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OPTEMPO AND TRAINING EFFECTIVENESS

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OPTEMPO AND TRAINING EFFECTIVENESS

Linda C. Cavalluzzo*

Abstract

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ABSTRACT

The primary purpose of nondeployed operations is to prepare personnel for deployment. This paper looks at evidence amassed to date of the association between nondeployed activities and training readiness. For ships, activity is measured in alternative models by fuel consumption, days underway per quarter, and time spent in particular underway activities such as training, operations, and transit. For aircraft, the value of nondeployed flying hours is measured in alternative models by test scores, landing proficiency, and bombing accuracy. Results confirm a positive association between nondeployed activity and training readiness for both ships and aircraft.

OPTEMPO AND TRAINING EFFECTIVENESS

1. INTRODUCTION

The primary mission of the nondeployed fleets of the U.S. Navy (USN) is to prepare personnel for deployment. On-the-job training while underway allows a crew to work as an integrated unit in a hands-on setting. But it is very expensive, and until now, no one from the analytical community has tried to measure the readiness payoff of the expenditure. Thus, it is not possible to say with any degree of precision what would be gained by stepping up nondeployed activities, or conversely, what would be lost by cutting back. Although more work is needed, preliminary estimates of the association between nondeployed activity and training readiness, based on a variety of measures, are positive.

2. SHIP ANALYSES

The USN speaks of "optempo" (operational tempo), the number of days underway per quarter, when discussing the intensity of activity in the fleets. It has always been assumed that larger fuel budgets, by allowing a rise in optempo, would increase the skills of those destined to man the forward forces of the USN. But translating fuel dollars to training readiness, while conceptually sound, is a less-than-trivial endeavor. Identifying appropriate measures of input and output is the first and primary problem, so the discussion now turns to sources of data, highlighting their strengths and weaknesses.

2.1 Input Measures

Since we are concerned primarily with evaluating the marginal payoff to fuel dollars, fuel consumption is an obvious variable for consideration. Fuel consumption's greatest advantage is that analytical results have an appearance, at least, of bearing directly on the budget. It is an "appearance" in the sense that historical associations can be expected to predict future ones only if fuel continues to be used for roughly the same purposes and with roughly the same efficiency as in the past. In other words, fuel acts merely as a proxy variable for underlying productivity-enhancing activities that take place as fuel is consumed.

To the extent that rising fuel prices lead to more efficient rates of fuel consumption, estimates of the productive value of fuel will be underestimated. There are a number of ways in which fuel may be used more efficiently. One way is to slow down. Presumably, the same training can go on whether a ship steams at 15 or 20 knots. At the slower speed, however, fuel usage can be stretched out, permitting more training per fuel dollar. A second method of fuel preservation is to cut back use of the engines themselves. During the FY 1982 USN ship-fuel budget decline, commanders from the U.S. Pacific Surface Fleet discovered that ships could be safely operated

on a single screw, with the second shut down, at considerable savings [1]. In addition, these officers found that some exercises traditionally conducted at sea could be executed in port, again with substantial savings. As a result, Pacific Fleet readiness officers found that fuel cutbacks had a transitory negative effect on training readiness, but that over time, operational adjustments returned readiness to pre-1982 levels [1]. Put another way, the association between use of fuel and the underlying variable it is intended to represent is subject to sporadic changes over time, making fuel less than ideal as a proxy for productive activity. In addition, since fuel is consumed whether a ship is in port or underway, albeit at different rates, it provides only a vague indication of ship activity.

Steaming hours underway is a somewhat better input measure. It brings us a step closer to our conceptual notion of activity by separating time underway from speed, concepts that are intertwined in the fuel measure. The alternative measure also permits direct analyses of optempo, the USN's yardstick of budgeted activity. In spite of the advantages, steaming hours underway still give an incomplete picture of training effectiveness, since any number of things may be going on while a ship is at sea.

