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crews, management, materials, operational readiness, readiness, resources, unit readiness

20. ABSTRACT (Continue on reverse side if necessary and identify by block number):

This study examines the feasibility of developing a quantitative resource to readiness model. A hierarchy for potential definitions of readiness is presented and the conceptual flow of resources into this hierarchy is illustrated. Existing data systems and models are surveyed, and their constraint on a comprehensive model's development is discussed. Recommendations are made for funding and managing future resource to readiness research.

[7] Participants: Cdr. James L. Bagby, USN; Cdr. Allan Sherman, USN; Richard L. Klobuchar; Peter Roane

CNR 1 / September 1979

RELATING RESOURCES TO READINESS

Stanley A. Horowitz, Study Director
Norma J. Hibbs

Enclosure (1) to CNO 1tr Ser 96/594021 dated 30 July 1980.

Institute of Naval Studies

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1. The Congress has directed that the Services provide estimates of the effects that funds requested for material support are likely to have on material readiness. The Relating Resources to Readiness Study was undertaken to investigate the feasibility of developing a system that relates funds, resources, and readiness, and to determine the courses of action available to the Navy.

2. None of the indicators that are now used to evaluate expenditures are a complete measure of material readiness, nor will it be possible to accomplish this with a single indicator. In only narrowly restricted areas has previous analysis developed quantitative relationships existing between resource expenditure and force readiness. The Study Group developed a conceptual model of how resources could be related to readiness and readiness to effectiveness. It examined the applicability of existing analyses, models, and reporting systems to the conceptual model and also conducted a partial survey of research firms to learn how they could help develop a resource to readiness system. Lastly, it formulated several options that are available to the Navy.

3. The study concludes that it is feasible now to begin modeling the relationships between the resources available to units and the readiness of those units to carry out their missions. This would initially involve a difficult and lengthy process showing how resources affect the material condition of equipment. Relating budget changes to the resources available will be even more difficult, however. A sizable body of work in these areas has been produced, but it has not been managed or monitored systematically. The study outlines several options for relating resources to readiness and makes recommendations for funding and managing future resources to readiness research.

4. Enclosure (1) is forwarded.

M. S. HOLCOMB
Vice Admiral, U.S. Navy
Director, Navy Program Planning

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Relating Resources-to-Readiness

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SUMMARY

The primary objectives of the study were to:

- Determine the feasibility of developing a meaningful system to relate resources to readiness,
- Describe alternative ways the Navy might proceed to develop and manage such a system, if it is feasible, considering costs and benefits,
- Recommend the alternative which would most likely satisfy requirements for developing resource-to-readiness relationships.

A diagram of flows of resources into readiness was developed. This illustrated the general flow from operations and support dollars into functional areas impacting on Navy-wide resources and into unit (ship or aircraft squadron) resources. These determine the state of personnel, training and supply at individual units, which influences the availability of the units' equipment. The units' material readiness, crew readiness, and design capability influence its effectiveness, which also varies with the threat, scenario, strategy, etc. This conceptual model is presented as a framework rather than in mathematical terms; it was not the purpose of the study to develop a mathematical description or to quantify links between resources and readiness.

The study surveyed previous research and existing data systems to determine the likelihood of developing and implementing a quantitative model. On the positive side, there are many examples of analytic efforts which have developed relationships between some aspect of a unit's resources and its readiness. On the negative side, most of these examples do not include the cost of improving readiness. Nor did the study find successful analyses of relations between more aggregated variables, such as budgeted funds, readiness levels, and force effectiveness. There also appears to be a lack of models or data systems which could track the effect of budget changes to a unit's resources, particularly at the mission level.

The study concluded that development of a resource-to-readiness system consisting of a set of independently developed relationships is feasible. A more unified approach is probably not feasible now and would be a risky and costly effort.

It is recommended that the Navy establish a readiness analysis office to:

- Monitor and manage future research on resource-to-readiness relationships

- Keep track of readiness trends
- Coordinate responses to readiness questions
- Act as an advisory board to the CNO on readiness matters.

This office should fund a decentralized research program concentrating on material readiness with some exploratory work on operational readiness. The study concluded that this represents the best compromise between comprehensiveness, cost and feasibility.

INTRODUCTION

In FY 1978 the Navy spent $11 billion on operations and maintenance, largely to maintain or improve the readiness of the ships and aircraft in the fleet. This expenditure is only the tip of the readiness iceberg, since large portions of the manpower and training costs borne by the services are really expenditures to improve readiness.

If the Navy had an explicit, quantitative method for showing the effect of spending money on readiness, it would be able to evaluate decisions better and make the right choice more often. Realizing this, Congress wrote a requirement for increased attention to relationships between resources and readiness into the FY 78 Defense Authorization Act. Section 812 of the Act states that,

> "The budget for the Department of Defense submitted to Congress... shall include data projecting the effect (on readiness) of the appropriations requested for material readiness requirements."

The Act also called for "a report setting forth quantifiable and measurable materiel readiness requirements."

OSD immediately recognized "a few little minor problems standing in the way of complying with this tasking... Among them:

- in general, we have not agreed upon 'quantifiable and measurable materiel readiness requirements';
- although several services specify standards or goals for operational readiness... those goals generally are not relatable to any analysis of the combat capability needed to accomplish specified wartime missions; and
- worst of all, we currently have no ability to 'project'... the effect of appropriations requested for materiel readiness requirements."[1]

The purpose of our study is to delve into this last problem. Our primary objective is to determine the feasibility of developing a system to relate resources to readiness. Since this is a feasibility study, we do not develop such a system here. Rather, we examine whether and how the Navy should proceed in developing such a system.

A conceptual model describing relationships between resources and readiness is developed. A review of previous work relevant to

[1] OSD Memorandum on Readiness Analysis, 28 Jun 1977.

relating resources to readiness is performed to allow an assessment of how existing cost and readiness information systems and models could be used to support the conceptual model. We determine what kind of work needs to be done to develop an acceptable resource-to-readiness system, and roughly estimate the cost of several alternative approaches to this work. Finally recommendations for Navy action are made.

