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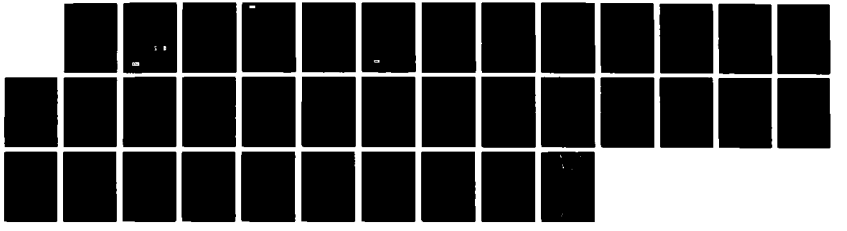

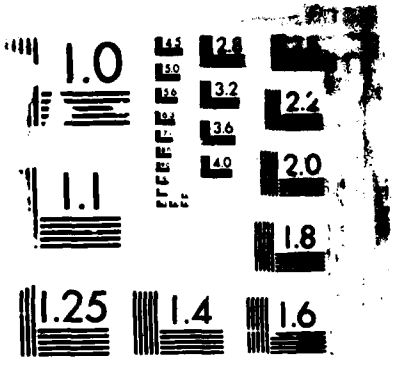
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RESEARCH MEMORANDUM

COMPARISON OF CIVILIAN AND MILITARY OVERHEAD SPENDING: THREE CASE STUDIES

Daniel B. Levine
Colin P. Hammon

CENTER FOR NAVAL ANALYSES

Work conducted under contract N00014-82-C-0814

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Ref: (a) CNR 73, May 1984

Encl: (1) CRM 84-8, "Comparison of Civilian and Military Overhead Spending: Three Case Studies," by Daniel B. Levine and Colin P. Hammon, May 1984

1. Enclosure (1) and reference (a), which will be provided under separate cover, constitute the final report of work conducted by CNA for the Office of the Assistant Secretary of Defense for Manpower, Installations and Logistics under contract N00014-82-C-0814 and purchase order N00014-84-M-0086.

2. Enclosure (1) looks at three kinds of base operating support (BOS) activities that are also performed by the private sector: maintenance of family housing, clerical support and operation of airfields. It compares the military and civilian funding levels to gauge whether the military services are performing these activities efficiently.

3. Enclosure (1) is forwarded for information and retention as a matter of possible interest.

Phil E. DePoy
Director of Research

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COMPARISON OF CIVILIAN AND MILITARY OVERHEAD SPENDING: THREE CASE STUDIES

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ABSTRACT

This paper looks at three kinds of base operating support (BOS) activities that are also performed by the private sector: maintenance of family housing, clerical support, and operation of airfields. It compares the military and civilian funding levels to gauge whether the military services are performing these activities efficiently.

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INTRODUCTION

This paper reports the results of one of a series of analyses of base operating support (BOS) performed by the Center for Naval Analyses (CNA) for the Office of the Secretary of Defense under contract N00014-82-C-0814.

Results of the other analyses, which all used a cost estimating relationship (CER) methodology, were published in "Tri-Service Analysis of BOS Costs" [1]. Because the analysis reported here did not use the CER methodology and was inconclusive, it is being issued separately.

This paper responds to OSD's request that CNA identify several kinds of BOS activities that are also performed by the private sector, and compare the military and private spending levels. We studied three activities that are not essentially "military" and that are carried out in the private sector as well: maintenance of family housing, clerical support, and operation of airfields.

Such military-private comparisons are an attempt to obtain indirect evidence on efficiency at relatively low cost. Private organizations consider both costs and benefits when they decide how much to spend on these activities. If DoD is funding these activities at about the same level as the private sector, this suggests that costs and benefits are in reasonable balance in the military sector as well.

TASK 1: MAINTENANCE OF FAMILY HOUSING

Maintaining family housing is the same activity in the private and military sectors. The distribution of sizes and types might vary, but there is nothing "military" about the military houses or how they are maintained.

The question of interest is whether military installations are spending a reasonable amount to maintain their family housing. Specific questions are whether the services are providing the right level of upkeep, and whether they are performing the upkeep at the lowest cost.

The analysis is limited to on-base military housing. Military families who live off the base spend what they wish on maintenance. Since base pay, Basic Allowance for Quarters (BAQ) and Variable Housing Allowance (VHA) can be spent for anything--food, recreation, etc.--the "off-base issue" is one of total compensation, not housing maintenance.

Maintenance of Military Family Housing

Military housing maintenance costs (table 1) were obtained from the Defense Housing Management Systems Office (OSD Manpower, Installations, and Logistics). The figures for the Navy include the Marine Corps. The high Navy total is due to high "M&R (maintenance and repair) of

dwellings," which is due, in turn, to especially high Marine Corps costs in this category: $2,666 per family vs. $1,455 per family for the Navy alone. (The $1,769 is a weighted average).

TABLE 1

MILITARY HOUSING MAINTENANCE COSTS
(FY 1982 costs in dollars)

	Average expenditure per family			
	Army	Navy	Air Force	All DoD
M&R of dwellings[a]	1,231	1,769	1,275	1,396
M&R of exterior utilities[a]	76	87	73	78
M&R of other property[a]	117	177	155	149
Alterations & additions[a]	8	2	26	13
Regular improvements[b]	76	166	322	197
Energy improvements[b]	226	116	83	140
Minor construction[b]	29	33	10	22
Total[c]	1,762	2,349	1,944	1,995

[a]Expenditures listed under Maintenance of Real Property in the Family Housing portion of the Operations & Maintenance appropriation.
[b]From the Post Acquisition Construction entries under the Family Housing portion of the Military Construction appropriation.
[c]Some columns do not add up due to rounding.

Maintenance of Private Family Housing

The first five categories of private housing cost (table 2) were calculated from data in a Census Bureau survey of 6,200 households.

These figures include the same expenditure categories as in the military costs. Two adjustments were made to further increase comparability. First, many private homeowners do some repair work on their own houses, whereas service personnel are often encouraged to leave everything to the base's maintenance crew. Table 2 includes only the materials for the do-it-yourself projects. We estimated the labor costs by noting that commercial home repairs generally run twice the cost of materials. The expenditures for labor (plus capital) are thus about the same as for materials, so we imputed a labor cost equal to the Census Bureau's figure for the cost of building materials purchased by the owner. For the second adjustment, we assumed that private families

move half as frequently as military families, and added in an extra share of yearly painting costs for purposes of comparability.

