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AN EXAMINATION OF SKILL DETERIORATION AND RETRAINING IN THE UNI--ETC(U)

SEP 77 J E TAYLOR, D M THALMAN

UNCLASSIFIED NL

1 OF 2

AD A050009

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NAVAL POSTGRADUATE SCHOOL

Monterey, California

(9) Master's THESIS,

(12) 123p.

(6) An Examination of Skill Deterioration and Retraining in the United States Navy.

by

(10) James Edward/Taylor

David Marvin/Thalman

(11) Sep[redacted]77

Thesis Advisor: D. E. Neil

251450

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) An Examination of Skill Deterioration and Retraining in the United States Navy		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis September 1977 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) James Edward Taylor David Marvin Thalman		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		12. REPORT DATE September 1977 13. NUMBER OF PAGES 124
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) Naval Postgraduate School Monterey, California 93940		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

training
retraining
skill loss
task analysis
performance assessment
retention
Reserve training

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

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(Page 1) S/N 0102-014-6601 |

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An Examination of Skill Deterioration and Retraining in the United States Navy

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
September 1977

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ABSTRACT

The U. S. Navy, in fulfilling its mission, requires a tremendous amount of skilled manpower. A significant percentage of this population is frequently assigned outside their respective skill areas. The resulting skill deterioration incurred during these assignments affects the amount of retraining required to reestablish currency and insure fleet readiness. This study suggests potential approaches for determining skill loss as the initial step for decision-makers in specifying the degree of retraining necessary. To this end, an extensive literature and agency survey of skill retention and related topics was conducted to identify areas where further research is required. Also, two conceptual models of possible retraining systems are formulated and discussed. Finally, recommendations are submitted which have implications in the areas of Reserve training, manpower planning, and personnel management.

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ACKNOWLEDGEMENTS

Many individuals and agencies contributed ideas and guidance to this study. Special thanks go to those agencies listed in Section III of the survey whose talented personnel enlightened us in many areas and provided encouragement along the way. Also appreciated is the farsightedness of Commander Fred Breaux (OP 9666) for recognizing the gravity of the skill retention problem in the Navy. The retraining study sponsored by his office provided motivation and direction for this effort.

Dr. Douglas E. Neil and Dr. James K. Arima of the Naval Postgraduate School are deserving of special acknowledgement. Their constant guidance often prevented the methods and procedures from going astray and kept the objectives clear in mind.

Finally, sincere graditude is extended to the Thalman and Taylor families whose patience and moral support were ever-present during this undertaking.

I. INTRODUCTION

A. BACKGROUND

Between 1964 and 1969, annual federal expenditures on manpower training and development programs increased from 400 million to approximately 2.2 billion dollars. In 1972, the United States Office of Education was budgeted in excess of five billion dollars, and allocated roughly 800 million dollars on instructional materials and media alone. One major U. S. corporation [Holt, 1963] reports spending 75 million dollars on salaries of employees undergoing some form of training or retraining. The indicators pointing towards increased emphasis on training are limitless, and it is an appropriate follow-on to briefly investigate the causes for the increased activity in the training area during the last two decades.

Perhaps the strongest motivation behind the intensification of training techniques has been the impact of increasingly complex technology on the total work force. The ensuing reduction in worker effectiveness resulting from a lack of knowledge of new technologies can be succinctly described in one word - obsolescence. What may be considered innovative today will most likely be considered antiquated in a few short years. Lukasiewics [1971], in his study of the engineering profession, has stated the useful productive life of an engineer after graduation is only five years unless adequate retraining is provided. Associated with the notion of obsolescence is the impending shift of the need for unskilled labor to a highly skilled or multi-skilled labor force.

In addition to the consequences of advanced technology, the rate of unemployment determined by economic fluctuations also necessitates the need for greater emphasis in training/retraining programs. To this end, the Manpower Development and Training Act (MDTA) of 1962 was established and charged with the responsibility of initiating large scale training systems to help curb unemployment by offering retraining as an avenue of reentry into the work force. In the first ten years of operation beginning in 1963, MDTA programs have accounted for 4.7 billion dollars in federal funds [Mangum and Walsh, 1973], with a commensurate improvement in employment of those individuals involved with the program.

Inherent with industrial growth and technological expansion is the need for a flexible work force. Generally described as occupational mobility, this flexibility manifests itself in the shifting of jobs both within and between skills, and is a necessary evil in the realization that without proper retraining of skills, the result will be an increase in unemployment. Taylor [1968] indicates that members of the American labor force change jobs on the average of every three to five years. This vast occupational mobility can prove to be an asset if properly channeled via appropriate retraining practices, or an unmanageable liability if left unattended.

Retraining, as the reader will have noticed, has begun to frequently reappear in the discussion thus far, and not unduly so. An integral part of any effective training program, retraining or updating of skills is as important as the more conventional courses which enlighten the employee as to how to operate in his present situation, but fall short of supplying him the knowledge of how to cope with a changing environment. Ida Hoos [1965] has illustrated this shortcoming by stating:

> A survey of industry has uncovered the fact that retraining on a large scale for workers threatened with skill obsolescence is rarely undertaken. Courses in safety practices, salesmanship, and management development prevail among industry sponsored endeavors. Indoctrination and orientation are commonplace; specialized instructions given by equipment vendors is a favoured practice. But programmes specifically designed to provide employees with new skills for job security in anticipation of technological change are exceedingly infrequent.

This is not to imply retraining is the panacea for worker obsolescence and unpredictable economic fluctuations, but rather to emphasize the relatively new field of skill maintenance and rehabilitation in conjunction with the more orthodox training techniques now in use. Retraining takes place both within a specific skill and/or entirely exclusive of a previously learned skill. The former entails such descriptors as upgrading of skills and keeping abreast of one's field, while the latter is typified by complete acquisition of a new skill and would hopefully include some positive transference from prior skill experience.

Before moving on to a discussion of terms relevant to this study, it is more than fair to ask about the gains to be realized for the large expenditures certain to be required for retraining programs. Perhaps the most numerative benefit is that such expenditures are both a social and economic investment toward adequate maintenance of the labor force. At the federal level, reductions in unemployment after retraining are readily apparent. Somers [1968] states that in almost all the surveys made on rehabilitating the unemployed, 75% of the trainees were placed within their new skill specialty. In a study of post-retraining in West Virginia, it was found that the trainee recovered personal costs in four months; and the government was able to recoup its investment within one year. At the corporate level, an effective retraining system facilitates job security and instills a sense of loyalty in the work force towards the organization. In addition, company employees with established service have proven their reliability, and it would be both wasteful and entail some degree of risk to hire outside personnel to fill new positions. Finally, the corporate image is enhanced if an organization has a reputation for retraining internally to fill positions created by new technologies before resorting to external resources. Both quantitative and qualitative factors, as are mentioned here, influence the costs and returns to be expected and must be considered before a decision about the scope of retraining can be made.

B. DEFINITION AND DISCUSSION OF TERMS

Although costs and benefits of training are the fundamental parameters used in decision making, the initial understanding for the need to train or retrain must take seed in a discussion of basic terms germane to the general area of training. These terms will also serve as descriptors and indicate more specifically the direction this study will follow.

Learning theory has evolved continuously along with man from the days of Aristotle and is an internal process in which the individual digests incoming stimuli and effects changes in behavior. The process that brings about learning is called training. Training processes must include the material to be learned, the method to best stimulate learning, and the evaluation of the resulting modified behavior. Since the areas of learning and training have received broad applications, several related terms specific to this study are presented and discussed. The following terms also provide a rough chronology of the processes involved herein.