FEASIBILITY OF A RESOURCE-TO-READINESS SYSTEM

A GENERAL MODEL

The reason for being interested in readiness is concern that the Navy be able to perform successfully if it is called on. Figures 1 and 2 put resources in a framework that reflects this ability. On the right in figure 1 we find the notion of expected effectiveness, which has been defined as "the ability of a force, unit, weapon system, or equipment to achieve a specifically defined wartime objective."[1] Expected force effectiveness depends on the size of the force, on the capability (modernization level) of the units in the force, on the specific threat they face, on the decisions of the command structure regarding strategy and tactics, and on the ability of units to operate their equipment, as well as their ability to keep it operable.

Expected unit effectiveness is a less encompassing notion than expected force effectiveness. It still depends, however, on both threat and capability.

Moving to the left in figure 1, we find the notion of unit readiness. This has been defined by the DoD Readiness Management Steering Group as "the ability of a force, unit, ship, weapon system or equipment to perform the function for which it is organized or designed." As the figure shows, unit readiness depends on the availability and reliability of the equipment needed to perform the mission -- material mission readiness -- and on the ability of the unit to operate the equipment -- operational mission readiness. The feasibility of modeling readiness is contingent on the existence of data to measure or quantify these terms.

The Navy spends money on many things in order to improve readiness. These include expenditures on personnel, training, maintenance, design enhancement, and supply. Many of these affect readiness by affecting resources available at individual units; that is, by affecting what we will call the state of the unit. Thus, for example, expenditures on recruiting and training influence readiness by improving the availability and performance of unit personnel. Similarly, expenditures on transportation and supply should affect readiness by increasing the availability of spares at the unit level.

Other expenditures, such as reliability and maintainability enhancement programs, do not directly affect the resources available

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[1] "Force Readiness," prepared by DMIA #11, Industrial College of the Armed Forces, Jun 1978.