A richer data source originates from Type Commanders, who give very detailed orders to ships under their operational control. These orders, or ship employment schedules, are dispensed quarterly and prescribe the full menu of daily activities that each ship is to undertake. At the end of the quarter, ships return their schedules to the fleet commands, noting any deviations from the original agenda. Finally, the employment schedules are routed to the Fleet Operations Readiness and Navy Command Center (Op-643), where they are corrected to reflect actual activity and retained. Although the schedules are classified before their execution, they are downgraded to unclassified 90 days after completion of the quarter.

The employment schedules use over 400 distinct "employment terms" to describe the daily agenda of the U.S. fleets. The terms are grouped into 27 numeric categories that provide generic descriptions of activities, such as inspections, major exercises, and support services. These data likely represent the single most accurate and detailed records of any aspect of the U.S. surface Navy.* An example of the data file is provided in table 1.

* Because the data are used to convey orders, and Type Commanders require reports on deviations from those orders, the data should be quite accurate. Some deviations between actual and stated activity must, however, be expected. According to sources in Op-643, the data are 80-90 percent accurate.

TABLE 1

FF 1062 EMPLOYMENT HISTORY
4/15/81 - 5/29/81

<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>
<u>BDate</u>	<u>EDate</u>	<u>Dur</u>	<u>Type</u>	<u>Term</u>	<u>Cat</u>	<u>Suf</u>	<u>Location</u>
810415	810415	01	2	IPT	07	A	Subic Bay
810416	810422	07	2	ESC	20	B	South China Sea
810423	810427	05	2	TRANSITEX	10	B	Middle Pacific
810428	810527	30	2	LVUPK	05	A	Pearl Harbor
810504	810522	19	3	IMAV	04	A	Pearl Harbor
810528	810529	02	2	TYTIPT	15	A	Pearl Harbor

Table 1 displays an excerpt from the employment records of the USS Whipple, a Knox-class frigate. In the example, the Whipple was returning from an overseas deployment. The records indicate that on 15 April 1981, the Whipple was in port (IPT) in Subic Bay, a not-underway activity (Suf A). For the next 7 days, the Whipple acted as an escort vessel (ESC). That this is an underway activity is indicated by the "B" in column 7. Over the next 5 days, the ship remained underway, conducting training exercises while in transit. TRANSITEX is a joint exercise, as indicated by generic category 10 in column 6. At the end of the month, the ship returned from its deployment for a 30-day leave and upkeep (LVUPK). Looking at column 4, one sees, as indicated by record type 2, that LVUPK was the primary activity during the period. Concurrent with that (record type 3), the ship was undergoing an IMAV, or intermediate maintenance availability. Finally, the maintenance availability was followed by an in-port training activity.

From the foregoing description, it is clear that employment histories afford researchers the unusual luxury of choosing the desired level of precision in any analysis involving ship activity. One may focus study on specific activities, designated by the employment term; generic activities, designated by employment categories; or at the most aggregate level, days underway, designated by the employment suffix. Because there are so many employment terms, a good first cut at the data would attempt to relate the generic "categories" to training effectiveness. Table 2 describes the employment categories and shows how they were combined into five descriptors of underway activity in the analyses discussed below.

The detail contained in the employment records gives rise to a difficult accounting issue. Specifically, what activity should be credited to a day listing concurrent activities? One approach would be to credit the day to the primary activity. This rule is simple to implement since there is one and only one primary activity for every calendar day. The problem with the approach is that it may

misrepresent the true distribution of ship activities. Lengthy underway activities, for example, are often broken up by weekends in port, which are listed concurrently. In such a case, it is clear that the two activities cannot be taking place simultaneously. Alternatively, a ship may reasonably participate in several activities concurrently, or in succession, over the course of a day. How one chooses to count the activities will depend on familiarity with the employment records, familiarity with the surface Navy, and personal judgement. In the analyses described below, activity refers to primary activity. Future analyses will test the sensitivity of the results to other accounting schemes.