1. Skill

Skill has been defined somewhat nebulously by a variety of sources which makes discussion of the concept less trivial than it would first appear. One source is the Oxford New English Dictionary whose definition reads, "practical knowledge in combination with ability." Another is "ease, rapidity and precision (usually) of muscular action," found in Dictionary of Psychology [Drever, 1965]. A perhaps more useful definition was presented by Guthrie [1952], "Skill consists in the ability to bring about some end result with maximum certainty and minimum outlay of energy and time." In the context of this study the term skill needs to reflect not only a manual dexterity, but also intellectual processes.

Salvendy and Seymour [1973] break these specialized abilities into four divisions of labor:

a. Sensory reception of stimuli.

b. Mental perception and organization of information necessary to perform the task.

c. Cognitive decision-making to organize the proper response.

d. The response involving motor actions.

The ability to perform a given skill, therefore, constitutes the marrying of these stages into one continuous operation. In essence, several skills may be used to complete a single task, and several tasks may be performed to complete a job. Thus, a skill will be strongly related to performance as defined by how well an individual accomplishes his job. In addition, skill used in later discussions reflects the individual's ability to perform a specific task.

2. Nonutilization

Given that a skill has been learned and employed effectively to some productive end, nonutilization will be the term used to denote a period of disuse of that skill. During this period, the skill or set of related skills are not practiced. A nonutilization period will generally refer to an extended amount of time between one and four years. Causes of such periods are varied and may include promotion, reassignment, extended periods of schooling, or a change of employer. Although absenteeism for whatever reason is also a period of skill disuse, its time span falls too low on a hierarchial level to be used synonymously with nonutilization. Nonutilization results in obsolescence and a reduction in technical effectiveness.

3. Skill Deterioration

Given that a skill has been learned and then followed by a period of nonutilization, the resulting affliction is called skill deterioration. This term simply refers to a decline of proficiency in performing a skill. Skill deterioration has the inverse connotation of skill retention. Several variables of skill deterioration have been set forth by Naylor and Briggs [1961]. The first deals with task variables, which can be classified as discrete or continuous (sequential). Next, there are learning variables which play an important role in skill deterioration, and refer to the method employed for original skill acquisition such as part versus whole task approaches. They also account for the amount of training provided. One of the most influential variables is the length of the retention interval or the period of nonutilization. As discussed previously, this is the period of no practice. Later sections will discuss in detail the underlying variables associated with the nonutilization period relating to the types of activities undertaken during this period. Finally, there are recall variables such as environmental and mental conditions at the time the deteriorated skill is once again required. These variables all interplay with one another to produce a level of skill deterioration.

4. Retraining

As stated earlier, retraining in the civilian employment sector refers mainly to teaching a new skill to those unemployed. The three R's for a healthy economy seem to be relocate, retrain, and reemploy. This connotation is contrary to the one desired for this study. In keeping with the chronology of terms presented above, retraining denotes a period of relearning following skill deterioration. Traditionally in the military, one is trained in the skill areas required every time a new assignment or new equipment is received. If, for any reason, a period of nonutilization of a particular skill is encountered, a period of retraining is required to reestablish the skill and alleviate the effects of skill deterioration. Thus, in this study, retraining will not refer to learning a new skill; but instead, will refer to relearning and updating a previous or highly related skill.

II. STATEMENT OF THE PROBLEM

A. THE SKILLED LABOR FORCE WITHIN THE NAVY

As was mentioned before, there is an impending shift of the need for unskilled labor to a highly or multi-skilled labor force in the civilian sector. This trend is also prevalent in the military, and is produced by the same technological impacts which make production in industry so complex. According to Haber [1974], in his study of occupational structure, there have been significant increases in craftsmen and related occupation areas both in the civilian and military sectors. The numbers of occupations requiring skilled personnel within the military have been increasing at an alarming rate and comprise roughly 30 percent for the Army and Marine Corps, 51 percent for the Air Force and 75 percent for the Navy. The wide scope of the Navy's mission and the fact that ships (combatants especially) are far more complex than aircraft, somewhat explains the Navy's greater need for a higher ratio of technical skill in both the enlisted and officer forces. It is quite likely that these percentages will increase in the future, and the implication for retraining considerations becomes obvious. Unless viable retraining programs are established, future fleet readiness may be jeopardized.

The DOD Military Manpower Training Report for FY 1976 indicates the Navy spending 878.5 million on specialized skill training of approximately 620,000 personnel with an average school length of 22 days, which leads to a cost per student day of 63 dollars. These figures exclude flight training, recruit training, officer acquisition and professional development education. Data for rehabilitative training (retraining) is unavailable, but on the basis of the figures presented, we can assume retraining costs to be at least as high per student day as for initial training. It would then be in the Navy's best interest to construct cost effective retraining programs to maintain an adequate supply of technical personnel throughout the Navy's organizational structure. However, substantial groundwork is necessary before the retraining question in the Navy can be answered.

B. CATEGORIES OF NONUTILIZATION

The majority of Navy personnel are highly trained, and as high as 25 percent are assigned outside their skill areas and require retraining upon return to their occupational specialties. The status of the individual during nonutilization will have a direct bearing on the amount of skill deterioration encountered. For example, personnel on inactive reserve status will incur less skill deterioration if his occupation in the civilian sector is closely related to his previously learned skill in the military. In order to reflect the entire Navy organizational structure, this study will consider the following categories of nonutilization with respect to deterioration of a previously learned skill:

1) Active duty outside of skill area, but still within the Navy.

2) Active duty with another Service.

3) Navy veteran with obligatory reserve service.

4) Navy veteran without obligatory service.

In addition to categorizing the types of nonutilization, it should be emphasized that the Navy reserve force (selected, ready, and standby active) of roughly 260,000 personnel represents a major portion of the target population. Since 1971, the importance of the reserve structure has greatly increased. The Military Service Act of 1971 and the Defense Authorization Act of 1973 established the "Total Force Concept" which tasked the reserves with the responsibility of augmenting the active force in lieu of conscription.

C. SKILL DETERIORATION

Since various periods of nonutilization occur in approximately 25 percent of the Navy's total enlisted force, the resulting deterioration of skills poses a significant problem to the Navy. Before skill deterioration can be combated, its variables must be identified and studied. It would seem reasonable to assume at this early juncture of the study that several factors will be found which impact differently upon various skill areas. For example, skill type, length of nonutilization period, and type of duty during the nonutilization period are several of these relevant factors. The scope of the problem dictates, therefore, that an investigation of these variables is not only necessary to identify those which are applicable, but additionally is needed to determine the effects of these variables on skill degradation. Optimistically, this study will point toward a future effort to develop a system to quantify relevant factors which predict the amount of skill deterioration experienced over varying periods of nonutilization for the purpose of deciding how much retraining will be required.

D RETRAINING REQUIREMENTS

Once it is known how much skill deterioration can be expected to occur, the area of retraining can be investigated. When personnel return to previously held billets following a period of nonutilization for whatever reason, they must first receive a period of retraining. Currently, the Navy lacks sufficient data to determine how much and what kind of retraining is required. This situation leads to decisions prescribing either too much or too little retraining. The former alternative results in decreased manhours for the fleet and increased training costs while the latter decision leads to decreased fleet readiness. The decision-maker's problem can thus be simplified to one of obtaining suitable information to enable him to make the trade-off between retraining costs and readiness.