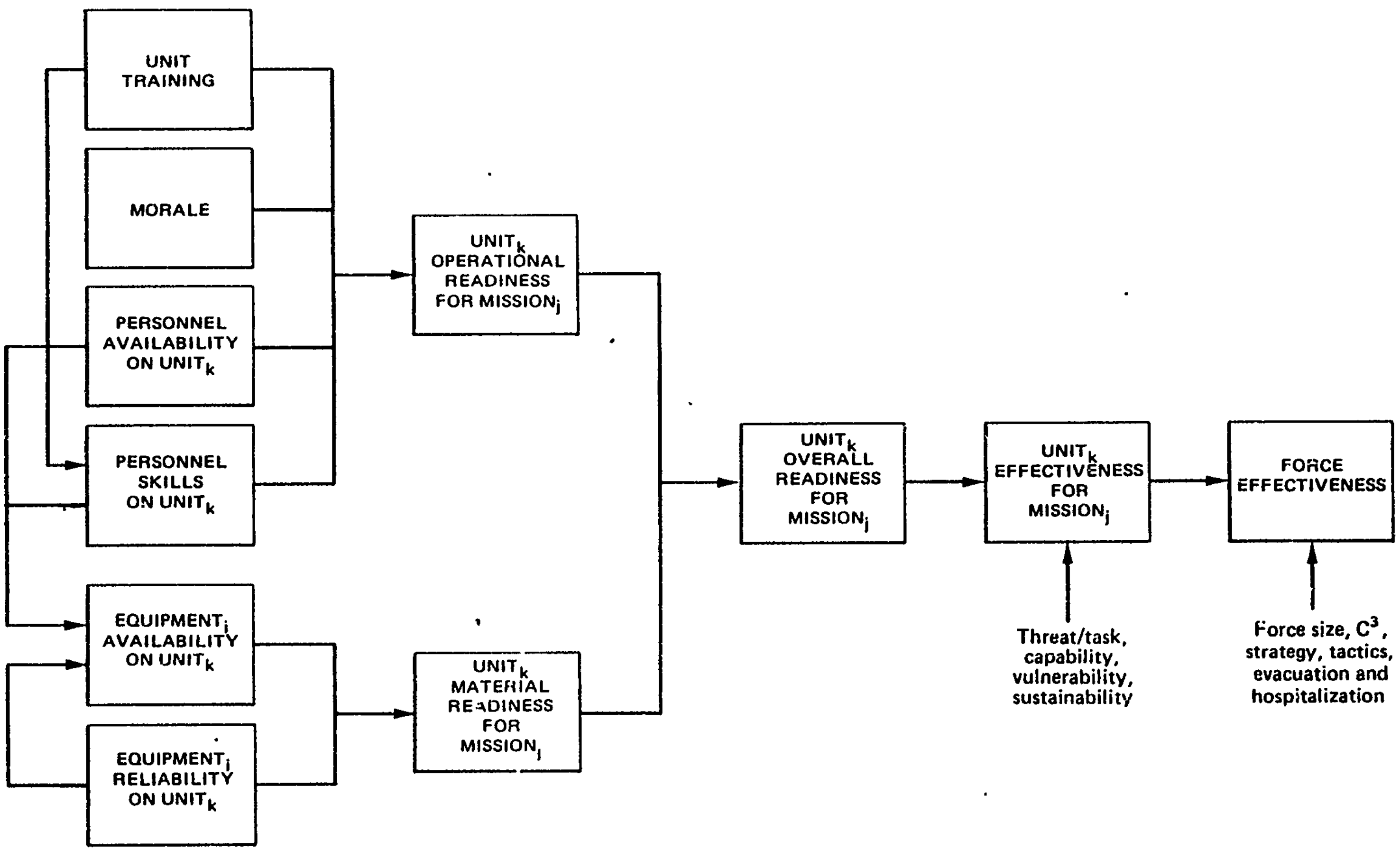

FIG. 1: CONCEPTUAL MODEL – READINESS AND EFFECTIVENESS

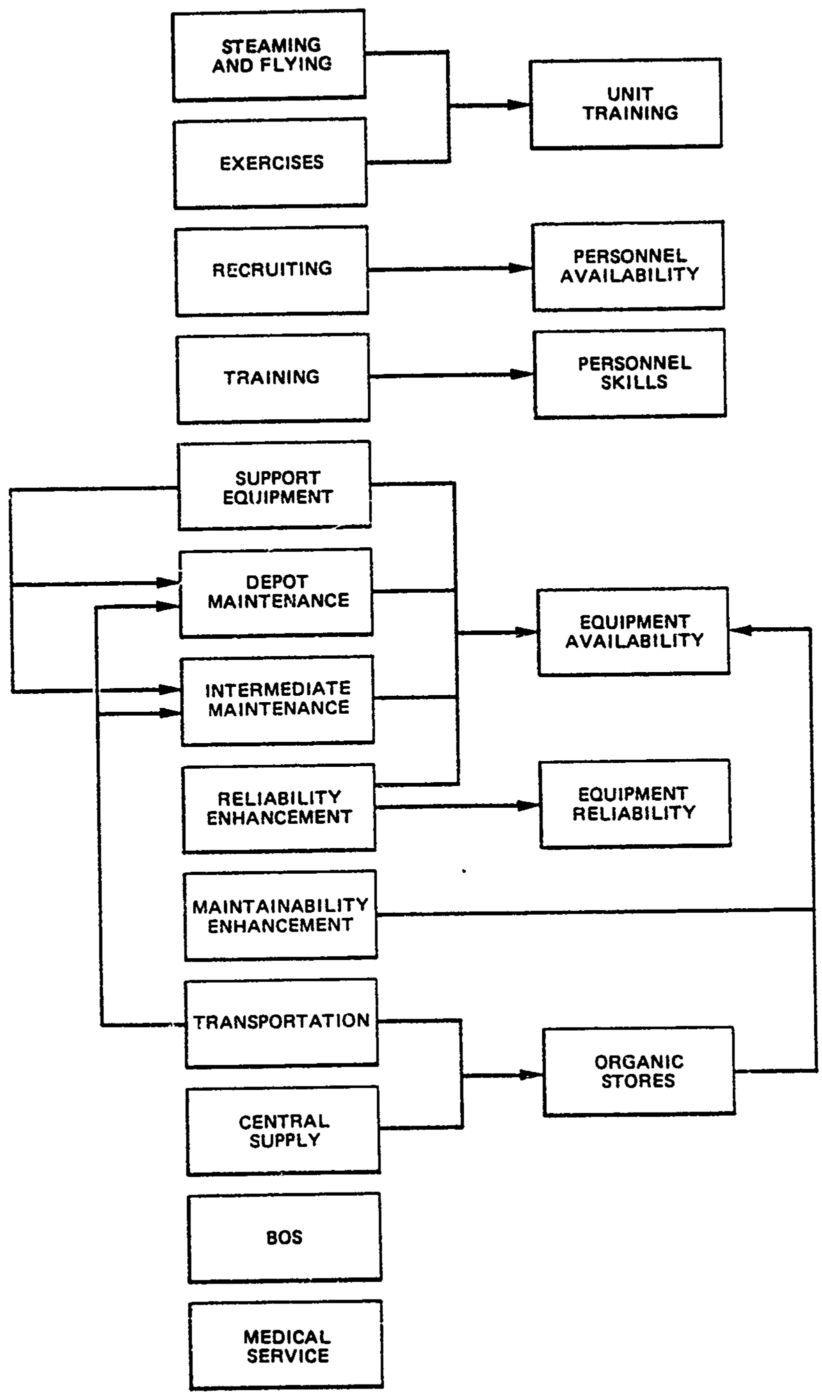

FIG. 2: CONCEPTUAL MODEL – BUDGET, RESOURCES, AND READINESS

at the unit level. Rather, they assist a unit with a particular level of resources to reach higher readiness levels.

Figure 2 illustrates flows between general resources, unit resources, material readiness and operational readiness. It adds the notions of budget and resources to figure 1.

This conceptual model has several shortcomings. It doesn't show which categories of budget expenditures affect what resources. It does not categorize resources in detail. Recruiting expenditures, for example, conceptually include advertising, recruiters' salaries, and the level of pay offered to prospective recruits. Similar decompositions are possible for all the resources shown in the figure. It fails to illustrate some important relationships between resources and readiness. For instance, the resources that affect crew performance and availability probably influence material condition through their impact on operator-induced failures. It does not capture leadership and morale explicitly. Our approach assumes that the effect of resource use on leadership and morale will be implicitly picked up by quantification of more objectively verifiable relationships.[1] This may cause us to miss some opportunities to improve readiness by improving morale through resources not addressed in the model. Finally, it is not quantitative. One might say that it just shows that everything influences everything else. Acceptance of that truism does not constitute development of a system relating resources to readiness. That development requires the functional links depicted in the general model to have numerical sensitivities attached to them.

ADEQUACY OF EXISTING DATA AND RESEARCH

Present Sources

Readiness

Several existing information systems may be used as indicators of the effect of a unit's state or resources on its ability to carry out a mission. SCIR, TIGER, and FORSTAT are all examples of systems which can be used directly to document this link.

The SCIR (Subsystem Capability and Impact Reporting) system links the non-availability of an aircraft's subsystems to its mission capability. Mission-essential subsystems are identified and

[1]For example, expenditures on retention that increase the proportion of senior enlisted men ought to improve readiness in part by improving leadership. A relationship between retention and readiness will include this effect, even though leadership cannot be measured explicitly.

associated with required mission capabilities through the Aircraft Operational Capability Matrix, as illustrated by table 1. When SCIR is implemented on operational units, information on subsystem downtime will be used with this matrix to produce a report showing the time a given mission could be performed.