TABLE 2
UNDERWAY SHIP ACTIVITIES

<u>Activity</u>	<u>Category^a</u>	<u>Description</u>
Transit	24	Transit
Training	2	Sea trials
	9	Joint exercises
	10	Major exercises
	11	Training exercises
	12	Training
	13	Training inspections
	14	Training support services
Operations	20	Operations
	21	Patrol surveillance
Support	25	Project support
Other	7	Logistics miscellaneous
	18	Public affairs events
	23	Logistics maintenance support
	26	Other

^aCategories shown are based on [2]. Historical data, which categorized terms in accordance with previous versions of [2], were regrouped to conform with current methodology.

2.2 Output Measures

Ideally, we would like to merge ship employment histories with objective indicators of training readiness to derive estimates of the learning value associated with different ship activities. One candidate measure would be a ship's operational readiness, as indicated by

the number of Casualty Reports (CASREPs) filed.* In a 1977 study, Horowitz and Sherman related CASREPs to the experience mix of ships' personnel [3]. They report that ships experience fewer major equipment malfunctions when more experienced personnel are aboard. If we think of experience as cumulative training, their results offer a measurable payoff to training. From the point of view of the current research, however, CASREPs have distinct disadvantages. The most important is that CASREPs indicate the level of a ship's operational capability and say nothing about the ability of the crew to make use of functioning equipment. Therefore, one cannot draw inferences about the fighting capabilities of an available warfare unit. A better analysis would use output measures that bear more directly on the proficient use of available platforms.

Scores of specific shipboard exercises are required of non-deployed crews before they are considered ready for deployment. But disaggregate analyses of all of the exercise data would present a monumental task, whereas analyses of only a handful of exercises would raise questions about the selection of reported results and their implications for the broader training program, particularly if results were mixed. A good first cut can be made at the data, however, through the Unit Status and Identity Report (UNITREP).

UNITREP is the official reporting mechanism used to convey timely readiness information to the Joint Chiefs of Staff. Readiness is reported in four dimensions: personnel, training, material condition, and supplies on board. The UNITREP training-readiness index (CRTRNG) is a composite measure, relative to prescribed requirements, of shipboard exercises satisfactorily completed, personnel who have attended formal schools, and personnel qualified to oversee watch-stations.

There is no apparent reason to expect the formal-schooling component of training readiness to be related to steaming. At the same time, this input is quite stable and influenced only by personnel turnover. As a result, formal schooling has a more significant influence on the level of the training-readiness index than on changes in the index over short intervals. Watch-station qualifications, on the other hand, are a clear reflection of on-the-job training. Time at sea increases the opportunities for personnel to learn the operations of a station well enough to supervise a watch-station in a safe and efficient manner.

The exercise component of CRTRNG should also be influenced by steaming since, other things being equal, more steaming time permits the successful completion of more exercises. In the absence of ample steaming time, skills acquired through explicit exercises will naturally decay, and this decay is reflected in the computation of

* Casualty Reports are filed in the event of material malfunctions that are expected to result in equipment downtime of 48 or more hours.

the exercise component of training readiness for each primary mission area. CRTRNG, the readiness measure used in the analyses below, is a composite reflection of readiness in each of the primary mission areas.

CRTRNG scores range from C1 to C5 where: C1 indicates full combat readiness; C2 indicates that the unit is "substantially" combat ready; C3 indicates "marginal" combat readiness; C4 identifies a unit with such major deficiencies that it cannot effectively perform the wartime mission for which it is designed; and C5 indicates that a unit is not readily available for combat. C5 status is reserved for such circumstances as overhaul or major equipment conversion.

The advantages of CRTRNG as a measure of training readiness are clear:

- It is a composite measure.
- It is the USN's official indicator of training readiness.
- It is an automated system.
- It records readiness data on a daily basis.