E. SUMMARY

In summary, the total problem can be stated concisely as follows: The U. S. Navy, in fulfilling its mission, requires a vast amount of skilled manpower. A significant percentage of this population is sometimes assigned outside respective specialized areas. The resulting periods of nonutilization lead to skill deterioration. Upon reassignment, retraining is necessary to reestablish currency and ensure a high degree of fleet readiness. Simply stated, the ultimate question is how much retraining is necessary. The scope of this study will seek to provide the initial steps toward providing the information necessary for decision-makers to determine the degree of retraining. This will be accomplished by a review of the literature and current projects being conducted by agencies that relate to the problem stated herein. The next step will be to identify the areas where further information is needed and to identify agencies where subsequent studies might be conducted. Finally, conceptual models of how the skill retention problem might be handled will be presented. Results from this effort may have implications in the areas of training and readiness of the Reserve, length of service requirements, and mobilization manpower and personnel planning.

III. INFORMATIONAL SOURCES

A. SCOPE

Skill retention can be affected by a myriad of variables and conditions, some of which are extremely hard to quantify, and attempting to be all-inclusive would produce a literature review of unwieldy proportions. Therefore, an effort has been made to review only those studies which are amenable to providing insight for the Navy's particular skill deterioration and retraining problem. In essence, emphasis was placed on studies which dealt closely with operational conditions. Of higher concern was job-oriented procedural, perceptual, and cognitive skills rather than more simplistic motor skills. As the overview developed, identification was made of areas where sufficient amounts of information were lacking and warrant additional external effort. The skill deterioration and retraining approach further structured this review and will continue to be the common thread proliferating through this paper. It was the intent of this search to cover relevant studies for supplying the Navy with data of a recency of five to ten years. This survey involved formal searches with the following sources:

1) Naval Postgraduate School Library, Monterey, CA.
2) Defense Documentation Center (DDC)
3) National Technical Information Service (NTIS)
4) Psychological Abstracts Search and Retreival (PASAR)
5) Human Resources Research Organization (HUM RRO) Library, Carmel, CA.

Additionally, an agency survey was conducted and included several human resource laboratories and research activities in the Navy, Air Force, Army, and civilian sectors. In all, 16 agencies were visited, while many others were contacted by telephone. A comprehensive discussion of the organizations, contacts, and related studies/projects is presented immediately following the literature review.

Finally, the areas identified as having a paucity of information, or gaps in available data, will be discussed further in hopes of determining the criticality of such gaps and for suggesting areas of further study.

B. LITERATURE REVIEW

1. Skills

Since one of the purposes of this paper is to examine previous literature which may be of interest to skill retention in the Navy, the first area of investigation must be the skilled job areas themselves. It would seem reasonable to assume at this point that any conceptual solution(s) to the problem must include an analysis of job skills. It is important to know how skills are acquired, how they can be classified and how they can be assessed. These three areas, then, form the organization of this section of the literature review.

a. Acquisition of Skills

This brief section serves as a background into some problems, variables, and experiments dealing with the learning of a skilled task. Bilodeau [1966] edited a collection of papers on skill acquisition which provides an excellent starting point. The first chapter contains a paper [Irion, 1966] which reviews the history of skill acquisition research. Jones [1966] then treats individual differences in learning and makes the point that genetic contributions are more prominent in the early stages of practice. Next, Fleishman [1966] states that basic abilities underlie skill levels. These basic abilities are cultivated early in life and remain constant thereafter because of overlearning. The abilities required for a particular skill change as the amount of practice increases. For example, verbal and spatial abilities decrease as motor abilities (kinesthetics) increase. In a later article, Fleishman [1971] found that skill acquisition may be enhanced by concentrating on the abilities useful for final proficiency while deemphasizing those abilities used in early stages of learning.

Craig and Bittel [1967] identified the requirements of learning which include motivation, an appropriate stimuli, a required response, and confirmation in the form of reward or feedback. Heimstra and Ellingstad [1972] identified learning variables as being practice conditions; the nature of the material; prior experience; and again, motivation. Individual differences also are a factor affecting skill acquisition which has led to a vast amount of research with implications for selection and training of skilled personnel. They also have found whole methods superior to part methods in skill learning. This means that a skill should be presented and practiced in its entirety and not divided into segments. Finally, they stress that feedback or knowledge of results is probably the single most important factor in skill acquisition.

The importance of sensori-perceptual and decision-making components of occupational skilled performance is emphasized by Salvendy and Seymour [1973]. Skilled performance involves sensory reception of information, perceptual organization of this information as it relates to the task, cognitive decision making to determine the necessary movements, and muscular action which accomplishes the task. Feedback is a vital input to the decision-making process if skilled performance is to be continued. They also reviewed some early work in the area of acquisition of occupational skills and reported the following findings:

1) Learning speed improves as the size of the unit comprising the task increase;
2) Skilled performance relies on kinesthetic feedback as well as visual inputs;
3) Comparison of learning curve plots is useful for evaluation of training methods;
4) Skilled performance is a function of early practice patterns that can be associated with other similarly learned skills.

Thus, it appears such variables as feedback, individual basic abilities, aptitude, and structure of the learning situation itself all have considerable effect on skill acquisition. There have been many others who have investigated this area, but it is hoped that this brief review furnishes a flavor of the types of ideas that have been studied.

b. Classification of Skills

The next logical step taken in a discussion of skills is the work done in the area of skill classification, often referred to by the term, taxonomy. The conceptual sections of this thesis will undoubtedly necessitate an effort to classify various Navy skills, and it is therefore important to briefly review the efforts made toward this goal to date. It should not be surprising that a majority of the skill taxonomy work has been motivated by the military.

At this point it is both necessary and convenient to clarify several terms used to describe various hierarchies of classification. First, on the highest level, is vocational analysis which encompasses several occupations within an industry. A military example would be analysis pertaining to all squadron maintenance personnel. The next classification level is the most applicable to this study and involves occupational or job analysis. Since this thesis is to have implications for manpower and planning, information specific to individual billets is useful for making evaluations of skill deterioration and decisions about retraining requirements. The term skills analysis is also used synonymously with occupation and job analysis. Finally, at the lowest level, is task analysis which is concerned with each segment of the job. The emphasis here is on the sensori-perceptual and psycho-motor processes involved to perform each job function. The remaining portion of this section is devoted to a brief review of the literature on task classification and analysis.

Heimstra and Ellingstad [1972] refer to job analysis as being useful to discover the behaviors necessary for skilled performance. Types of job analysis discussed include interview, questionnaire, work participation, and critical incident methods. Another pair of authors [Salvendy and Seymour, 1973] talk about job analysis in terms of answering the question, "What does the worker do?" Analysis considerations must include psychological, physiological, physical, and industrial engineering disciplines and approaches. With these disciplines in mind, several methods of analysis are presented under each category while all methods have in common the following items: complete job description, list of responsibilities, types of equipment used, and condition of work. On the other hand, task analysis poses the question,"How does the person perform his job?"; which must be answered prior to the development of a training program. They also discuss the main classes of occupational skills which include handwork, handwork with tools, single-purpose machine work, multi-purpose machine work, group machine work, and nonrepetitive work. In order to be utilized in the training and retraining of workers, task analysis should be applied to performance which has reached what is referred to as the experienced workers' standard (EWS).

Christensen and Mills [1967] in their study of complex systems operators found that there was little data on operator skill requirements in a military operational environment. The existing data, for the most part, came from simulated operations or simply from armchair conjecture. However, they maintain it is possible to obtain criteria for human performance under actual operational conditions. Also, they call for increased standardization of skill classification systems. In this regard, one of the more widely used taxonomies is presented in Table I. The advantages of this taxonomy are its ease of use and comprehensive coverage of specific behaviors. On the negative side, a disadvantage is that the best of specific behaviors is by no means exhaustive, making it difficult and in some cases impossible, to fit all military personnel activities to this taxonomy.