The TIGER model applies a similar concept to ships.[1] The model divides a ship's mission into phases, as shown by table 2 for the FF 1052. The matrix associating mission phases with various systems is illustrated for the FF 1052 by table 3. The ability to perform each of the mission phases is related to the availability of these systems. The availability of a system is determined by the availability of its subsystems or equipment through logic diagrams of equipment configurations.[2] An example showing part of the configuration of the steam generation and propulsion system is shown in figure 3. This diagram indicates redundant items as well as the number required for various mission phases.

Thus, TIGER and SCIR model the link between equipment availability and mission material readiness.[3] However, these systems do not treat contributions of personnel, training and supply to overall readiness for a mission.

FORSTAT, on the other hand, explicitly incorporates the effects of all these resources on readiness.[4] (Further, all units file reports.) Units now report only their readiness ratings by these resource categories and by overall mission category. However, more detail could be reported because the unit must analyze the status of each resource for each mission as illustrated by table 4. Logic schemes or decision trees are provided by type commanders to guide units in filling in the matrix. Figure 4 is an example of a SurfLant instruction to relate equipment status to readiness status for mobility.[5]

---

[1]TIGER was developed by the Naval Ship Engineering Center to evaluate reliability, maintainability and availability of new ship classes during contract design. Many of these ship classes are now operational.

[2]The logic diagrams can also be represented mathematically by structure functions.

[3]SCIR is being implemented for all aircraft; TIGER wiring diagrams have been developed for most ship classes.

[4]The way in which personnel training and supply readiness is measured in FORSTAT is extremely arbitrary. FORSTAT material readiness is fairly closely tied to CASREPs filed by ships.

[5]Most FORSTAT logic schemes are much more complex than this example.

TABLE 1

AIRCRAFT OPERATIONAL CAPABILITY MATRIX

FOR TEST PURPOSES ONLY
ITEMS WERE DERIVED FROM VEDA CORP. STUDY

NAVMACLANT

TEST

F4J READINESS MATRIX

SUB-SYSTEM CODE	FSC A	FIGHTER FULL B	ATTACK FULL C	ALLWEATHER FIGHTER D	LIM ALLWEATHER FIGHTER E	NITE FIGHTER VFR F	NITE ATTACK VFR G	DAY FIGHTER VFR H	DAY ATTACK VFR J	K	L	M	IFR TRAINER X	VFR ONLY Y	NSF Z	REPORTING CODE
11 VTAS (IF EQUIPPED)	X	X														C-11
12 DATA LINK (VECTORING)	X	X														C-12
13 A-A IFF INTERROGATOR	X	X														C-13
14 E-IFF INTERROGATOR	X	X														C-14
15																
16 RHAWS	X	X	X													D-16
17 DECM	X	X	X													D-17
18 CHAFF SYSTEM	X	X	X													D-18
19 VOICE CRYPTO	X	X	X													D-19
20																
21 ELECTRICAL FUZING SYSTEM	X		X													D-21
22 RADAR BEACON	X		X													D-22
23 DATA LINK (PRECISION BOMBING)	X		X													D-23
24																
25 PULSE & PD TRACK SYSTEM	X	X		X												E-25
26 SPARROW SYSTEM	X	X		X	X											F-26
27 PULSE OR PD TRACK SYSTEM	X	X		X	X	X										G-27
28																
29 PULSE SEARCH RADAR	X	X	X	X	X	X	X									H-29
30 NAV COMPUTER	X	X	X	X	X		X									H-30
31																
32 SIDEWINDER SYSTEM	X	X		X	X	X		X								J-32
33																
34 OPTICAL SIGHT UNIT	X	X	X	X	X	X	X	X	X							K-34
35 CONV WEAPON CARRIAGE & REL SYSTEM	X						X		X							K-35
36																
37 DATA LINK (ACLS)	X	X	X	X	X	X	X	X	X				X			Y-37
38 AFCS	X	X	X	X	X	X	X	X	X				X			Y-38
39 EXTERNAL FUEL TRANSFER	X	X	X	X	X	X	X	X	X				X			Y-39
40 AIR REFUEL RECEIVER	X	X	X	X	X	X	X	X	X				X			Y-40
41 CAT & ARREST SYSTEM	X	X	X	X	X	X	X	X	X				X			Y-41
42 AUX RECEIVER/ADF	X	X	X	X	X	X	X	X	X				X			Y-42
43 RADAR ALTIMETER	X	X	X	X	X	X	X	X	X				X			Y-43
44																
45 TACAN	X	X	X	X	X	X	X	X	X				X	X		Z-45
46 UHF COMMUNICATIONS	X	X	X	X	X	X	X	X	X				X	X		Z-46
47																
89 POWER PLANTS	X	X	X	X	X	X	X	X	X				X	X		Z-89
90 AIR FRAME	X	X	X	X	X	X	X	X	X				X	X		Z-90
91 ELECTRICAL	X	X	X	X	X	X	X	X	X				X	X		Z-91
92 AVIONICS	X	X	X	X	X	X	X	X	X				X	X		Z-92
93 WEAPONS	X	X	X	X	X	X	X	X	X				X	X		Z-93
94 SURVIVAL EQUIPMENT	X	X	X	X	X	X	X	X	X				X	X		Z-94
95 ACE INSPECTIONS	X	X	X	X	X	X	X	X	X				X	X		Z-95
96 SPECIAL INSPECTIONS	X	X	X	X	X	X	X	X	X				X	X		Z-96
97 CONDITIONAL INSPECTIONS	X	X	X	X	X	X	X	X	X				X	X		Z-97
98 PHASE INSPECTIONS	X	X	X	X	X	X	X	X	X				X	X		Z-98
99 TDC	X	X	X	X	X	X	X	X	X				X	X		Z-99