TABLE 2

PRIVATE HOUSING MAINTENANCE COSTS[a]
(CY 1982 costs in dollars)

	Average expenditure per property[b]			
	0,1	0,2-4	R,1	R,2-4
Maintenance and repair	183	223	228	561
Additions to residential structure	45	26		
Alterations to residential structure	170	225	125	337
Additions/alterations to property outside of residential structure	97	30		
Major replacements	135	117	134	230
Adjustments				
Imputed labor	30	30	30	30
Extra painting	68	68	68	68
Total	728	719	585	1,226
Per family[c]	728	240	585	409

[a]From [2].
[b]0,1 = owner occupied, 1 unit. 0,2-4 = owner occupied, 2-4 units. R,1 = solely renter occupied, 1 unit. R,2-4 = solely renter occupied, 2-4 units. The costs for rented property are those paid by the owner, whether any of the units are occupied by the owner or not. Reference [2] refers to a 1975 study that showed that expenditures by renters account for only 2 percent of all expenditures.
[c]The costs for 2-4 family units have been divided by 3, the midpoint.

Comparison of Results

Tables 1 and 2 show that military expenditures are well over twice as large as private expenditures, with an absolute dollar differential of around $1,500 per family. Some of this differential is due to a reporting bias: a difference in accounting methods between the military and private data. The military costs in table 1 include neighborhood improvements like maintaining water, gas, and electricity lines. These costs are paid for by property taxes in the private sector and thus not picked up in the Census Bureau's household survey. The extent of this bias is at most $200, the second and third entries from table 1, those

containing neighborhood activities. Eliminating these entries reduces the military-private differential to $1,300.

Our analysis thus shows that the military does spend more for housing maintenance. The question is "Why?" There are three possibilities: 1) the services are keeping their housing in better repair than are private households, 2) the level of repair is about the same, but the services are less efficient in providing it, and 3) the military houses are larger, older, or have other features that make them harder to maintain.

There is some "soft" evidence against the first two possibilities. The Navy conducted a survey of personnel attitudes several years ago and found that family housing was a major source of discontent. This supports the conventional wisdom that military personnel are not living better than their civilian counterparts. On the question of efficiency, the Logistics Management Institute's review of past contracting-out of military housing maintenance projects under OMB Circular A-76 found that commercial firms typically save only 27 percent over military costs [3]. Even this figure is an overestimate because the sample includes only those cases where the commercial firm won the competition with the military. That suggests the military is not simply inefficient, spending much more to perform the same maintenanc. A 27-percent saving is better than nothing, but it doesn't explain much of the military-private differential we have estimated.

That leaves the third possibility, that there is something about military houses that make them harder to maintain. That's what the conventional wisdom says, and we have found some support for it. The theory is that military housing was neglected for many years, and that the services have decided, with the concurrence of OSD and Congress, to spend more money on housing to reverse the decay. The strategy is to modernize and make energy-conservation improvements in many of the older houses in hopes of reducing their periodic maintenance costs in years to come, eventually making it possible to provide good living quarters within moderate budgets. These modernization costs are presumably what is pushing up the military housing costs shown in table 1. There is a military-private differential because private households have been modernizing their older houses all along.

Aggregate data support this theory. Figure 1 shows a definite upward shift in military family housing costs in the early 1970s (in constant dollars). There are large fluctuations from year to year, but the steady-state level rose about 33 percent, from $1.5 billion to $2.0 billion. The figures in table 1 support the claim that some of this increase is for modernization to reduce periodic maintenance. The DoD total of $1,995 per family is about 23 percent higher than the $1,623 for the three M&R entries alone.

Detailed data are at least consistent with the theory. The older military houses do cost more to maintain (table 3). This leaves open the hope that the services' modernization program will, in time, reduce costs. Data from the private sector support this hope. Older private homes cost no more to maintain than newer ones (table 4).

To estimate the maximum returns DoD could obtain from the military's housing modernization program, we assumed that modernizing an older military house would lower the maintenance cost per square foot to that of the newest military houses. This would reduce the DoD-wide average cost per family from $1,995 (table 1) to $1,172 (calculation not shown). That is much closer to the $700 for private homes (table 2). We would have to look elsewhere to explain the remaining differential.

TASK 2: CLERICAL SUPPORT

Navy-Wide

Military and private organizations perform similar kinds of clerical tasks in their day-to-day business: meeting the payroll, keeping personnel records, managing procurement projects, etc. Because these tasks are general in nature, we expect that military and private organizations of similar size would employ similar numbers of clerical workers. To see whether this is so, we compared the clerical support used by the Department of the Navy with that used by various classes of industries in the business sector.

Summary figures show that about 11 percent of the Navy's uniformed and civilian workforce is formally assigned to clerical tasks (table 5). Personnel in non-clerical ratings are sometimes used for clerical tasks on a temporary basis, but the number cannot be easily estimated.

Clerical workers used by private industries are shown in table 6. (The data are a year or two older than the Navy data, but conditions should be stable enough for general comparison.)

The figures in tables 5 and 6 suggest that the Navy is not overinvesting in clerical support. Its 11-percent usage rate is much lower than that of the four industries in the bottom half of table 6, the industries with which the Navy is most comparable. These industries are