As a result, the data may be combined with the employment histories to obtain a concise picture of activities and associated readiness. The merged data file permits a relatively speedy, broad-brush look at the training effectiveness of various underway activities for a large sample of ships over time.*

3. BUDGETARY CHANGES AND READINESS

3.1 Historical View

Between FY 1977 and FY 1983, the cost of fuel rose dramatically, and the Navy's cash outlays for surface-ship fuel increased from \$332 million to \$1.1 billion, or 245 percent. These outlays translated to a real budget increase of only 11 percent over the same period, however. As shown in table 3, the real budget changes were sporadic over the period: declining during the FY 1977-78 and FY 1982-83 periods and increasing over FY 1978-79 and FY 1980-81.

* The drawbacks to CRTRNG as an indicator of readiness are also clear. The index responds slowly to individual readiness elements, and more importantly, it does not measure performance.

TABLE 3

REAL CHANGE IN NAVY FUEL BUDGET
FY 1977 - FY 1983

	Percentage change between fiscal years						
	77-78	78-79	79-80	80-81	81-82	82-83	77-83
Total surface-ship fuel budget	-4					-10	11
Budget per ship ^a							
Carriers	-11					-32	-5
Cruisers	-11				-2	-23	-34
Destroyers	2				-8	8	19
Frigates	-3				6	-4	6
Patrol combatants	25	-44			10	27	3
Amphibious vessels	2	-7	12	19	2	-5	19
Mine warfare vessels	28	39	-35	-4	-23	66	41
Mobile logistic ships	2	2	11	1	-8	-9	17
Support ships	5	30	-20	29	-15	29	45

NOTE: Real budget changes are measured in terms of barrels.

SOURCE: [4].

^aConventionally powered surface ships only.

The distribution of the increasing fuel budget among ship categories shows that historically the expanded budget has not been shared equally. The fuel allotment for support ships increased by 45 percent over the 6-year period, while the allotment to conventionally powered carriers and cruisers fell by 5 percent and 34 percent, respectively. Remaining ship groups experienced gains more modest than that of support ships. For budget planning purposes, however, how fuel dollars are shared is less important than the relationship between fuel dollars and ship readiness. We now turn to that issue.

3.2 Statistical Implications

We estimated the equation:

$$\ln\left(\frac{C_{j,t}}{1-C_{j,t}}\right) = \alpha_0 + \alpha_1 BA_{j,t} + \sum_1^8 \alpha_k (\text{SHIPTYPE}_k) \quad (1)$$

where

$C_{j,t}$ = readiness status probability for shiptype j in year t

SHIPTYPE $_k$ = a vector of eight dummy variables controlling for ship type, where $k = 1$, if $k = j$,
 $k = 0$, otherwise,
 and amphibious ships are the control group

BA $_{j,t}$ = average budget allocation per ship, measured by barrels of fuel consumed, for ship type j in year t .

Estimates of the relationship between fuel consumption and training readiness are based on analyses of the Second and Sixth Fleets of the USN for the period 1977-81.

Equation (1) was estimated separately for deployed and non-deployed ships, for each of the training-readiness categories C1 through C4. Observations were weighted by the number of ships represented by a given ship type and year. Finally, the functional form of the model shown in (1) was selected over a linear specification due to the boundary restrictions of the probability measure $C_{j,t}$.*

Estimates of α_j for each of the readiness categories are translated to elasticities at the mean of the data and reported in table 4. These elasticities may be interpreted as the percentage change in readiness caused by a 1-percent increase in the real fuel budget. To take an example, the proportion of time in training-readiness status C1 will go up by 0.34 percent for every 1-percent increase in the fuel budget of nondeployed ships.

TABLE 4

TRAINING-READINESS BUDGET ELASTICITIES

Deployment status	Training-readiness category			
	C1	C2	C3	C4
Nondeployed	.34	-.28	.27	-.43
Deployed	.80	-.88	-4.78	n/a

* It is well known that linear estimation in the presence of a limited-dependent variable produces inefficient, though unbiased, results. Replacement of the dependent probability variable with the log-of-the-odds-ratio is a common alternative [5].