TABLE 2

FF 1052 MISSION PHASE DESIGNATORS

PHASE DESIGNATORS/CONDITIONS	% ENROUTE	% UNDERWAY WITH ESCORT
Ø1 - EN ROUTE - 12kt, 1 BOILER	25	
Ø2 - UNDERWAY - 12kt, 1 BOILER		7.5
Ø3 - EN ROUTE - 20kt, 1 BOILER	75	
Ø4 - UNDERWAY - 20kt, 1 BOILER		19
Ø5 - UNDERWAY - 20-25kt, 2 BOILERS		33
Ø6 - UNDERWAY - FULL POWER, 2 BOILERS		0.5
Ø7 - UNDERWAY - ASW HELO - 20-25kt		10
Ø8 - UNDERWAY - ASW EXER - 20-25kt		18
Ø9 - UNDERWAY - ASW EXER - FULL PWR		2
Ø10 - UNDERWAY - AAW EXER - 20-25kt		3
Ø11 - UNDERWAY - SUW EXER - 20-25kt		7
Ø12 - IN PORT, 1 BOILER - LESS THAN 10 DAYS		
Ø13 - IN PORT, COLD IRON - 10 DAYS OR MORE		

Fleet and unit exercises represent another potential data source. These include the recurring fleet exercises listed in table 5 and the FXP series of individual ship exercises which are administered and controlled by the type commanders. CNA field representatives have also recommended Operational Readiness Evaluations as a fruitful source of data for analyzing tactical readiness.

Effectiveness

It should be possible to link unit readiness to force effectiveness through the models used for war games and campaign analyses. Conversations with researchers at the Naval War College and Naval Underwater Systems Center indicate that readiness levels are incorporated in these models.

TABLE 3

FF 1052 SYSTEM UTILIZATION MATRIX

SYSTEM	MISSION PHASE 1	2	3	4	5	6	7	8	9	10	11	12	13
AUXILIARIES													
AIR CONDITIONING	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ASROC HEATING & COOLING	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ELECTRONICS COOLING WATER	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
FUEL OIL SERVICE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
FRESH WATER	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
REFRIGERATION	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
STEERING	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
SEA WATER	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
JP-5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
AVIATION							✓	✓	✓	✓	✓		
COMPRESSED AIR	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
FIN STABILIZER							✓	✓	✓	✓	✓		
PRAIRIE MASKER	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
ELECTRICAL	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
STEAM GENERATION & PROPULSION	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
NAVIGATION													
OWN SHIP	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
HELO AID							✓	✓	✓	✓	✓		
EXTERIOR COMMUNICATIONS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
COMBAT SYSTEM	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		

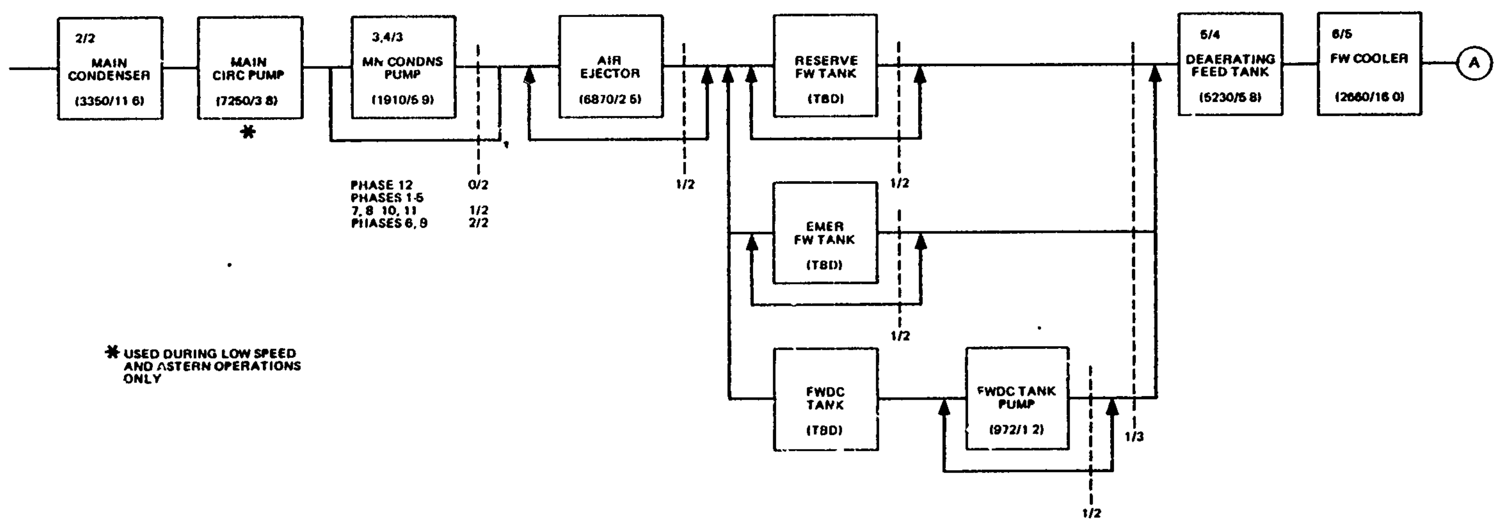

FIG. 3: CONFIGURAT:ON DIAGRAM FOR STEAM GENERATION AND PROPULSION SYSTEM, PHASES 1-12

TABLE 4

SAMPLE FORSTAT REPORTING MATRIX

MISSION AREAS	RESOURCE AREAS				MISSION AREA M-RATING
	PERSONNEL	SUPPLY	EQUIPMENT	TRAINING	
AAW	M2	M2	M3	M1	M3
ASW	M2	M2	M1	M2	M2
SUW	M2	M3	M2	M3	M3
CAC	M1	M1	M1	M2	M2
MOB	M2	M2	M3	M3	M3
RESOURCE AREA C-RATING	C-2	C-3	C-3	C-3	OVERALL C-3