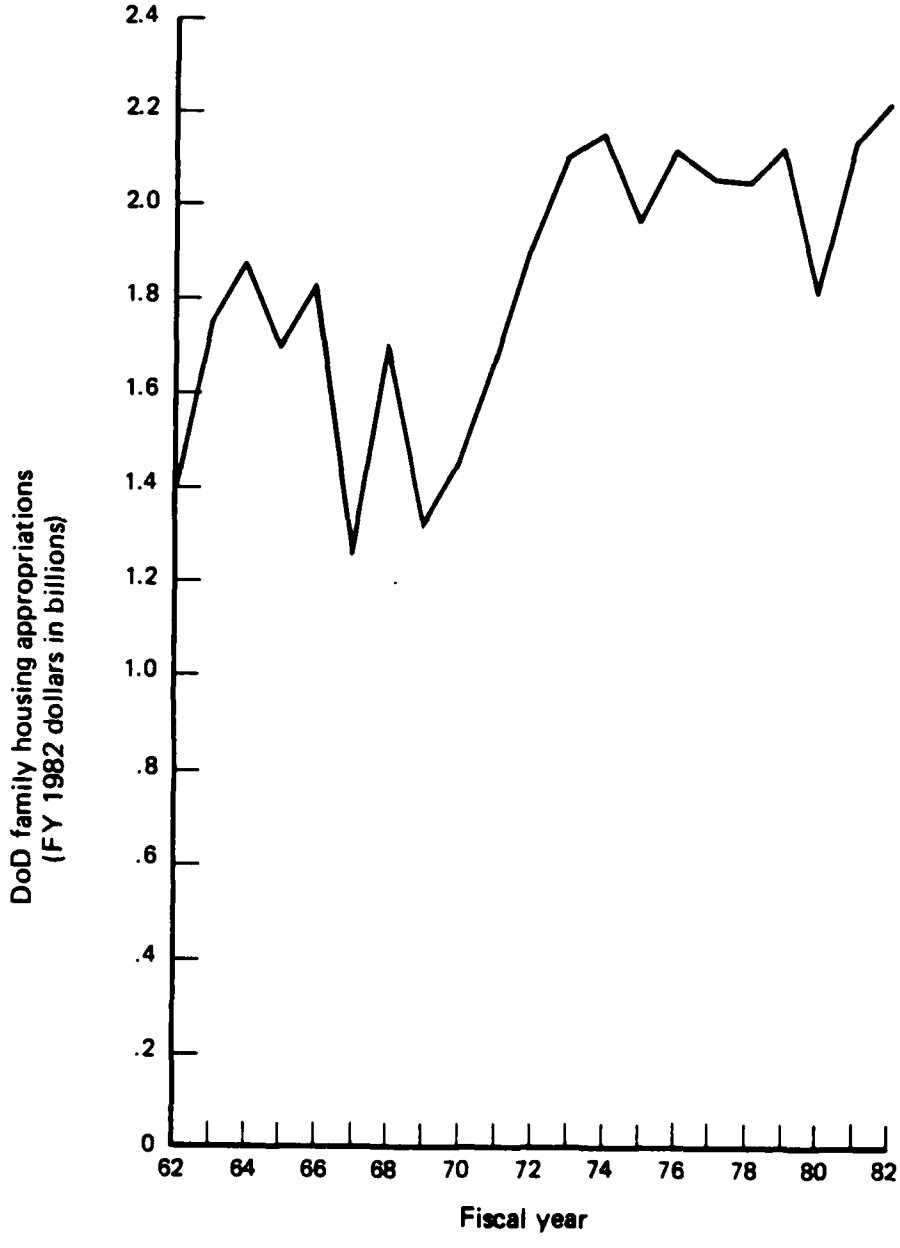

FIG. 1: TRENDS IN DOD FAMILY HOUSING APPROPRIATION

TABLE 3

MILITARY HOUSING MAINTENANCE SPENDING VS. AGE
(FY 1982 costs)

Type of house[a]	Year built	Average area (sq. ft.)	Average cost ($ per sq. ft.)
a (wherry)	early 1950s	1,077	1.72
b	1970-82	1,390	0.74
c	1950-70	1,270	1.14
d	pre-1950	2,211	1.54
e (substandard)	mostly 1940-50	893	2.76

[a]Designations used by the Defense Housing Management Systems Office.

TABLE 4

CIVILIAN HOUSING MAINTENANCE SPENDING VS. AGE[a]
(Single unit, owner occupied)

Year built	Average expenditure per family, CY 1982 dollars
1980 to 1982	708
1970 to 1979	716
1960 to 1969	674
1950 to 1959	509
1940 to 1949	621
Before 1940	627

[a]From [2].

TABLE 5

NAVY USE OF CLERICAL WORKERS

	Total workers	Clerical workers (percent of total)	
Uniformed			
Rated	—	38,094[a]	
Trainees	—	11,885[b]	
	536,483[c]	49,979	(9.3)
Civilian	338,743[d]	43,465[d]	(12.8)
Total	875,226	93,444	(10.7)

[a]Yeoman (YN), aviation storekeeper (AK), disbursing clerk (DK), data processing technician (DP), administrative cryptologic technician (CTA), legalman (LN), personnelman (PN), and storekeeper (SK). Figures from Defense Manpower Data Center for September 1980.

[b]Estimated from the number of rated clerical personnel by assuming:

$$(\text{trainees/ratings})_{\text{clerical}} = (\text{trainees/ratings})_{\text{total}}$$

= 31.2%, the current Navy-wide average.

[c]From [4]; figures for March 1981.

[d]Op-15 Personnel of the Naval Shore Establishment (PONSE) report; figures for March 1983.

TABLE 6

PRIVATE USE OF CLERICAL WORKERS

Industry	Percent of employees doing clerical work[a]
Agriculture	2.5
Construction	7.0
Mining	11.4
Manufacturing	12.0
Wholesale and retail trade	17.5
Services	19.3
Transportation and public utilities	22.6
Finance, insurance and real estate	45.1

[a]From [5]; figures for 1979.

relatively labor intensive and thus require much record keeping for payroll and training, government accounting purposes, and EEO requirements. The top two industries in table 6, with usage under the Navy's 11 percent, are less labor intensive and often deal in large projects, which have less clerical overhead costs per dollar of expenditure.

Three Individual Bases

What is true for the Navy as a whole might not be true for individual bases. Some bases might be very efficient and others very inefficient, even though the Navy-wide average compares favorably with the civilian sector. We checked on this by looking at three bases for which data were easily obtained (table 7).

TABLE 7

USE OF CLERICAL WORKERS AT SELECTED INSTALLATIONS[a]

	Naval Air Station, Moffett Field			Naval Air Station, Oceana			Naval Training Center, Orlando		
	Total	Clerical		Total	Clerical		Total	Clerical	
Uniformed									
Rated[b]	1,349	123	(9%)	1,319	113	(9%)	1,104	39	(4%)
Trainees[c]		38			35			12	
Civilian	455	162	(36%)	360	109	(30%)	1,026	275	(27%)
Total	1,804	323	(18%)	1,679	257	(15%)	2,130	326	(15%)

[a]FY 1981 data.
[b]The bases had readily available data for only the four largest clerical ratings (YN, DK, SK, and PN). We scaled up the figures, using the fact that these ratings were 77 percent of the total rated clerical population in 1983.
[c]Estimated by assuming the current 31.2-percent ratio of trainees to rated personnel (see table 5, footnote b).

These bases used 15-18 percent of their uniformed and civilian workforce for clerical tasks (last line of table 7), compared to only 11 percent for the Navy as a whole. But this is still at the low end of the similar private industries in table 6. It is curious, however, that the three bases use so many of their civilians for clerical tasks--27 to 36 percent--compared to only about 13 percent for the Navy as a whole

(table 5). Perhaps the number of civilians doing clerical work is under-reported in the Navy-wide data.

TASK 3: AIRFIELD MAINTENANCE

Maintaining airfields is another activity that is carried out in both the military and private sectors. We compared 12 naval air stations and a Military Airlift Command (MAC) Air Force Base (McChord) with SEA-TAC, the Port of Seattle International Airport. SEA-TAC is the only private airfield we could get quick and easy access to, but it is not a random selection. SEA-TAC is generally regarded as a very well-run field.

SEA-TAC and the military airfields were compared using four measures of base operating support (BOS) resource use: 1) BOS cost per building area, 2) BOS cost per landing, 3) BOS personnel per building area, and 4) BOS personnel per landing. For comparability, we estimated SEA-TAC's "BOS cost" by adding up the expenditures for those types of activities that are included in BOS for military airfields: maintenance of terminal and airfield, utilities and custodial services, administrative overhead, fire and police protection, and passenger support services. The full comparison is reported in the appendix and summarized in table 8.

TABLE 8

MILITARY VS. PRIVATE AIRFIELD BOS[a]

	BOS cost per area ($/sq.ft.)	BOS cost per landing ($/landing)	BOS personnel per area (people/1000 sq.ft)	BOS personnel per landing (people/1,000 landings)
SEA-TAC	7.7	140	0.20	3.7
Range of military airfields	4.6-24[b]	78-2,500	0.19-0.90[c]	4.0-93.5

[a]From table A-4 of the appendix.
[b]Omitting McChord Air Force Base, whose value of $65 per square foot lies far beyond the values for the other bases.
[c]Omitting McChord Air Force Base, whose value of 2.16 people per thousand square feet lies far beyond the values for the other bases.

