy better decisions.

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