Also, Fleishman [1967], one of the foremost researchers in the area of skilled operator performance, completed a study on performance assessment related to a task taxonomy. Although there has been a large quantity of task analysis data collected in the past, new systems differ significantly with respect to application, mission, and technology making prior analysis inapplicable for the problems of skill identification, training, and performance, now and in the future. He discussed the need for a task taxonomy, and stressed throughout his work that the taxonomy must be founded on an empirical approach. To this end he identified the following eleven psychomotor factors:

1) Control Precision - fine muscular adjustments usually in large muscle groups.

Processes	Activities	Specific Behaviors
1 Perceptual Processes	1 Searching for and Receiving Information	Detects Inspects Observes Reads Receives Scans Surveys
	2 Identifying Objects, Actions, Events	Discriminates Identifies Locates
2 Mediational Processes	1 Information Processing	Categorizes Calculates Codes Computes Interpolates Itemizes Tabulates Translates
	2 Problem Solving and Decision Making	Analyzes Calculates Chooses Compares Computes Estimates Plans
3 Communication Processes		Advises Answers Communicates Directs Indicates Informs Instructs Requests Transmits
4 Motor Processes	1 Simple/Discrete	Activates Closes Connects Disconnects Joins Moves Presses Sets

Table I. Classification of Behavior

Processes	Activities	Specific Behaviors
	2 Complex/Continuous	Adjusts Aligns Regulates Synchronizes Tracks

Source: Christensen and Mills

Table I. Classification of Behavior (continued)

2) Multi-limb Coordination - found in tasks requiring simultaneous control of hands and/or feet.

3) Response Orientation - involves rapid visual discrimination and response in psychomotor tasks.

4) Reaction Time - the speed of response to a stimulus.

5) Speed of Arm Movement - involves simply the speed of gross arm movements and is independent of reactor time.

6) Rate Control - Ability to trace a constantly changing target in both dimensions of speed and direction.

7) Manual Dexterity - involves directing large objects with arm-hand movements under speed conditions.

8) Finger Dexterity - involves directing small objects using, primary, finger movements.

9) Arm-Hand Steadiness - ability to maintain a desired position with precise arm-hand movements.

10) Wrist, Finger Speed - little used factor measured by "tapping" a pencil on paper.

11) Aiming - involves eye-hand coordination in hitting a target with a finger.

Additionally, Fleishman has identified the following nine factors of physical proficiency: extent flexibility, dynamic flexibility, explosive strength, static strength, dynamic strength, trunk strength, gross body coordinator, gross body equilibrium, and stamina. Both sets of factors account for the majority of common variance across a wide variety of tasks. However, at the same time, he stressed that these lists of factors were by no means exhaustive. Fleishman's approach for development of a behavior taxonomy was presented in four phases; analysis of real tasks, synthesis and testing of tasks, definition of behavior categories, and performance evaluation. In a later paper [Fleishman, 1972] on human performance, he concluded from studying individual differences in learning, that development of a skilled performance taxonomy germane to applied problems should be centered around experimental and correlational methods.

The Navy currently is using several classification systems for task analysis, and the primary system is the Navy Enlisted Occupational Classification System (NEOCS). The system was established to identify personnel and manpower requirements, facilitate effective manpower management, provide for personnel career welfare, and provide uniform terminology for enlisted occupational abilities, training, and experience. Recently a study of NEOCS was undertaken to identify problem areas and recommend improvements ["NEOCS Study," 1974]. Problems discovered were its unwieldy size due to over specialization, lack of easy adaption to new enlisted skills, abundance of indistinct skill definitions, and failure to provide a meaningful base for advancement.

In essence, the classification of skills should be job oriented and based upon carefully developed taxonomies. Also, since the ultimate goal is to determine skill loss, the classification scheme should reflect the degree of importance (criticality) of each task. Performance can then be measured as a function of critical task completion based on a hierarchial system of classification. Finally, continuity should be maintained by developing a standardized system amenable to both training and assessment communities.

c. Skill Assessment

An investigation of the measurement of skill is in order for the purpose of providing background information as well as identifying notable research in this area. It would seem relevant when discussing skill retention and retraining to include a survey of methods to assess skill proficiency. To determine the extent of skill degradation and the amount of retraining necessary, one must first be capable of measuring the level of skill proficiency. There have been a number of notable projects undertaken through the years in search of a reliable and efficient method to assess performance. In the interest of brevity, the work deemed most relevant to the present problem is reviewed here.

To begin, Salvendy and Seymour [1973] define the often used term, criterion. When discussing behavior or performance measurement, the term criterion is frequently used to denote a standard of evaluation. A criterion referenced test is one in which an individual's performance is evaluated against what he must do in order to successfully complete a task. On the contrary, a normative referenced test compares an individual's performance to that of the group taking the same exam. A method of measurement qualifies as a criterion reference only if it is relevant to the skill being evaluated, and if it can identify individual differences. Three types of criterion measures are ranking, counting, and establishing standards.

Christensen and Mills [1967] contend that because little operational data is utilized for performance evaluation, simulated operational experiments may never really measure the criteria associated with actual job performance. If such data is to be utilized, it must be highly correlated with operational data. They stress that although performance data collected under actual operational conditions is more difficult and may not be as "pure" as laboratory data, its utility far outweighs the disadvantages. It is recommended that systems be designed with the capability to efficiently collect periodic performance data.

Fleishman [1967] has been one of the prominent pioneers of performance assessment. His work in this area was begun by trying to solve the military problem of predicting pilot performance. While based on empirically derived task taxonomies, tests should be evaluated on the amount of performance change they can detect. However, at the same time they must be capable of measuring across various experience levels. He recommends use of interim performance measures validated against operational performance, while task taxonomies are being developed. More recently Fleishman, et. al. [1973], developed guidelines for a research program on human performance. While focusing on identification and evaluation of critical performance tasks, the authors discuss human reliability, performance optimization aids, performance standards, and skill and task structure. Several of these areas have implications for the previous section on task classification. Performance standards involve development of specific, dynamic criterion for measurement of performance. Thus, a quantitative criterion based assessment tool should be utilized, vice a subjective supervisory rating. The report sees a need for the Navy to incorporate two approaches into its performance assessment program: one approach is Fleishman's [1972] use of empirical correlations of task interrelationships, and the other is Alluisi's [1970] synthesized human function tasks. Because of its use of time sharing in a multi-channel setting, the latter approach is more operationally oriented. Once more, it is emphasized that assessment of performance must be as much like the actual operational job as possible. Points of common deficiency in this area are failure to consider complex, multi-dimensional, and sustained performance conditions; as well as motivation, general behavior, stress, and time-sharing tasks. Any assessment mode outside the operational environment must prove to be a valid measurement under actual conditions.

The U. S. Army Research Institute for the Behavioral and Social Sciences [Mailer, 1976], sponsored a study to determine the feasibility of hands-on performance tests for technical jobs. The study indicated when constructing any type of performance measure, an objective must first be developed which consists of task description, standards of performance required, and conditions under which the task must be performed. A literature review was conducted which showed trends in performance measurement shifting from normative reference tests to criterion referenced tests. Examples of criterion references are the time to complete a task, the quality of the output, the correct use of equipment, and the use of proper procedures. They constructed and successfully used a hands-on performance test for an electronic maintenance MOS. Possible problem areas included lack of equipment availability for testing and time constraints on the evaluation period. The latter may detract from total job performance. The results of the effort have been published in a guidebook for constructing and administering criterion referenced tests [Sweezy and Pearlstein, 1975]. Several other military agencies are currently engaged in projects on performance measures and these will be discussed in a later section of this study.

Summarily, the assessment of skill should be operationally measured, utilizing the same criteria emphasized during the training period. This criteria should reflect task criticality and should be derived from operational data and not a controlled laboratory environment. If proper attention is given the method of assessment, the results will provide information for eventually determining retraining requirements.