The results are quite interesting. For nondeployed ships, C4 time is replaced by C3 time, just as C2 time is replaced by C1. This analytical result reflects the stepwise improvement that ships experience as they proceed through training evaluations in preparation for deployment. Also of interest is the finding that deployed ships too improve their training readiness as they steam. In this case, C1 time supplants less desirable readiness levels. The results for the deployed ships suggest that designated training exercises are not the only way to gain measurable improvements in readiness.

Given the makeup of the UNITREP index, discussed above, the findings for deployed ships are likely driven by improvements in watch-station qualifications, coupled with stable levels of personnel who have attended formal schools and stable or minimally deteriorating qualifications normally ascribed to explicit training exercises.

4. ALTERNATIVE SHIP ACTIVITIES AND READINESS

In the previous section, we saw that increases in the fuel budget lead to improvements in training readiness for both deployed and nondeployed ships. The results suggest that a variety of underway ship activities improve training readiness. In this section, ship employment histories replace fuel data in a more detailed analysis of the training effectiveness of underway ship activities.

4.1 Historical View

Although training is the primary mission of the nondeployed fleets, historical data show that more than one-third of the time spent underway is devoted to nontraining activities. Table 5 displays the mean distribution of activities on a quarterly basis between October 1978 and June 1984, inclusive.

Notice first that 21 percent of the time spent underway is devoted to transit. Taken together, operations and project support account for another 12 percent of the total time underway in the nondeployed fleets. Operations and project support are typically ordered in response to contemporaneous events that cannot be planned for in the normal scheduling process. Fuel allocations are made in advance of these perturbations to requirements, so when operations and project support exceed planned levels they cut directly into time earmarked for training.

TABLE 5

DISTRIBUTION OF NONDEPLOYED UNDERWAY ACTIVITIES
OCTOBER 1978 - JUNE 1984

Days per quarter (percentage of time underway)

	<u>Operations</u>	<u>Training/ training support</u>	<u>Transit</u>	<u>Project support</u>	<u>Other</u>	<u>Optempo^a</u>
Carriers	3 (9)	27 (75)	5 (15)	0 (0)	0 (0)	36
Other surface combatants	3 (11)	16 (69)	5 (20)	<1 (<1)	<1 (<1)	24
Amphibious vessels	2 (10)	16 (69)	5 (20)	<1 (<1)	<1 (<1)	23
Mobile logistic support force	1 (5)	11 (63)	6 (32)	<1 (<1)	<1 (1)	18
Other ships	7 (26)	13 (50)	5 (18)	1 (5)	<1 (1)	26
All ships	3 (11)	15 (67)	5 (21)	<1 (1)	<1 (<1)	23

NOTE: Statistics exclude interdeployment periods of less than 6 months and more than 2 years.

^aDays underway per quarter. Days underway by category may not sum to optempo due to round-off error.

4.2 Statistical Implications

The analyses reported here are limited to examination of non-deployed ship activities. Because it is of interest to know how variation in nondeployed activities affects readiness at the time of deployment, the data were organized in the following way.

Each observation corresponds to a portion of a single ship's employment history. Each ship is tracked from the date its readiness is upgraded from C5 to C4 (that is, from the completion of a major overhaul or other restricted availability) until the first date of deployment. The proportion of time spent underway and the proportion of underway time devoted to different activities are based on this time frame. If ships were nondeployed for less than 6 months or more than 2 years, they probably were not in a full and normal training evolution, and we excluded them from the data.

Because we are interested in determining the marginal value of increases in time spent underway on the training readiness of deploying ships, UNITREP data are drawn from the first 30 days of the deployment. The dependent variable, training readiness, was assigned a value of one if C1 training readiness was reported in each of the first 30 deployed days. Ships devoid of C1 time during the period were assigned a value of zero.*

Observations are drawn from the historical records for FY 1979 through the first three quarters of FY 1984. Figure 1 provides a pictorial representation of a unit of observation.