In each measure, SEA-TAC is near the lower (more efficient) end of the range of values of the military fields. Some of the higher costs of the military fields could be due to the distinctly military nature of

some of their tasks. In addition to moving people and cargo like the civilian fields, the naval air stations support ASW operations, train pilots, and perform some BOS functions for tenants, such as Naval Air Rework Facilities. The costs of these activities may not be fully reflected in output measures such as building area and landings.

It's curious, however, that the MAC terminal (McChord AFB), whose principal task of moving people and cargo is like that of the civilian fields, compares so poorly with SEA-TAC and the naval air stations in BOS cost and BOS personnel per square foot (see footnotes b and c of table 8). McChord is, however, in step with the air stations in terms of BOS cost and BOS personnel per landing.

REFERENCES

[1] CNA, Report 73, "Tri-Service Analysis of BOS Costs," by Daniel B. Levine and Philip M. Lurie, Unclassified, May 1984

[2] U.S. Bureau of the Census, Report C50-82-A, "Residential Alterations and Repairs: Annual 1982," Apr 1983

[3] Logistics Management Institute, "How Winners Win: Lessons Learned From Contractor Competition in Base Operations Support," by John B. Handy and Dennis J. O'Connor, Unclassified, May 1984

[4] "People." Defense 81, Sep 1981:20

[5] U.S. Bureau of Labor Statistics, Bulletin 2070, Handbook of Labor Statistics, Dec 1980

APPENDIX

COMPARISON OF CIVIL AND MILITARY AIRFIELD MAINTENANCE COSTS

APPENDIX

COMPARISON OF CIVIL AND MILITARY AIRFIELD MAINTENANCE COSTS

This appendix documents the comparative analysis of civilian and military airfield maintenance costs that is described in task 3 of the main text.

DATA BASE

A complete summary of operations and maintenance cost data was obtained from the Port of Seattle SEA-TAC International Airport, along with its planning manual and a description of its maintenance organization.* SEA-TAC data were analyzed and compared with DoD's Domestic Base Factors Report (DBFR) and flight statistics data for selected military air stations. This preliminary analysis indicates that a comparative study of BOS costs and decision criteria for BOS spending at civil and military airports is both feasible and desirable. The initial study indicates that data are available and that sufficient comparability exists for a meaningful comparison to be made.

Available data included:

- Domestic Base Factors Report (DBFR) file for 1982
- Chief of Naval Operations Flight Activity Report for Naval Aircraft
- Port of Seattle Budget Comparison Report (Report GLR513) for Airport Operations and Maintenance
- Port of Seattle SEA-TAC International Airport Maintenance Department Management Manual
- Port of Seattle SEA-TAC International Airport Traffic and Operations Report, 19 January 1983
- Summary of Airport Survey Results for a survey conducted 18-22 April 1983 by SEA-TAC Maintenance Department.

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* The airport name was recently changed to the Henry M. Jackson International Airport. This action was appealed by petition and (non-binding) referendum, and is currently being reconsidered. For brevity, the name SEA-TAC will be used in this paper.

SEA-TAC INTERNATIONAL DATA

Table A-1 shows the number of passengers, amount of cargo, and number of aircraft operations for SEA-TAC International for 1981 and 1982. An aircraft operation is either a takeoff or landing. For purposes of this study, SEA-TAC aircraft operations divided by two are counted as number of landings. The same procedure is used for McChord Air Force Base. Table A-2 is a summary of SEA-TAC statistics comparable to DBFR data. These were derived from various documents and internal records provided by the Port of Seattle. The building area shown in table A-2 does not include aviation hangars, except those of United Air Lines and Northwest. In general, hangars are leased by the carriers, who are completely responsible for maintenance. Utilities, including electricity, sewage, water, steam, and industrial waste disposal, are purchased by the air carriers from the Port of Seattle. Natural gas is bought directly from Washington Natural Gas Company. This study therefore includes utilities, except natural gas, without including all of the building area that uses the utilities. Total square feet of building area and gas usage could be obtained for a follow-on study.

The entire police department is included. The police department, however, handles everything from traffic to capital crimes on Port of Seattle land. Additionally, much of the airport police effort is devoted to drug seizures and investigation. Including the entire police department probably inflates the number of BOS personnel and dollar cost relative to the military airfields.

Table A-3 lists those operations and maintenance costs that can be identified as comparable to military BOS costs. These amounted to $20.6 million in 1982 and represented 68 percent of SEA-TAC's total operations and maintenance costs.

FINDINGS

Table A-4 lists selected DBFR data plus number of flights and number of landings for selected naval air stations, McChord Air Force Base and SEA-TAC International Airport. The particular military bases were chosen because they offer a variety of acreage, building area, and aircraft types. Three of the bases, Kingsville, Chase Field, and Whiting, are training bases. McChord Air Force Base is primarily a Military Airlift Command base and is located approximately 15 miles from SEA-TAC. The base's mission, size, and location are comparable to those of SEA-TAC International.

TABLE A-1

SEA-TAC INTERNATIONAL AIRPORT OPERATING DATA 1981-1982

	1982	1981
Passengers		
Domestic passengers - In	4,274,979	4,080,562
Domestic passengers - Out	4,242,833	4,070,076
Subtotal - Domestic passengers	8,517,812	8,150,638
International passengers - In	395,125	500,511
International passengers - Out	365,800	466,496
Subtotal - International passengers	760,925	969,007
Total passengers - In	4,670,104	4,581,073
Total passengers - Out	4,608,6233	4,536,572
Passenger grand total	9,278,737	9,117,645
Cargo (Metric Tons)		
Air mail - In	27,063	25,615
Air mail - Out	23,633	23,580
Subtotal - Air mail	50,696	49,195
Air freight - In	63,648	70,862
Air freight - Out	84,338	90,573
Subtotal - Air freight	147,986	161,435
Total cargo - In	90,711	96,477
Total cargo - Out	107,971	114,153
Cargo grand total	198,682	210,630
Operations		
Air carrier	138,415	141,015
Air taxi	49,040	39,400
Military	356	477
General aviation	23,583	27,053
Total operations	211,394	207,945

Source: Port of Seattle SEA-TAC International Airport Traffic and Operations Report, Report OP-0100-01, 19 January 1983.