2. Skill Deterioration

An investigation into the deterioration of technical skills comprises a major portion of the scope of this study. This section will review pertinent literature on the subject of skill retention and will also strive to pull together the important findings in the area to date. The subject of skill retention has been a relevent topic for study by both industry and the military. This popularity has produced several literature reviews over the past fifteen years, the most recent of which is Prophet [1976]. Thus, to prevent redundancy of effort, the past literature reviews will be discussed thoroughly along with several significant references which will serve as a background to the topic.

To begin, skill deterioration is most difficult to measure. Only by subtracting what is retained from what was originally learned, can one estimate how much information was lost. This is what Ebbinghaus did as early as 1885. His studies resulted in the formulation of a "forgetting curve" which showed huge losses in retention shortly after the learning period. As time increased the forgetting rate decreased.

Since Ebbinghaus, others have found many more variables affecting retention in addition to time. Four factors influencing retention are identified by Heimstra and Ellingstad [1972]. The first is the meaningfulness of the material. It is generally agreed that the more meaningful or the more organized the information is to the learner, the better it will be remembered. Second, the type of practice utilized in the training environment can have a positive effect of retention. For example, retention is enhanced by many small practice sessions vice a larger massed session. The third deals with proficiency, where the level of mastery of a skill is strongly believed to be inversely proportional to the amount of skill deterioration experienced. Finally, a fourth variable of retention is its method of measurement. The following three such methods were discussed:

1) Recall - In this situation the learner must reproduce what was learned previously. This is the least accurate method due to the amount of other factors besides

retention that could prevent the subject from expressing the correct response.

2) Recognition - Here one must identify the correct response(s) from a field of incorrect distractors. The accuracy is dubious because the correct answer can be arrived at by guessing.

3) Savings - This method requires the subject to relearn a previously known task while quantifying the number of repetitions required and comparing that to previous training sessions. This method is the most accurate measure of retention.

Fleishman and Parker [1961] studied retention of motor skills. They varied retention intervals, type of initial training, and level of initial training. The most significant variable found was individual differences in the level of original training. The length of the interval for these types of skills was not an important factor

There is one additional study [Armstrong, 1975] that bears mentioning when discussing the various variables of skill deterioration. The factors of retention are categorized into the following four areas:

1) Type of tasks - Motor type skills are usually retained longer than verbal/procedural type skills. Examples of motor skills are cycling, swimming, and basic flying. Examples of a procedural task are electronic repair and computer programming.

2) Types and amount of training - Retention seems to be proportional to the amount of original proficiency

and to the amount of organization in the training environment. Also, the likeness of the recall surroundings to the initial training environment affects the amount of retention.

3) Retention interval - Retention generally decreases over time. Skill decay, in addition, depends on what occurs in the nonutilization period. For example, the types of practice, if any, performed on the task or the learning of another moderately related skill can significantly affect retention.

4) Retraining situation - Retraining time is directly dependent on the proficiency of original training and on the length of the period of disuse.

Since industry does not suffer from skill deterioration due to nonutilization of the same magnitude as the military, their skill degradation efforts are focused around the problem of obsolescence. A modern Navy also suffers from this form of technological turbulence as well as nonutilization. Thus, this seems an appropriate place to briefly discuss this topic. Obsolescence is a form of skill deterioration although it results from an external source. It is not one's retention of a skill that changes in this case; rather, it is skill requirements that vary. Dubin [1974] reported that very little research has been conducted in identifying the variables of obsolescence. Obsolescence is defined by many to be a reduction in performance with time, which results from the development of new technologies since the worker's last period of training. Mali [1969] developed an obsolescence index:

$$OI = \frac{\text{Current knowledge understood by personnel}}{\text{Current knowledge in the field}}$$

In relation to training, it is suggested that obsolescence be defined as the difference between the knowledge and skills of a current graduate, and the practicing individual in the fleet.

As mentioned previously, there have been several literature surveys in the skills retention (or deterioration) area since 1960. Four of these reviews will now be discussed in order to lend brevity to this portion of the present skill retention overview.

Perhaps the first milestone study was performed by Naylor and Briggs [1961] for the Air Force in the specific area of flight skills retention. Over 120 items were covered, but were predominantly research and not operationally oriented. In any case, the authors classified skill retention variables into task, learning, retention interval, and recall categories. Of primary interest here are the retention interval considerations. Although there is a paucity of data highlighting the effects of varying amounts of practice during the period of retention, it was found that longer periods produced larger performance decrements and also, this relationship was found to be nonlinear, wherein the greater performance decrements occur early on, then taper off. Other significant findings were:

1) Continuous (tracking) tasks are retained better than discrete (procedural) tasks

2) The higher the degree of mastery during initial acquisition, the longer the retention of a skill.

3) The greater degree to which a task is integrated and specified, the better it is retained.

4) Whole learning, as opposed to modular, can lead to better retention, especially for more complex tasks.

5) Measurement plays a key role in ascertaining the degree of retention. It is of great importance to insure the criterion used and measurement be critical to the successful completion of the task.

The Naylor Briggs review is quite comprehensive, but to a large degree is oriented toward verbal learning and memory. Of more concern in the present study are the procedural and psychomotor skills which are involved in Navy technical ratings.

A. J. Rose and T. B. Turner [1967] investigated the high incidence of skill loss when Navy personnel were assigned to non-rating related billets ashore. The initial phase of the investigation was primarily a bibliographic survey, and unfortunately funding for a subsequent longitudinal study wasn't available. However, the initial report represents one of the first concerted efforts to provide the Navy with data on retention of technical skills. In the statement of the problem, skill loss was defined as loss of a previously learned technical skill, and the important difference between skill loss and obsolescence was pointed out:

> The inability of personnel to perform assigned duties due to changes in equipment between previous

and present billet assignments [obsolescence] should not be confused with inability to perform due to skill loss through lack of opportunity to practice job skills.

Rose and Turner summarized the following points from their combined literature and agency survey:

1) Discrete tasks involving sequential steps incurred considerable skill loss over time, while continuous tasks suffered no decrease in retention.
2) Job skill research has been predominantly oriented towards operational skills and not maintenance skills.
3) Few reports exist on skill loss due to nonpractice of those skills.

The next important skill retention review was conducted by G. R. Gardlin and T. E. Sitterley [1972] of the Boeing Company, working under contract for NASA in 1972. They separated retention variables into four categories: (1) amount of training; (2) duration of retention interval; (3) task organization; and (4) task environment. In general skill retention appears to be functionally proportional to amount of training, extent of task organization, and the degree of similarity between task environment and operational setting. Conversely skill retention, except in regard to continuous skills, is most likely inversely proportional to duration of the nonutilization period. A commonality shared by all four above mentioned categories is the level of skill attained just prior to the retention interval; "...the key factor in predicting skill retention for a given no practice interval appears to be the final level of skill acquisition. Other variables were seen only to modify this level."

The authors also express caution about extrapolatin retention data gained from controlled laboratory environments to the operational setting. Most of the literature involves the investigation of performance wherein the operator is concerned only with a single task. More often, an operator hand multiple tasks, and interference effects inherently increase the task difficulty. For example, an intercept operator aboard a modern fighter aircraft will perform three tasks, perhaps simultaneously: (1) track a target on a radar scope (continuous task); (2) vector the pilot towards the target (discrete task); and (3) arm and fire a missile (discrete task). The secondary task of vectoring the pilot can produce decrements in initial retention test performance in the prima task of tracking the target. It is in situations as just described where effective task organization and the use of high fidelity simulators can significantly improve retention and/or maintenance of skills.