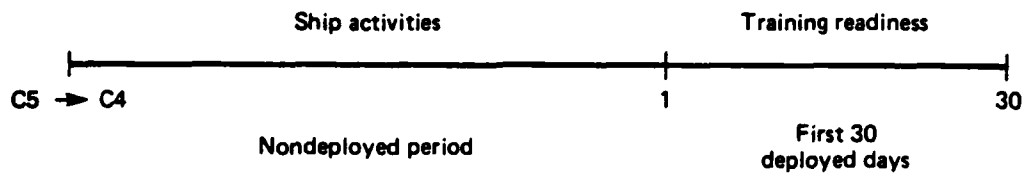


FIG. 1: UNIT OF OBSERVATION

The statistical results reported in table 6 are slope estimates, transformed at the mean of the data from logit coefficients, estimated via the method of maximum likelihood. The results show that the tempo of operations is strongly associated with the level of training readiness upon deployment. In the simplest specification of the model, the percentage of ships that are C1-ready upon deployment increases by 1.84 percentage points given a 1-day increase in steaming days per nondeployed quarter. In the second model, steaming days per quarter is disaggregated into the five underway categories previously discussed. In this more general specification of the model, the association between training readiness and different underway activities is permitted to vary, and therefore allows comparison among the activities. According to model 2, a 1-day-per-quarter rise in training, ceteris paribus, is associated with a 2.26-percentage-point rise in the number of ships that are C1-ready upon deployment. Project support and operations also have statistically significant effects on training readiness, whereas transit time and other miscellaneous activities have no measurable training value.

* In approximately 10 percent of the cases some C1 time was reported; these were omitted from the analysis. Including these cases and assigning them a value of one had the anticipated effects: coefficients fell slightly, and statistical significance followed the pattern reported in table 6.

TABLE 6

RELATION BETWEEN SHIP ACTIVITIES AND
PERCENTAGE OF SHIPS REPORTING C1 UPON DEPLOYMENT

	Model		
	1	2	3
Optempo	1.84 (6.89)		1.49
Days per quarter			
Training		2.26 (7.28)	
Transit		-.80 (1.38)	
Project support		4.34 (2.22)	
Operations		1.61 (2.98)	
Other		-1.62 (.20)	
Percentage of underway time			
Transit			-.69 (4.85)
Project support			.27 (.60)
Operations			-.12 (.78)
Other			-.78 (.66)
χ^2	53.25	81.48	79.93

NOTE: n = 679.

Absolute value of t-statistics given in parentheses.

Although model 2 indicates that project support has a stronger influence on readiness than explicit training activities, we see that the difference is not statistically significant in model 3. The third model considers various underway activities measured as a percentage of total underway time. Training is excluded from this estimate. Therefore, the value of the remaining activities is seen relative to that of training. From model 3 we see that, with the exception of transit time, the non-training activities influence training readiness similarly.

5. AIRCRAFT ANALYSES*

This section looks at the historical association between aircraft flying hours and several indicators of training readiness.

* Analyses in this section reflect the combined research efforts of the author, Stan Horowitz, Cdr. Gary Johnson, and Ron Nickel.

5.1 Historical View

Within the USN air community, optempo signifies flying hours per quarter. The flying hour goal has been stable between FY 1977 and FY 1984. Budgeted flying hours have fallen continuously, however, over the same period; see table 7.

TABLE 7

USN TACAIR FLYING HOURS BUDGETED
AS A PERCENTAGE OF GOAL

	<u>Fiscal year</u>							
	<u>77</u>	<u>78</u>	<u>79</u>	<u>80</u>	<u>81</u>	<u>82</u>	<u>83</u>	<u>84</u>
Percentage of goal budgeted	86	86	85	85	82	82	81	80

For nondeployed squadrons alone, the numbers are even lower because deployed squadrons have averaged approximately 115 percent of goal, and the difference must be made up by the nondeployed community. The association between actual flying hours during the nondeployed period and readiness at the time of deployment is analyzed below.