TABLE A-2

SEA-TAC INTERNATIONAL AIRPORT
PHYSICAL PLANT AND EMPLOYEE DATA

Total land area	2,400 acres
Building area	
Main terminal plus satellites, includes flight kitchen	1,845,000 gross square feet
Air cargo 1 and 2 buildings	91,619 GSF
Total	1,936,619 GSF
BOS personnel	
Maintenance department	130
Contract cleaning	130
Fire department	63
Police department	68
Total	391
Utilities	
Electricity	80,768 million KWH (23,665 MBTU)
Natural gas	146,000 MBTU
Total	169,665 MBTU
Heating degree days	5,185
Cooling degree days	184

TABLE A-3

SEA-TAC INTERNATIONAL AIRPORT
MAINTENANCE AND SELECTED OPERATING COSTS
(dollars)

802	Administrative direct management[a]		612,529
803	Administrative maintenance[a]		777,318
806	Central control		206,977
820	Water distribution[a]	160,245	
821	Electric distribution[a]	1,620,185	
822	Industrial waste[a]	132,076	
823	Sewer[a]	146,863	
	Natural gas	708,733[b]	
	Total utilities		2,788,102
824	Roads and grounds[a]		418,738
850	Airfield operations and maintenance[a]		931,314
860	Passenger terminal operations and maintenance	2,424,012	
	Less: baggage handling	951,084[c]	
	satellite transit	1,314,515[c]	
	Total		158,413
861	Passenger terminal overhead		1,723,367
	Operations (heating plant, lighting supplies, etc.)		219,600
870	Parking garage		110,899
	Leased areas		51,827
804	Fire department[a]		2,557,879
805	Police department[a]		4,237,030
	Total		14,933,993

[a]Includes both operations and maintenance. Only maintenance is included for the remaining activities.
[b]Heat allocated to maintenance and fire departments subtracted to avoid double counting. Natural gas is metered direct to tenants except in the terminal building, flight kitchen, and air cargo buildings.
[c]These systems unique to SEA-TAC.

TABLE A-4

SELECTED DOMESTIC BASE FACTOR REPORT DATA,
ANNUAL FLIGHTS AND LANDINGS, AND AVERAGE BASE OPERATING COSTS (1982)

Key	Name	AREA Building area GSF (000)	ACRE Field area (acres)	FLTS Annual no. of flights (000)	LNDG Annual no. of landings (000)	BOS COST Total BOS (M $)	BOSP Number[a] of BOS personnel	BOSP/ AREA	BOSP/ LNDG	BOS COST/ AREA		BOS COST/ LNDG	BOSP/ FLTS	BOS COST/ FLTS
A	South Weymouth	1,003	2,238	6.600	18.159	13.208	575	0.57	31.7	1.3	E-2	0.73	87.1	2.0
B	Willow Grove	1,180	1,177	6.776	11.422	28.728	1,068	0.90	93.5	2.4	E-2	2.5	157.6	4.2
C	Glenview	1,283	1,285	5.948	11.911	9.417	406	0.32	34.2	0.73	E-2	0.79	68.9	1.6
D	Kingsville	1,524	5,582	47.502	177.186	13.852	706	0.46	4.0	0.91	E-2	0.078	14.9	0.29
E	Chase Field	1,602	9,633	41.458	160.360	15.226	667	0.42	4.2	0.95	E-2	0.095	16.0	0.37
F	Whiting	2,024	11,121	21.177	137.644	19.661	949	0.47	6.9	0.97	E-2	0.14	44.7	0.93
G	Barbers Point	2,369	32,778	8.793	37.062	30.457	1,048	0.44	28.3	1.1	E-2	0.82	119.2	3.5
H	Brunswick	2,479	7,254	4.784	17.957	27.603	1,324	0.53	73.7	1.1	E-2	1.5	276.9	5.8
I	Moffett	3,321	3,909	7.618	35.821	28.439	1,821	0.55	50.8	0.85	E-2	0.79	239.0	3.7
J	Whidbey Island	4,365	71,042	19.440	56.464	69.256	2,142	0.49	37.9	1.6	E-2	1.23	109.8	3.6
K	Norfolk	7,486	3,200	26.313	125.214	114.407	3,317	0.44	26.5	1.5	E-2	0.91	126.1	4.3
L	Alameda	8,538	2,720	9.802	22.923	39.242	1,662	0.19	72.5	0.46	E-2	1.7	169.6	4.0
M	McChord	1,003	7,199	98.188	49.094	64.835	2,169	2.16	44.2	6.5	E-2	1.3	22.1	0.66
S	SEA-TAC	1,936	2,400	211.394	105.697	14.934	391	0.20	3.7	0.77	E-2	0.14	1.8	0.07

[a]Includes military, civilian, and contract.

The numbers of flights and landings were chosen as measures of output with some comparability across services, and between military and civil airports. BOS costs and decision criteria are not exactly comparable between military and civilian activities. For example, military personnel assigned to BOS activities also perform military duties. Military personnel should therefore be counted at some fraction of their strength. The fraction is an empirical matter and can be determined objectively. Similar calculations should be performed for measures of output. A civil airport cannot be exactly comparable to a military airport unless their missions are the same. Comparing additional civil airports and primary MAC airfields is one of the recommendations of this paper. In general, numbers of landings and flights are related to mission in a somewhat different way for different bases. For example, a training base would be expected to have more flights and more landings for a given level of BOS than, say, a P-3 patrol aircraft base. Both, however, should be related by some factor that can be determined.

Figures A-1 through A-7 are graphs of average cost using numbers of BOS personnel (BOSP) and BOS dollars (BOS COST) as measures of input, and building area (AREA), number of landings (LNDG), and number of flights (FLTS) as measures of output. Previous CNA BOS analyses showed that building area is a good predictor of BOS cost. This is logical in that much of BOS cost has to do with maintenance, heat, or serving the people who occupy the buildings. Table A-5 lists energy usage for the sample. More straightforward measures of output are the annual numbers of landings and flights, and these are used in generating the average cost curves shown in figures A-3 through A-7.

Building Area

Curves have been sketched in by eye on figures A-1 and A-2. The curves exhibit increasing returns to scale, as would be expected. SEA-TAC and NAS South Weymouth, Glenview, Kingsville, and Chase Field show up as low-cost airfields. South Weymouth and Glenview are relatively small, primarily reserve bases. Figure 2 shows Whidbey Island, Norfolk, and McChord well above the curve, and they are treated as outliers. These average cost curves are uncontrolled for other variables and one can only speculate why these three points are where they are.

It must be noted that a straight line could be drawn through either set of data points. The dashed lines show one possibility. Only McChord Air Force Base is an outlier in this case. However, either a monotonic decreasing curve as sketched, or a "U" shaped average cost curve would be more in agreement with theory.