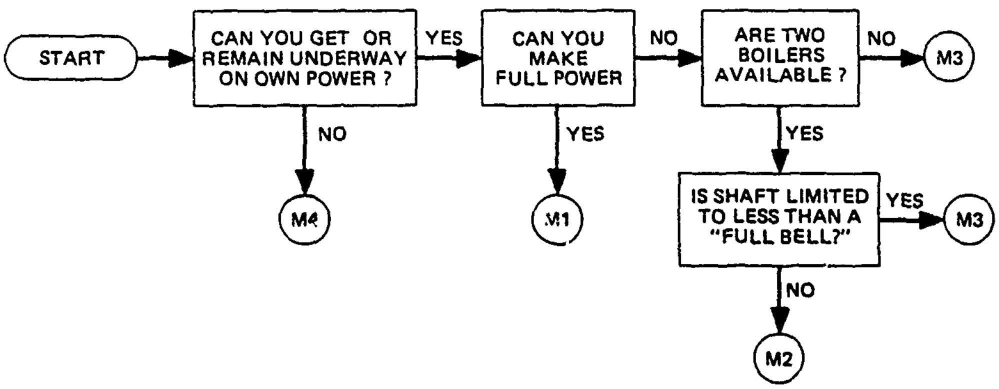

FIG. 4: FORSTAT LOGIC DIAGRAM FOR MOBILITY

TABLE 5

SUMMARY OF EXERCISES

Exercise	Frequency	Sponsor	Scope[1]	Duration	Primary Type[2]
SHAREM	Series	SWDG/3rd Fleet	Small	Few days	a,d
CSTEX	Series	2nd Fleet	Medium	Few days	c
CompTUEx	Series	2nd/3rd Fleet	Medium	2 weeks/ 1 week	c
CaribREx	Semi-Annual	2nd Fleet	Medium	Month	c
Solid Shield	Annual	CinCLant	Large	2-3 weeks	b
Northern Wedding	Annual	CinCHan SacLant	Large	2 weeks	b
MissilEx	Series	6th/7th Fleet	Small	Few days	d,a
NatWk	Semi-Annual	6th Fleet	Med-Large	Week	b
Display Determination	Annual	CinCSouth	Large	1 week	b
Dawn Patrol	Annual	CinCSouth	Large	2 weeks	b,c
ReadiEx	Quarterly	3rd Fleet	Med-Large	1 week	c
FleetEx	Semi-Annual	3rd Fleet	Med-Large	10 days	b,a
RIMPac	Annual	3rd Fleet	Med-Large	2-3 weeks	b
ReadEx	Quarterly	7th Fleet	Large	1 week	b,c
Ocean Safari	Annual	SacLant/CinCHan	Medium	2 weeks	b
Safe Pass	Annual	CinCWestLant	Medium	1-2 weeks	b
MultiplEx	Series	7th Fleet	Small-Med	Few days	c
Team Spirit	Annual	CinCUNC	Large	10-14 days	b

[1]Scope: Small scale refers to less than CVTG size. Medium scale refers to one CVTG size or group size. Large scale refers to multiple CVTGs, or 1 CVTG with an amphibious element or 1 CVTG with allied forces.

[2]Primary Types: the categories (a,b,c,d) refer to the following exercise objectives:
- a. System performance measurement and evaluation
- b. Fleet command, control, and operational effectiveness
- c. Ship/squadron deployment readiness
- d. Tactics development and evaluation

Budget Changes

So far we have treated the problem of relating changes in the level of a unit's resources to its readiness and perhaps then to effectiveness. The system could be partially completed by costing out the unit resources and aggregating these back to budget categories. This might help in justifying some budget requirements. But it would not answer questions about the impact of more general budget changes. To the extent that Congress is concerned about knowing the expected impact of changes in the budget on readiness, there is an additional link to be modeled. It is necessary to know how changes in funding aggregates visible at the budget level relate to changes in resources. It isn't always obvious what the implications of a budget change are for the nature, quantity, and location of resources being bought.

There are three ways of dealing with this problem. First, the tracking of resources in the budget could be improved to the point that one could identify budgeted funds at the same level as resources in the resource-to-readiness system adopted. Second, an approximate allocation procedure could be developed. This might assume that changes in a budget aggregate would be spread around proportionately among the items making up the aggregate. Such an assumption would often be wrong, but it is an approximation. Third, an ad hoc procedure could be used. This means that every time Congress (for example) identified a budget change of interest, the Navy would have to identify the resource implications of that change in a way that would allow an estimate of the readiness implications to be made. Drills like this are often performed today in the programming and budgeting process. The choice among these procedures depends on feasibility and accuracy.

The second procedure would allocate overall resources to units and missions. But existing data bases will not support this activity. The Navy Cost Information System shows funds aggregated across units and missions. And although VAMOSC, the Navy Resource Model, and the Logistics Resource Annex may help at the unit level, they do not have mission detail.

A further problem with measuring the impact of a budget change is that implementation affects the impact. The impact of a cut in the training budget, for example, depends on where the cut is taken. An across-the-board cut will have a bigger impact on readiness than a cut tailored to avoid critical ratings. For this reason, every budget change of interest must be examined individually to determine what resources will be affected. Logic diagrams to aid this task can be developed. But developing a system that automatically relates budget changes to readiness is severely limited by the uncertainty about where the change will really be made.

Research on Model Links

The study team reviewed the literature (see appendix A) to determine the scope of past research relating resources to readiness. The Navy Readiness Analysis Study (NRAS) was the only effort which had as its goal development of an all-encompassing model. The 1969 development plan for this system called for three groups which would collect operational performance data, provide information about the data bases, and analyze the data. The analysis groups would be staff elements of the CNO, fleet CINCs, and type commanders. The proposal estimated that the total cost (including hardware) would be over $100 million and that almost 500 people would be required. The plan was never fully implemented.

While NRAS was the most ambitious effort, many others have investigated some aspect of resource use, readiness, or a relationship between them. We summarized 76 such studies in references 2 and 3. Few studies addressed effectiveness (or capability as opposed to availability). Those which did either were conceptual models or applied to aircraft. About half considered multiple resources. "Resources" ranked by frequency of use as variables are: spares (most frequent), personnel, equipment availability, training, and operating tempo (steaming hours). About half the studies considered dollar cost; most of these concerned spares. About 55 percent used data; the rest were methodological or were proposals for systems, etc. The methodologies varied. Simulation was the technique used most and appeared (either alone or in combination with other methods) in about one-fourth of the models. More of the studies examined ship logistics than aircraft logistics. Most research applied at the unit (ship or squadron) level but about a third treated individual missions. Many more addressed relationships between unit resources and unit material readiness than between any other two general areas of the conceptual model.