Gardlin and Sitterley go on to say that training/retraining programs should be based heavily on critical performance dimensions. That is, essential task elements upon which the success of the mission depend must be identified and specifically stressed. In addition, any performance measure used should not be global in nature, but designed to determine whether or not the individual can perform those tasks deemed critical to job success. This applies to the broad spectrum of task skills, from those as complex as spaceflight to more mundane levels such as radar scope monitoring.

Propher [1976], the last review to be cited, is definitely the most comprehensive literature survey on skill retention to be undertaken to date. In his study of long-term retention of flying skills in 1976, Prophet reviewed 120 items published primarily in the sixties and seventies. He also discussed several previous literature surveys, including Naylor and Briggs, and Gardlin and Sitterley. In addition to a most detailed literature review, Prophet published an annotated bibliography under separate cover, as a companion report to the survey. Over 120 items are synopsized and are grouped on a scale of relevancy to flight skill retention.

As a first step in assessing the research activity, Prophet compares his survey with that of Naylor and Briggs, and Gardlin and Sitterley. Degree of recency (Table II) and amount of overlap (Table III) form the basis of comparison. From these extracted tables, it can be seen that Naylor and Briggs covered resources up to 1960, Gardlin and Sitterley focused on the sixties, and Prophet centered predominantly in the late sixties and the first half of the present decade. 79 of 120 items in Prophet's review were not covered in either of the other two surveys, largely because of recency. This indicates an increasing amount of activity in the skill retention field, but according to Prophet, not near enough:

Year of Publication	Naylor & Briggs	Gardlin & Sitterley	Prophet
1975-	0	0	6
1970-1974	0	4	40
1965-1969	0	62	40
1960-1964	1	37	25
1955-1959	25	8	6
1950-1954	28	5	1
1945-1949	5	0	1
1940-1944	11	0	1
1935-1939	14	0	0
1930-1934	19	0	0
1925-1929	6	0	0
1920-1924	6	0	0
1915-1919	3	0	0
1910-1914	2	0	0
1905-1909	2	0	0
1900-1904	0	0	0
1895-1899	0	0	0
1890-1894	0	0	0
1885-1889	1	0	0
Total	123	116	120

Table II. Publications Reviewed - By Year of Publication

Author(s)	Number of Items Reviewed
Naylor only	113
Gardlin only	72
Prophet only	79
Naylor-Gardlin	5
Naylor-Prophet	2
Gardlin-Prophet	36
Naylor-Gardlin-Prophet	3
Total	310

Table III. Commonality of Three Literature Reviews

> It would be a mistake to assume, however, that the problem [skill retention] is receiving adequate research attention, for of the several hundred studies included in this review, only a relative handful deal with skills of the magnitude of complexity of aircraft piloting, and very few deal with retention time intervals similar to those of concern to the USAF (1-3 years).

Prophet discusses his findings in terms of the following three categories: (1) general retention factors; (2) task or skill factors; and (3) retraining factors. As in the Sitterley review, Prophet indicates the best predictor in determining performance after intervals of nonuse is the highest level of skill acquired prior to the interval. In regard to the duration of the retention interval, no adequate quantitative depiction can be had from research to date. All that can be conclusively stated is the longer the period of no practice, the larger the decrement in performance. A hypothesis by R. H. Wright [1973] that flight skill degradation is rapid in the first 6-12 months of nonutilization is supported somewhat quantitatively, but performance ratings were self-judgements by the operator population, not actual inflight measurements. In trying to derive forgetting curves for combat pilots, M. B. Armstrong [1975] used returned POW's because of their variant periods of inactivity. However, because of the nonhomogeneity of the group, and relatively few data points, inferences about the shape of such a retention curve would be somewhat risky. Of much interest is Prophet's emphasis of interference factors during the period of no practice. Intuitively, one could think any related skill practice would enhance retention, but this is not always the case. Prophet cites several proficiency flying studies in which pilots who flew light aircraft during nonflying assignments, and then retrained in a more complex aircraft, required more retraining than did pilots who had not flown at all. Clearly, there exist such interference factors in other procedural related skills, especially within Navy technical ratings.

In discussion of discrete (procedural) versus continuous tasks, Prophet agrees with the consensus of reports indicating continuous tasks are retained better than discrete tasks. He goes on further to say that because of procedural task loading, instrument flying is more difficult to retain than visual flying. Finally Prophet highlights some pertinent retraining factors which are discussed in the retraining portion of the present literature review.

By far the most exploited of the research areas discussed in the present literature review, skill deterioration is the result of a myriad number of factors, perhaps the most prominent being the amount of original proficiency acquired just prior to nonutilization. This idea seems to be a common point of agreement. Other considerations such as length of nonuse, type of skill, interference variables and individual differences, impinge directly on skill retention; but not to the same degree as original proficiency. It would then appear the best antidote for skill loss is a high level of training prior to an assignment outside a respective skill area.

3. Retraining

During the last two decades, there has been a great deal of effort at the federal level to cope with unemployment by establishing government/state supported training programs such as those sponsored by the Manpower Development and Training Act (MDTA) of 1962, and the Area Redevelopment Act (ARA) of 1961. In essence, endeavors in the civilian sector have dealt with training new skills to the unemployed and not retraining or updating previously learned skills. In contrast, this study seeks to explore retraining on a basis which will have implications towards such things as retraining the selected, ready, and standby active reserves to augment the active duty force when necessary. Another application would be ascertaining the amount of retraining required of an individual returning to his unit after a period of temporary additional duty (TAD) such as Shore Patrol or Master at Arms. The immensity of the manpower involved is indicated by a figure of just under 260,000 Navy reservists and a significant percentage of the active force on duty outside their skill area.

Programs to retrain or update the skills of this large population upon reentry into active duty (i.e., during short term augmentation of active forces) are virtually non existent. However, some training techniques now being studied could be applicable. One such technique is that of generalized training, where some common denominator of mission, equipment, or operational technique exists between systems. The U. S. Navy is now considering this approach in Acoustic Sensor Operation (ASO) training, where a multiplicity of systems and training hardware are now in use. In a study sponsored by the Naval Training Equipment Center (NTEC), R. W. Daniels and D. G. Alden [1975] propose to take advantege of the commonality inherent across the broad spectrum of Navy acoustic sensor systems. The degree of commonality would depend on operator task, skill, and knowledge required. This generalized training concept could be used quite effectively in retraining areas, especially within a general mobilization plan for the reserves. As was mentioned before the effects of the "Total Force" concept and an all-volunteer Armed Services have placed the responsibility for augmentation of the regular service upon the reserve force structure in lieu of conscription. The Army was perhaps the first service to be affected and has taken steps to geographically realign its reserve components to facilitate training and mobilization. A Table of Organization and Equipment (TO&E's) has been initiated to relate every unit and individual to a specific mobilization force. This geographical realignment has done much to enhance the training effort and could certainly provide a foundation for implementing generalized training techniques already discussed.

Since there exists well established lines of authority and communication within the military, another option for retraining is available and already well developed. Systematic training, verv much similar to programmed instruction, entails a careful examination of material, detailed breakdowns, step-by-step presentation and frequency feedback of results. In his study of technological change, Seymour [1966] emphasizes that careful classification (taxonomy) of the tasks involved is an absolute necessity for any training program. Taxonomies have been mentioned before and the Navy currently has the Personnel Qualification Standard (PQS) which closely parallels the intent of job taxonomy and provides step-by-step procedures for most tasks in the Navy. PQS could be applied to reserve components during the mobilization phase prior to active duty augmentation.