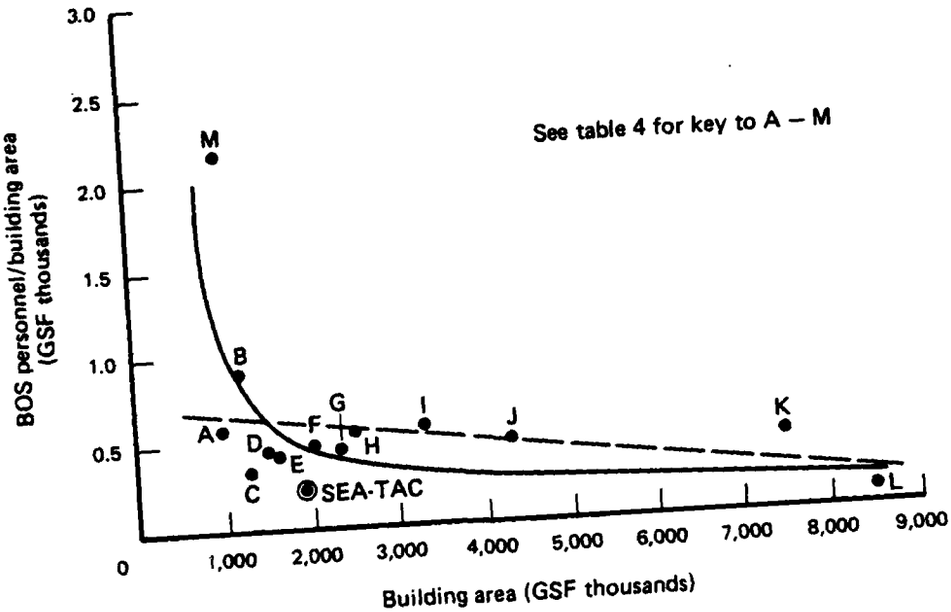

FIG. A-1: AVERAGE COST CURVE, NUMBER OF BOS PERSONNEL RELATIVE TO AREA OF BUILDINGS

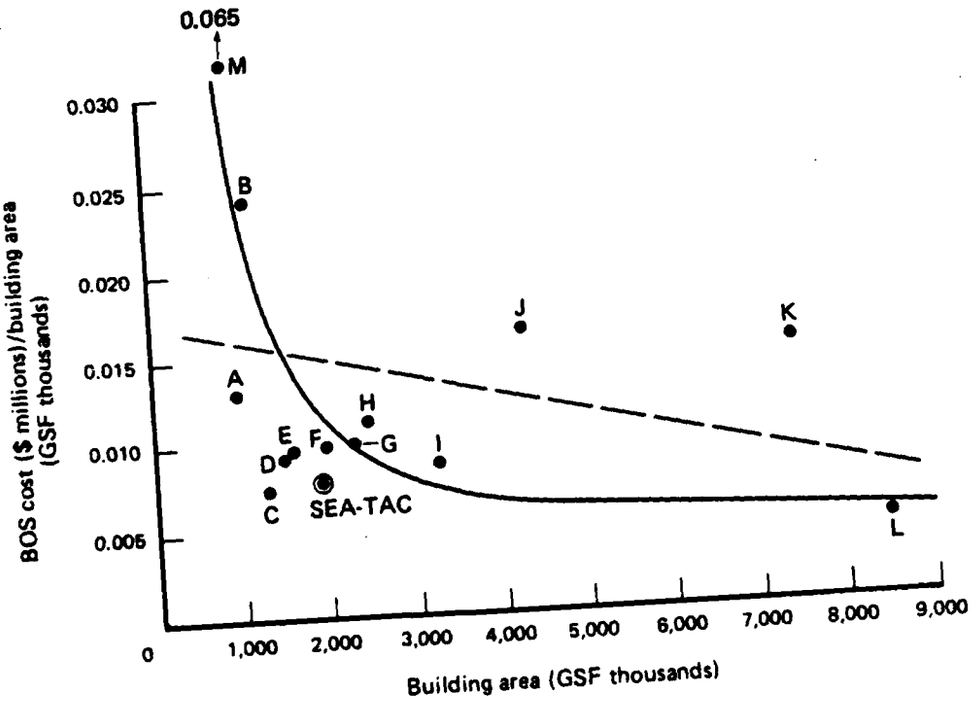

FIG. A-2: AVERAGE COST CURVE, BOS COST RELATIVE TO AREA OF BUILDINGS

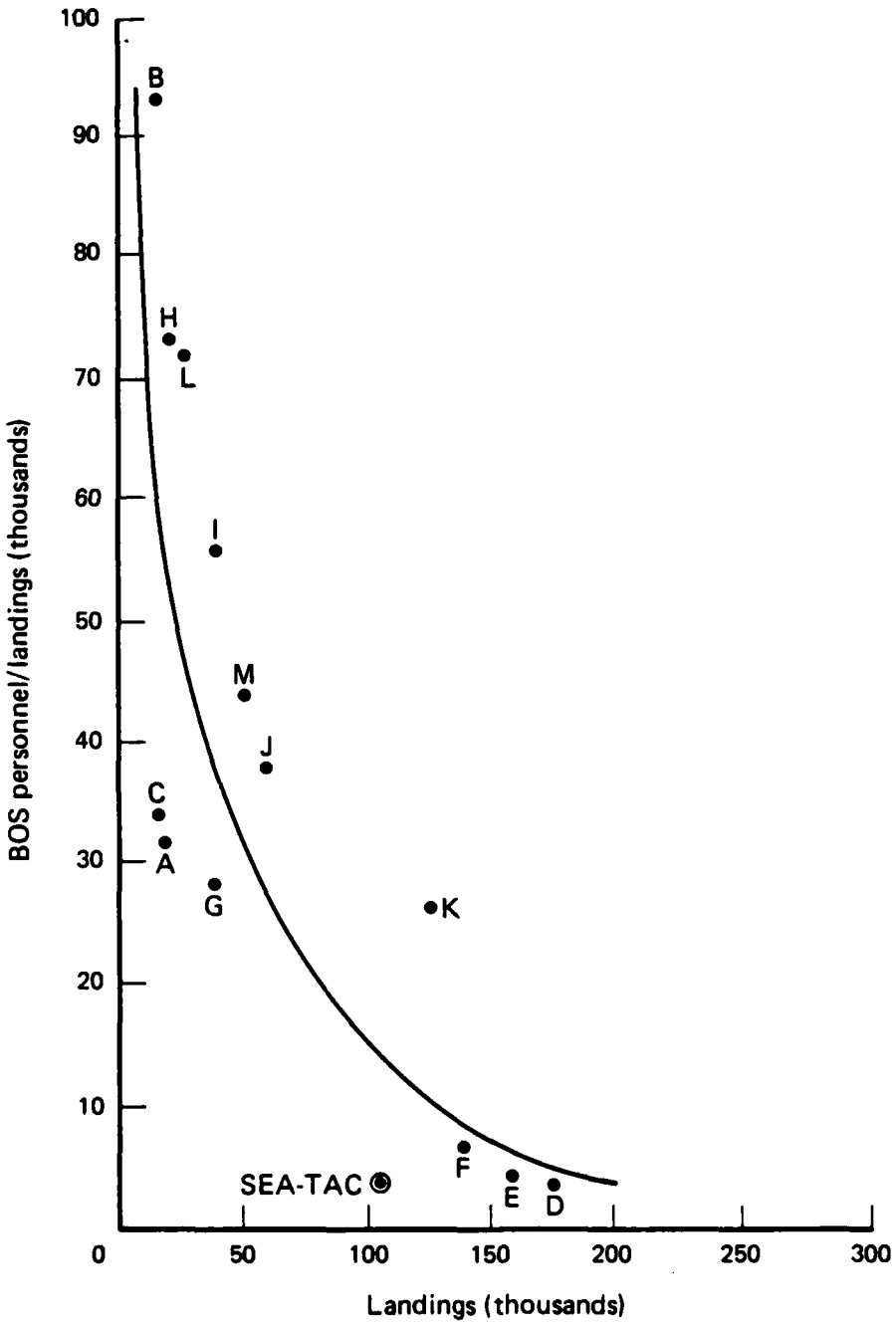

FIG. A-3: AVERAGE COST CURVE, NUMBER OF BOS PERSONNEL RELATIVE TO NUMBER OF LANDINGS

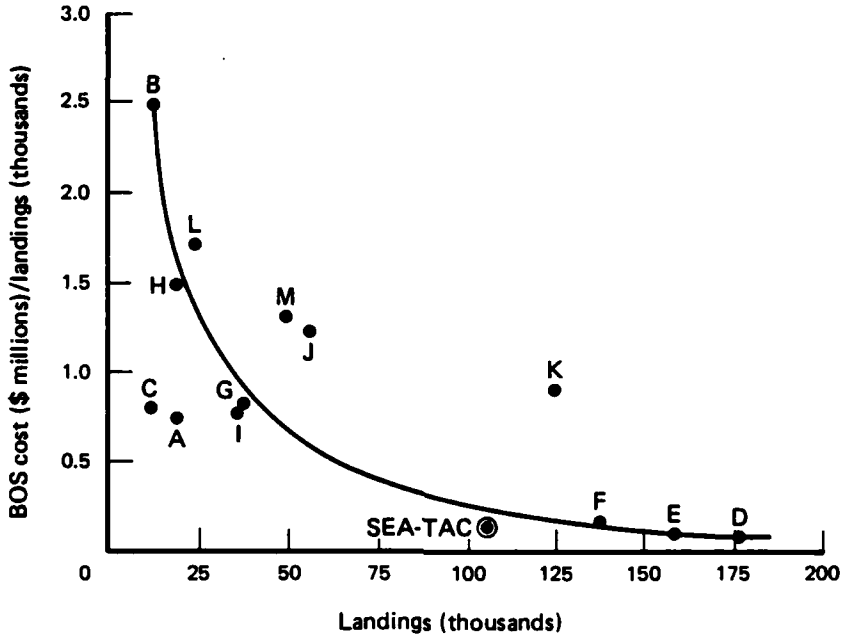

FIG. A-4: AVERAGE COST CURVE, BOS COST RELATIVE TO NUMBER OF LANDINGS

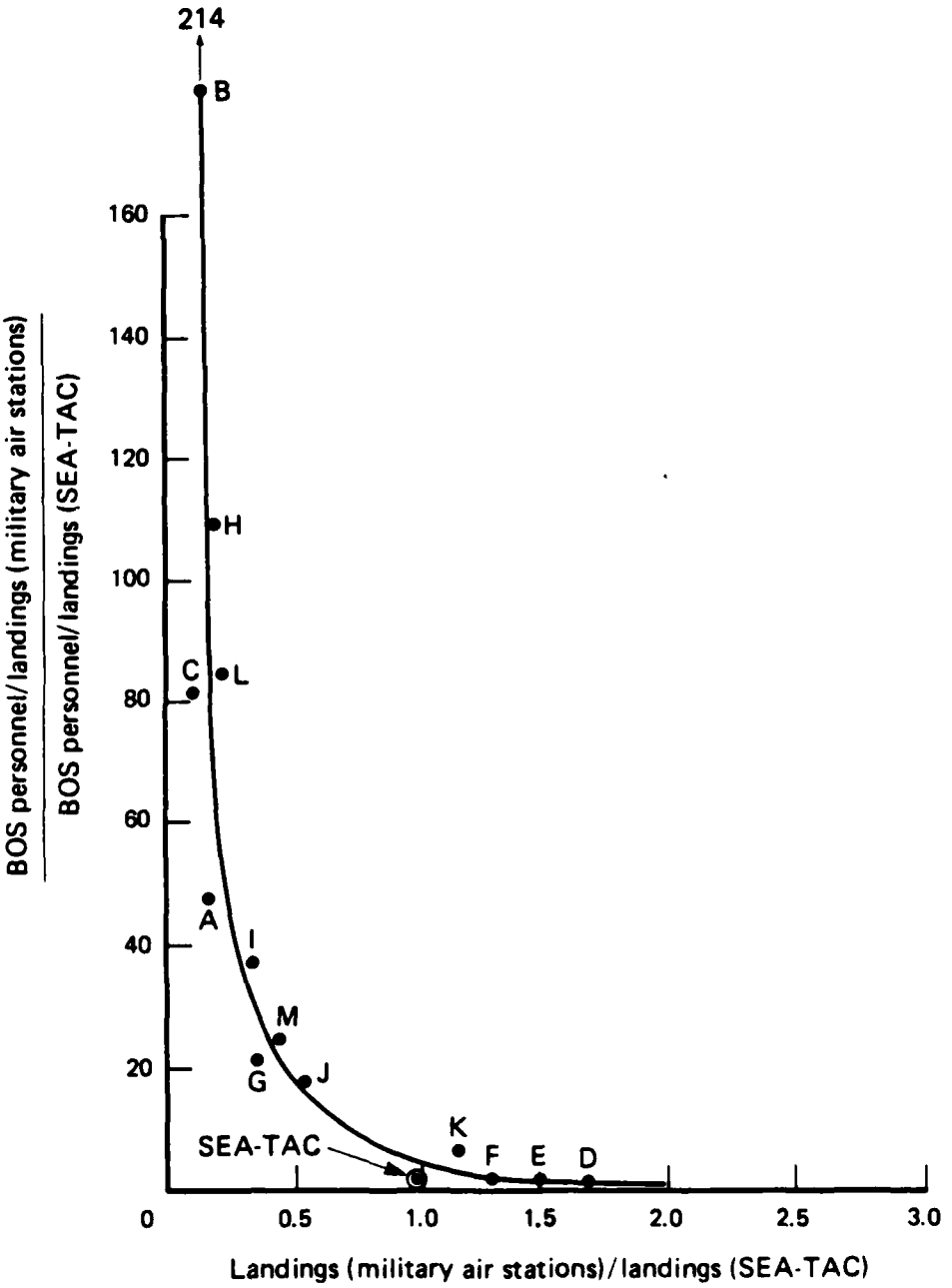

FIG. A-5: AVERAGE COST CURVE, MILITARY AIR STATIONS RELATIVE TO SEA-TAC

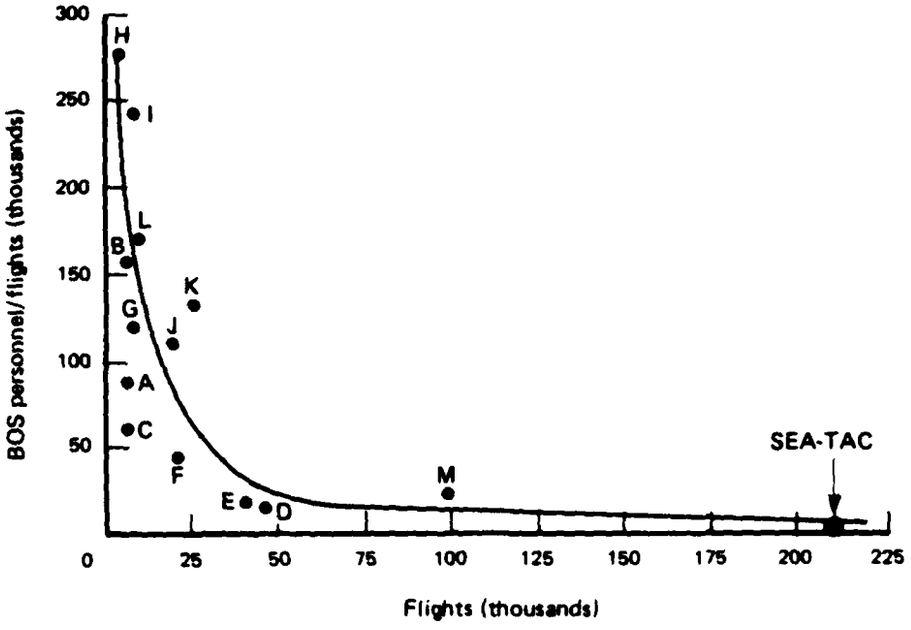

FIG. A-6: AVERAGE COST CURVE, BOS PERSONNEL RELATIVE TO NUMBER OF FLIGHTS

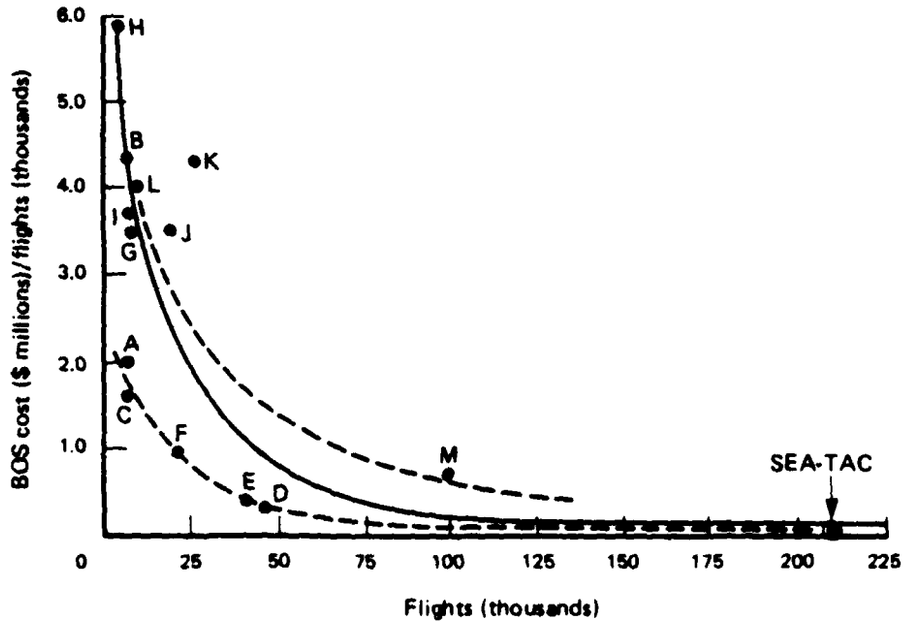

FIG. A-7: AVERAGE COST CURVE, BOS COST RELATIVE TO NUMBER OF FLIGHTS

TABLE A-5

SELECTED DOMESTIC BASE FACTOR REPORT DATA AND SUMMARIZED ENERGY AND WEATHER DATA

Key	Name	AREA Building area GSF (000)	ACRE Field area (acres)	FLTS Annual no. flights (000)	LNDG Annual no. landings (000)	BOS COST Total BOS (M $)	BOSP Number[a] of BOS personnel	Electric (MWH)	Other energy (MBTU)	Total energy (MBTU)	Deg. Days Heat / Cool
A	South Weymouth	1,003	2,238	6.600	18.159	13.208	575	8,300	127,487	129,917	5,621 66