Research, then, has not produced a unified model covering the path from the budget to effectiveness. This could be due to high cost (as estimated by the NRAS), high risk (implied by the weakness or lack of data for parts of the conceptual model), or lack of priority (there were too many current issues with higher priority). Nevertheless, past and current work could be used to construct modules of such a system.

But, although many links of the general model have been investigated, it is clear much work is still needed. Some areas not covered would probably be very difficult to quantify. For example, the effect of formal training on a person's contribution to overall mission readiness has not been shown. Some studies address cost but more work needs to be done in this area as well as the area of allocating the impact of funding changes to missions. The objective for a comprehensive model is to evaluate the impact of all allocating the impact of funding changes to missions. The objective for a comprehensive model is to evaluate the impact of all support funding changes on readiness. However, before it could actually serve this purpose, the whole system would have to be quantified and information derived from one link would have to be usable by the next. Such a product can be envisioned only in the long term. For the interim, there is a potential payoff to continuing the attack on specific areas.

INFORMAL PROPOSALS FROM RESEARCH ORGANIZATIONS

In order to get an independent assessment of the feasibility of continuing work, the group surveyed 12 organizations about their ideas for performing additional research on relating resources to readiness. Eight of them suggested areas of research and submitted rough cost estimates. Since our estimates of the costs of various options presented in the next section are based somewhat on these proposals, we have listed them in table 6, together with the proposer and estimates of the time and total cost required to do the work.

The organizations that responded to our inquiries have proposed work that covers a wide range of topics. Improved measurement of material readiness was addressed by MathTech and ARINC and implicitly by CACI and NavSec. Work on the impact of funding for central supply, aircraft intermediate maintenance, and ship depot maintenance on subsequent material condition has been proposed by CACI, ISI, and CNA. Readiness models that incorporate personnel and training have been suggested by two organizations: Pugh-Roberts' proposal for an aircraft simulation model would focus on material readiness for aircraft while TRW suggested an operational-readiness-oriented model for ships. ORI has shown interest in developing logic diagrams to analyze the budget allocation process. All of these respondents proposed research on a particular part of a resource-to-readiness system; none suggested a unified effort to solve the entire problem.

TABLE 6

PROPOSALS OF RESEARCH ORGANIZATIONS

Organization	Output	Level of research (option)	Estimated time	Estimated cost
MathTech	Measure of equipment criticality Measure of material condition Historical trends	3	2 years	$500,000
ARINC	Historical trends using TIGER	3	1 year	225,000
CACI	Readiness-based model of supply system	3	3 years	900,000
NavSec	Additional TIGER model	3	1 year	100,000
ISI	Simulation model of aviation IMA	4	1 year	80,000
CNA	Readiness-based model of ship overhauls	3	2 years	300,000
Pugh-Roberts	Readiness-based model of an aircraft type, including personnel and training	4	1 year	80,000
TRW	Operational-readiness-based personnel model	4	2 years	100,000
ORI	Analysis of budget allocation process	4	1 year	75,000

A NAVY PROGRAM FOR RELATING RESOURCES TO READINESS

OPTIONS

There are five alternative ways in which the Navy might proceed next in its efforts to relate resources to readiness. (There are really an infinite number of options available but these five represent the range.)

The first option is to continue current practice. One characteristic of current efforts to relate resources to readiness is the absence of central awareness of the overall research program. Research projects are undertaken in an uncoordinated way. Funding offices typically (and properly) commission work to help them do their particular jobs. Resource-to-readiness models are developed, but nobody outside the funding office is responsible for keeping track of all of them, gathering them into a library, or using them to build a coherent set of tools.

Option one would not cost anything above what's being spent now on readiness research, but it is probably insufficient to satisfy Congressional demands. It would perpetuate the current difficulty of routinely tracking readiness trends using multiple data sources and it would not improve the use of existing resource-to-readiness models and research for centralized program planning. That's not to say that the Navy wouldn't get smarter as time goes on. Resources-to-readiness research is being done, and some of the results of this research would eventually be adopted for use by future decision-makers.

The second option, representing the least ambitious change to current practice, would be to designate a readiness analysis office (RAO) to monitor the resources-to-readiness work funded by other offices. In addition, this readiness analysis office could be made responsible for tracking readiness trends. Currently nobody in OpNav performs this vital function for all the available indicators on a routine basis. This has caused difficulty in giving the CNO an up-to-date perspective on the readiness of the fleet and on the impact of expenditures.

Perhaps two officers or fairly senior civilians would be assigned to the readiness analysis office, with two enlisted men or civilians to help with data handling. Monitoring the work funded by other offices would entail minimum cost and lead to an accumulation of tools as time went on. Some unnecessary duplication of research would be avoided. Accumulating an identifiable tool bag from existing models and on-going research would increase the visibility of readiness considerations in planning, and might satisfy Congressional requirements. Better use would be made of existing models, but the development of new ones would still be largely accidental.

Options three and four would provide for a program of decentralized research funded by the RAO in areas it felt were being neglected by other offices. Option three takes a modest approach. In addition to monitoring work funded elsewhere, the readiness analysis office would promote research on material condition and the resources that affect it. Relationships would be derived for illustrative units. Complete fleet coverage would not be attempted until the research program was well established. An attempt would be made to focus on the material readiness of units to perform various phases of their primary missions -- the kind of readiness measure used by TIGER and SCIR. Following a rule-of-reason approach, work using less direct measures of material condition (like CASREP downtime, FORSTAT ratings, or mean requisition time) would be funded in areas where use of a better measure proved impossible. Several contractors would be selected to do analyses involving different resources. (This is what we mean by a decentralized research program.) Funding of more than one contractor in the same area is not ruled out because of the risks of failure inevitable in this kind of work.