In many skill areas, especially in the aerospace field, both maintenance of proficiency and retraining require operation of extremely sophisticated and costly equipment. Several studies have investigated the feasibility of using less complex equipment for major portions of continuous and/or retraining programs. The Air Force, in an effort to curb the high cost of large transport (C-141, C-5) proficiency flying, used the T-37 trainer as a Low Cost Aircraft (LCA) to maintain flying skills. Unfortunately, some degree of task interference was experienced and coupled with a less than enthusiastic subject response, the LCA program was not successful. However, the concept is valid, but especially difficult to apply to aircrew training. In a similar approach with U. S. Army missile technicians, D. L. Grimsley [1969] experienced a great deal more success than was had with transport aircrews. In a series of studies, Grimsley sought to provide performance rehabilitation using low fidelity simulators in place of high fiedlity (actual duplication) devices which were more costly to operate. He found that the use of such low fidelity systems had no adverse effect on level of proficiency, retention, time to retrain, or whether individual or group learning was used. Also, bear in mind the tasks required of missile technicians are extremely procedural in nature and would be representative of the technical skills required by scores of ratings in the Navy. It should also be noted that Grimsley considers a careful review of tasks to be taught be made <u>prior</u> to selection of such low fidelity training devices.

Perhaps the area which has received the greatest attention is the retention of flight skills, and not unduly so. In FY 1975, the various military services flew approximately 6.4 million hours at a cost of about 2.7 billion dollars. Most of this flying was for training to develop and maintain pilot proficiency as an integral part of military readiness. However, the figuring of this cost is easy, whereas the resultant impact from an increase or decrease of flying training and readiness is not. To this end, literally hundreds of studies have explored the relationship of skill retention and the myriad number of maintenance schemes intended to be cost effective <u>and</u> guarantee proficiency. Of the four major reviews mentioned already, Naylor and Briggs [1962], Rose and Turner [1967], Gardlin and Sitterley [1972], and Prophet [1976], Prophet's survey seems to be the most comprehensive and obviously the most recent. In his review of almost 120 studies and articles, and an accompanying annotated bibliography, Prophet concludes the following about flight skills maintenance/retraining:

1) Virtually all of the training required to reinstate basic flight control and procedural skills can be accomplished in modern flight simulators. In general, training devices can be used with high cost effectiveness in flight skills maintenance and retraining programs.

2) The length of retraining programs is a function of:

a) Careful specification of program objectives.

b) Deliberate design of program to achieve the objectives.

c) Adequate methods of measurement and quality control.

d) Use of individualized, self-paced training techniques.

e) Cost effective use of training devices.

3) Individual operator experience. As experience increases, the pilot "learns to learn" and enhances performance over time.

4) Concomitant with 3), there is a general decline in performance, starting in the late thirties or early forties of an operator's life.

5) Basic flight skills (psychomotor) are retained well over time and are more easily reinstated that instrument (procedural) skills.

6) Finally, Prophet discusses the concept of the "unviable pilot." Such a person may be unsuitable for retraining due to extensive periods of nonflying, poor initial training, or degradation of some physiological or psychological variable deemed necessary to function as a pilot. Retraining programs

should seek to identify such individuals upon reentry to the skill area and channel them elsewhere. To try and retrain all personnel would be as ineffective as retraining none. Some quantitative measure should be used to screen out the unviable portion of the population before retraining begins.

Even though Prophet's survey was concerned with flight skill retention, one must realize that flying skill depends upon both psychomotor and procedural subskills. Thus Prophet's conclusions will also have substantial impact in technical skill areas which are greatly procedural in nature.

Gardlin and Sitterley [1972], in a literature survey in support of their investigation of astronaut skill degradation for NASA, point out the need for skill maintenance over long durations of task inactivity. The extent of scheduled on-board refresher training would depend on several variables such as the nature of the astronaut tasks, the time since last performance, the degree (if any) of task overlearning, and the software/hardware complexity. As in the Prophet survey, Gardlin and Sitterley cite the lack of an adequate performance measure to quantify actual skill deterioration. They go on to say any such performance measures should be task oriented and conducted in an operational setting rather than an artificial laboratory environment.

Naylor and Briggs [1961], the earliest of the four major skill retention surveys discussed herein, dealt with verbal learning, as opposed to skills learning, and as opposed to skill retention field, and for this reason it was discussed in part C (Skill Deterioration) of this section. In regard to retraining programs, Naylor and Briggs brought out, as long ago as 1961, the inadequacy of measurement methodology. Specifically, their concern centered around measurements over periods of retention, such as pre/post testing. There was then, and apparertly presently, no consistent measurement of job performance. Again this opinion is shared by all four major skill retention surveys.

It is necessary that some essential ingredients of retraining be reemphasized at this time. It is well known that some of the active duty population and virtually the entire reserve structure, train, retrain, and requalify on equipment in varying stages of antiquation. The Army has come to grips with this problem and is currently outfitting their reserve components with up-to-date material Since 1969, Army Reserve Components have received over six billion dollars in new equipment. G. A. Leon [1975], in his discussion on the total force concept, implies the United States should equip its reserve forces with modern weapons and equipment to permit effective training and strength development. This should take precedence over supplying our allies with present generation weapons systems. Even the best of retraining programs will be of little value without adequate operational and training material. Until such a time when adequate funding becomes available for training equipment, exploitation of the other retraining factors should be explored. Use of low cost/low fidelity training devices, generalized retraining concepts, and self-paced instruction are just a few considerations. Since retraining appears to be proportional to the length of the nonutilization period, limits should be placed on the numbers of personnel assigned tours of duty outside their skill areas.

4. Summary

Before proceeding to the agency survey, a brief recounting of the more salient results from the literature is in order. First, interest must be directed towards skill acquisition and what factors affect the learning process such as feedback, individual aptitude, and the structure of the training environment. Second, the variables of retention need to be considered as they provide feedback to the training environment, and aid the decision-maker in determining retraining requirements. Amount of original proficiency, length of the retention interval, type of skill (e.g., continuous or discrete), interference factors, and individual differences are but a few considerations relative to the retention area. Next, the method of quantitatively measuring skill loss via performance assessment is discussed. Proper assessment criteria must be selected and matched with training criteria. Furthermore, the criteria should reflect task criticality and be based on operational vice laboratory data. It should also be generally noted that retention curves prove to be risky estimators, primarily because they are based on relatively few data points. Finally, the general retraining process is treated as it relates to rehabilitating a previously acquired skill. The use of both self-paced instruction and low cost, low fidelity training devices has proven to be beneficial to reducing retraining time. It is generally agreed that the amount of retraining required is approximately proportional to the length of the nonutilization period, but no quantification of this relationship is yet offered. A relatively new idea, the generalized training concept, which takes advantage of system commonalities (e.g., the operation of various sensor systems) to retrain basic procedures, has met with some success and should help in reducing the high cost of retraining. As a last consideration, the idea of retraining all personnel upon reentry to their respective skill areas should be scrutinized. Those individuals classified as "unviable" should be screened out and not retrained. Previous inadequate performance or unusually long periods of nonutilization could mean inordinately high retraining costs.

C. AGENCY REVIEW

Beyond a review of the literature, the scope of this study includes a review of the agencies who are currently engaged in related projects or have experience in the areas of skill deterioration and retraining. Several additional agencies were contacted that could not provide any useful information, and they will not be mentioned here. A vast majority of profitable contacts were made with military sources.

The structure of the agency review will be to first identify and give the location of the agency. Then the names, titles, and telephone numbers of points of contact within each agency are given. Finally, a brief description of the work and/or ideas of each agency relative to this study is discussed.