B	Willow Grove	1,180	1,177	6.776	11.422	28.728	1,068	16,811	762,864	767,790	4,953 968
C	Glenview	1,283	1,285	5.948	11.911	9.417	406	10,073	186,085	189,036	6,497 664
D	Kingsville	1,524	5,582	47.502	177.186	13.852	706	29,413	47,766	56,384	930 3,474
E	Chase Field	1,602	9,633	41.458	160.360	15.226	667	30,173	57,083	66,824	930 3,474
F	Whiting	2,024	11,121	21.177	137.644	19.661	941	26,601	209,134	216,928	
G	Barbers Point	2,369	32,778	8.793	37.062	30.457	1,048	18,974	15,011	20,570	0 4,221
H	Brunswick	2,479	7,254	4.784	17.957	27.603	1,324	26,352	354,501	362,122	
I	Moffett	3,321	3,909	7.618	35.821	28.439	1,821	33,351	253,870	263,642	3,042 108
J	Whidbey Island	4,365	71,042	19.44	56.464	69.256	2,142	79,142	416,294	439,483	5,185 129
K	Norfolk	7,486	3,200	26.313	125.214	114.407	3,317	105,247	1,080,732	1,111,569	3,488 1,441
L	Alameda	8,538	2,720	9.802	22.923	39.242	1,662	190,240	1,029,286	1,085,026	2,909 128
M	McChord	1,003	7,199	98.188	49.094	64.835	2,169	77,324	448,143	470,800	5,530 101
S	SEA-TAC	1,936	2,400	211.394	105.697	14.934	391	80,768	146,000	169,665	5,185 184

[a] Includes military, civilian, and contract.

Number of Landings

Figures A-3 and A-4 show about the same pattern as figures A-1 and A-2, with regard to low- and high-cost bases. The data points are much more consistent with the assumed curve form. Figure A-5 also shows this consistency of data points and the relation of SEA-TAC. This curve is generated by dividing the data points plotted in figure A-3 by the SEA-TAC value and is another representation of figure A-3. The picture is perhaps clearer because of the scale.

Number of Flights

Average cost curves, using number of flights as the measure of output, are graphed in figures A-6 and A-7. Note that these curves are considerably different from those in figures A-3 and A-4. For all but SEA-TAC and McChord, each flight may produce several landings. As a result, the relative location of data points changes between the LNDG and FLTS graphs. Note that the McChord and SEA-TAC data points appear more like they are from the same population in figure A-6 than in figures A-3 and A-4. In figure A-7, the graph could be interpreted as two curves that differ by a parameter. (See the dashed curves in figure A-7.) For the Navy bases, flights are perhaps a better measure of output than landings; a flight could generate many touch-and-go landings, which should not be expected to increase BOS costs to the same extent as number of flights.

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