5.2 ORE Analysis

Operational Readiness Evaluations (OREs) are tests of operational performance that are graded by observers from outside the airwing. The tests are conducted at the completion of nondeployed training evolutions. Grades are characterized as outstanding, low outstanding, high excellent, and excellent. Grades of excellent and high excellent are considered to reflect poorly on a squadron.

Table 8 compares average monthly flying hours for 90 squadrons to their ORE scores. The positive association between flying hours and ORE scores is clear. The consistency in the ordering of results held true throughout the analysis.

TABLE 8

ORE GRADES AND MONTHLY FLYING HOURS

<u>ORE grade</u>	<u>Average monthly flying hours</u>
Excellent	356
High excellent	384
Low outstanding	421
Outstanding	487

Interfleet comparisons yielded an equally dramatic difference. Squadrons in the Pacific Fleet average less than 80 percent as many monthly pre-ORE flying hours as those in the Atlantic Fleet.* Only 39 percent of Pacific Fleet squadrons received scores in the top two ORE categories, compared to 63 percent for the Atlantic Fleet.

5.3 Boarding-Rate Analysis

Although ORE scores undoubtedly contain a measure of subjectivity, the percentage of landing attempts that were successful (boarding rate) is one particularly objective component of the ORE grade. We now turn to analyses of these data.

Variations in average boarding rates during ORE show the same general pattern as the variations in ORE scores. As shown in table 9, however, as flying hours decline, there is a substantial increase in the dispersion of boarding rates. In short, as flying hours decline, boarding rates become more erratic and the average becomes less meaningful.

TABLE 9

AVERAGE BOARDING RATES DURING ORE

<u>Flying hours per squadron per month</u>	<u>Average boarding rate</u>	<u>Minimum boarding rate</u>	<u>Lower 25th percentile boarding rate</u>
Under 360	88.5	70.0	85.0
360 - 439	90.1	70.5	87.5
440 - 519	93.2	84.0	91.2
520 and over	94.1	89.3	n/a

* Assuming roughly equal total funding, this difference could be due to greater demands during the longer deployments in the Pacific.

Figure 2 graphically displays the dispersion noted above. The curved lines summarize the results of a statistical analysis of the data for the 90 squadrons involved in OREs. The results confirm our observations about table 9: At higher flying-hour rates, average boarding rates are not only higher but also clustered closer to the average. At lower flying-hour rates, a substantial percentage of squadrons will achieve boarding rates significantly below the average.