Option three would require increasing the staff of the office to perhaps four officers. Adoption of this alternative with a research budget of about one to 1.5 million dollars a year would probably fulfill Congressional requirements and provide an extensive set of resource-to-material-readiness models within five years. Two shortcomings would remain. The Navy would have limited ability to defend expenditures that support operational rather than material readiness. This has been a problem in the past. Second, even after five years, gaps would remain in the resource-to-readiness system. Models would still not exist for all resources and all kinds of units. We would expect, however, that at least illustrative models would exist for most resources that affect material readiness.

Option four broadens the scope to include research on the effects of resource use on operational readiness as well as on material condition. Getting into this more speculative area might require an additional million dollars a year and one additional officer in the readiness analysis office. Successful execution of this option not only would be likely to satisfy Congressional requirements, but would more fairly represent the relative contribution of different resources than option three would. It would still only supply a growing kit of analytic tools after five years rather than a unified resource-to-readiness system.

It might be feared that the decentralized research described for options three and four would yield unnecessary duplication of effort and would produce disparate resource-to-readiness models that didn't really fit together. To eliminate this problem, the fifth option proposes a unified effort run by a single contractor. Some of the work could be done under subcontract. The aim would be to develop resource-to-readiness models for all kinds of units. A consistent set of readiness indicators, perhaps from TIGER and SCIR, would be used. This option would cut down both the management burden and the degree of control of the readiness analysis office.

Perhaps the most striking thing about the list of proposals presented earlier is that nobody proposed developing such a resource-to-readiness system. Of course, there are many firms who might conceivably be interested, and a formal request for proposals to develop a unified system would probably generate some interest. Nonetheless, failure to find such interest highlights the problems of the fifth option.[1] Different organizations have different strengths and one may not be strong enough across the board to accept responsibility for a unified resources-to-readiness system. A complete, unified system would definitely meet Congressional requirements, but we think that at this point it would be risky. This option also has the highest cost; we estimate it could cost three times as much as option three.

RECOMMENDATION

Although it may eventually be possible to develop a system based on an effectiveness-oriented measure of readiness, experience has shown how expensive efforts to develop resource-to-readiness systems can be. For this reason we believe a relatively modest approach is called for. This entails limiting our present sights to a system that predicts changes in unit mission readiness or unit material readiness.

There are obvious advantages to having a resources-to-readiness system oriented toward force effectiveness. It would allow the Navy to compare the value of procurement and modernization with the value of operations and support in producing increased effectiveness. However, both practicality and responsiveness to Congressional requirements have caused us to favor unit mission readiness. Since support and operating expenditures influence total force readiness largely through their influence on unit readiness, not much is lost by evaluating such expenditures using the latter kind of indicator.

The choice between overall mission readiness and material mission readiness is more difficult. Overall readiness is harder to quantify; and the Congress has mandated only that attention be paid to

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[1]One respondent subsequently told us they didn't realize we were interested in such grandiose proposals, that they would have given us one had they known, but that they didn't think it was a good idea.

material readiness. On the other hand, the problem with focusing on material readiness is that the contributions of personnel and training, which play a role in operations as well as maintenance, will be understated.

We believe that a modification of option three -- the institution of a readiness analysis office funding a decentralized research program focusing on material readiness and also entertaining modest proposals to do exploratory work on overall readiness -- represents the best compromise between comprehensiveness, cost, and feasibility in the Navy's efforts to manage its support resources with an eye to their readiness implications. While no fixed date would be set forcompletion of a unified resources-to-readiness model, the continuing research program would allow progress toward that goal without excessive risk. Some projects would, no doubt, fail, but there would be enough progress to provide a pretty large tool kit after five years. The cost of this effort might be in the range of 6 to 9 million dollars over a five-year period.

We use five years for illustrative purposes. We think that a level-funded research program will encourage more researchers to dedicate themselves to this area. Even after five years, continuing research will be necessary to fill in gaps and to update relationships based on old data.

If this alternative is felt to be too costly, option two could improve the management of readiness analysis at a lower cost. This would still involve the development of an RAO.

The RAO should keep track of readiness trends. It should receive data on a priority basis from the offices responsible for maintaining the relevant data files. It should design and publish reports on readiness indices gathered from a variety of sources. These might include summary reports on: CASREPs, FORSTAT, Insurv MCI and PEB series from Op-04; personnel distributional or shortage indicators, training indicators, retention rates, etc. from Op-01; and supply time, inventory distribution, and transportation availability from NavSup. It should monitor (and perhaps provide guidance to) changes in resource or budget reporting for support cost.

The RAO should be apprised of all work developing theoretical or quantitative relationships between resource use and the result. This requirement holds both for work done in-house and for contract work funded by other Navy offices. It encompasses cost estimating relationships for resources that contribute to readiness; studies focusing on the proximate output of increased resource use;[1]

[1]E.g., how much does shorter transportation time improve spares availability?

studies of the determinants of equipment availability; and studies of the determinants of operational readiness. The RAO should be consulted before studies in these areas are undertaken in order to determine their degree of redundancy with other work. A representative of the RAO should sit on all advisory committees in these areas.

For both ships and aircraft, the RAO should adopt a general model of the kind developed in this study. Existing studies that adequately quantify links in the general models should be identified and used by the RAO in answering questions about how resource changes are likely to affect readiness. ADP support should be provided for this purpose where necessary.

The RAO should encourage studies in areas where no existing studies adequately quantify links in the general model. (This may entail funding material-readiness-oriented studies out of its own research budget.) Studies on improved measurement of material readiness are included.

The RAO should be responsible for developing or coordinating all OpNav responses concerning long-term readiness levels and the likely effect of changes in resource use on readiness.

The option chosen by the Navy for pursuing the relationships of resources to readiness should satisfy both short-range and long-range objectives. Developing models to improve management and fulfill Congressional requirements is a long-range effort. In the interim, questions on readiness will have to be answered on an ad hoc basis. An office dedicated to the problem would make both jobs easier.

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APPENDIX A

LIST OF STUDIES REVIEWED

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