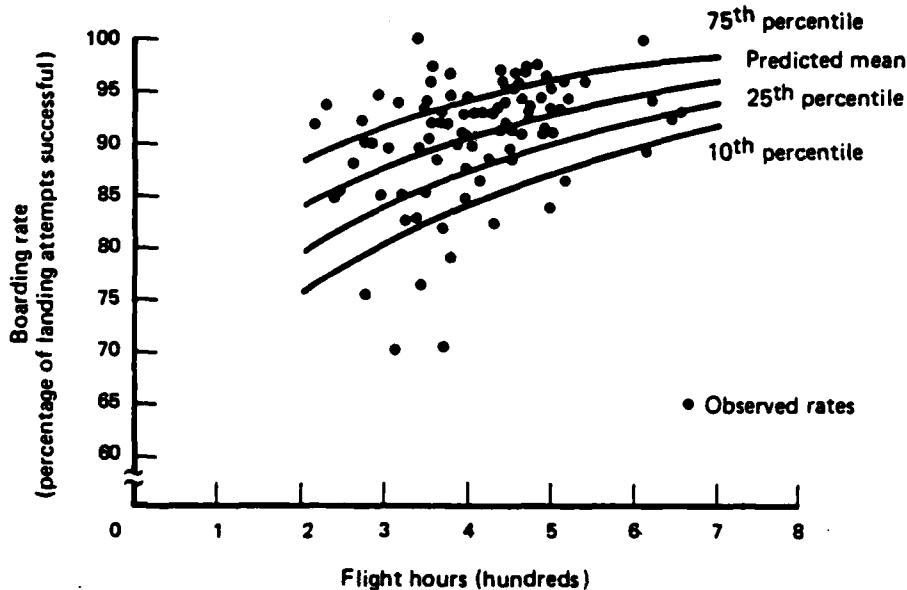


FIG. 2: SQUADRON ORE BOARDING RATES

5.4 Bombing Analysis

Although OREs provide a good overall picture of the association between flying hours and training readiness, we were also able to obtain data on the accuracy of bomb drops. These data likely represent the best peacetime proxy of warfighting capabilities for medium attack aircraft. Data were accumulated during training exercises at Whidbey Island between February and October 1983 for medium attack squadron VA-145.*

Four kinds of bombing runs are included in the analysis: straight path, airborne moving target indicator, bore sight day, and general loft-dive toss. The data set comprises over 2500 bombing runs. Since we only have squadron-wide information on flying hours, the analysis is done on an aggregate monthly basis. For each of the four kinds of bombing runs, we calculated the average miss distance

* Bombing accuracy information is available for additional squadrons, but flying hour data to perform the analysis have not been compiled. Preliminary results using quarterly data for VA-196 are consistent with the results reported here.

in a month. To put the four kinds of runs on a comparable basis, each monthly average was divided by the grand average for that kind of run, giving 36 monthly observations of bombing accuracy relative to average accuracy for the same run, or normalized bombing accuracy.

Discussion with the staff at Whidbey Island led us to expect accuracy in a month to be most affected by the amount of flying in the previous month.* We were also made aware of other important information: squadrons practice bombing at Whidbey; during the last half of the training cycle they spend significant time away from Whidbey, and are therefore deprived of the opportunity to bomb. For this reason, we adjusted flying hours to reflect time at Whidbey Island only.

Our results indicate that at the mean of the data a 1-percent reduction in monthly flying hours is associated with a 0.52-percent increase in the average miss distance for this squadron. As in the case of earlier analyses, this finding is statistically significant.

6. SUMMARY AND CONCLUSIONS

We reviewed the association between nondeployed activities and training readiness, using a variety of measures for both ships and aircraft. Results are consistent in that they uniformly report a measurable payoff to operational training.

Ship analyses considered the fuel budget, total time underway, and time devoted exclusively to underway training activities, in alternative models of training effectiveness. Training proficiency was measured by the composite UNITREP index for training. These analyses show that:

- For the period 1977-81, an increase in the real non-deployed fuel budget is associated with increases in nondeployed C1 and C3 time at the expense of C2 and C4 time. For deployed ships, a 1-percent fuel budget increase is associated with a 0.8-percent increase in C1 time and decreases in all lower readiness categories.
- For the period October 1978 through June 1984, a 1-day increase in underway days per quarter (optempo) is associated with a 1.84-percentage-point increase in the number of ships reporting C1 training readiness upon deployment.
- Disaggregation of optempo by type of underway activity indicates that transit is an inferior contributor to training readiness.

* In any event, our short observation period makes examination of longer lags difficult.

Aircraft relationships are inherently simpler to model; flying hours are a good measure of operational training time. Research in this community emphasizes alternative measures of readiness. Operational Readiness Evaluations, boarding rates, and bombing accuracy have been examined. According to these analyses:

- There is a positive association between flying hours and ORE scores.
- Boarding rates increase and the level of dispersion declines as flying hours increase.
- A 1-percent increase in flying hours devoted to bombing practice is associated with a 1/2-percent reduction in average miss distance.

For ships, future research would be fruitfully directed towards an exploration of better measures of effectiveness--objective measures of performance in specific mission areas, for example. In the case of aircraft, the data base needs to be broadened so that results may be confidently generalized to the air community overall. Also, the optimal mix of operational training activities is still an open and important question.

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