Chief of Naval Education and Training (CNET)

NAS Pensacola, Florida

Dr. Scanland, ACOS for Research and Program Development (AUTOVON 922-3466)

Mr. Douglas Davis, Occupational Standards Training Programs (AUTOVON 922-3466)

Mr. Hooprich, NAVPERSRANDCEN Liaison (AUTOVON 922-2621)

Although CNET has no current program efforts devoted to research pertaining specifically to this study, there were helpful contacts made which merit attention for possible future reference. First, Dr. Scanland stressed the need for more in the area of assessing job performance which is a little understood art. From a training point of view, learning criteria reference measures should be patterned after suitable job performance measures (JPM). JPM's are also good for helping to set standards and for instructional feedback. To accomplish this requires a synergistic training/performance system unlike the current diffuse subsystems that have no lines of communication between them.

Mr. Davis is the JPM expert at CNET. He states that training curricula are developed from computerized job data gathered on Job Data Worksheets (Figure 1). These worksheets are essentially a method of task analysis. There are 640 task action codes that identify specific Navywide skills.

Mr. Hooprich is a liaison between CNET and several other Navy agencies. He is, thus, able to keep in close contact with all CNET projects and most training related projects throughout the Navy. He helped tremendously with this thesis effort and would be a good point of contact for any future efforts.

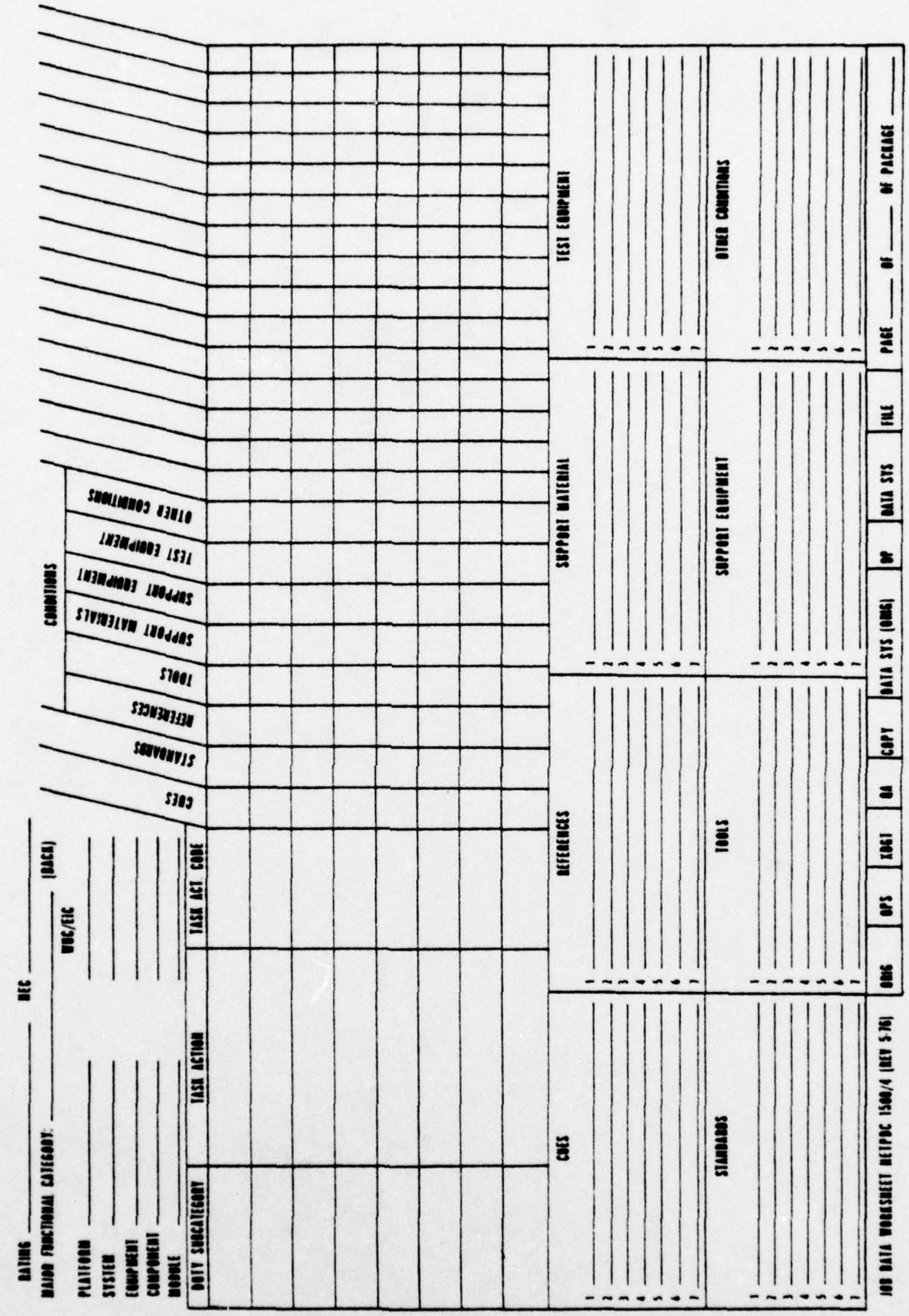

Figure 1. Job Data Worksheet

CNET Technical Analysis and Evaluation Group (TAEG)

NTC Orlando, Florida

Dr. Smode, Director (AUTOVON 791-5198)

TAEG is not currently engaged in any projects directly related to this study. However, Dr. Smode had several ideas worth noting on the subject of retraining. A possible approach to the problem should include the following three steps:

1) Define the job requirements.

2) Assess how well the worker can perform at the present time regardless of his nonutilization period variables.

3) Retrain the individual to the required level. Historically, collecting assessment, training, or skill deterioration data in an experimental setting has translated poorly to the operational environment. TAEG has had much success collecting actual operational data and believes this to be a much more viable route of progression.

Director of Naval Education and Training (DNET)

Arlington, Virginia

Captain M. K. Mailhorne, Deputy Director, Programs Division (AUTOVON 222-4835)

Captain Mailhorne is sponsoring the NPRDC study on the Performance Proficiency Assessment System, mentioned earlier. In addition to his position at DNET, he is also the Director for Plans and Policy for the Naval Reserve Readiness Command headquartered in Baltimore, Maryland. Though the NPRDC study on proficiency is longitudinal in nature, Captain Mailhorne believes a shorter term answer to skill deterioration is necessary. Some "gross cut" measure which will provide decision-makers a basis for determining retraining requirements for large numbers of skilled personnel, especially within the reserve structure. All too often, the lengthy longitudinal studies lose momentum when key individuals move on to other assignments.

In conjunction with his position in the reserve community, Capt. Mailhorne has submitted a point paper on training requirements to maintain proficiency in the Reserves. The adequacy of the present drill structure and active duty period is in question and a study is called for to:

> "......determine the effects of various drilling and ACDUTRA combinations upon the proficiency of post active duty drillers in various skill categories/field/applications... The intent of the effort would be to obtain 'ball park' information on the basis of which to exercise profesional judgement, rather than to create precise measurements and data."

In essence, there is some doubt whether current reserve drilling maintains even the simplest of general military skill, much less the technically oriented skill areas. Captain Mailhorne's views are shared by many senior officers in the reserve community, and the consequences of neglecting the expertise these views express could seriously degrade reserve readiness.

Fleet Anti-Submarine Warfare Training Center, Pacific

San Diego, California

Paul Asa-Dorian, Director of Curriculum Development and Standards (AUTOVON 225-4416)

Mr. Asa-Dorian has been active in the training area for over twenty years, and has often cooperated with the Naval Personnel Research and Development Center (NPRDC) on joint effort studies. An example is skill retention of weapons systems operators, especially sonar and various other acoustic sensor operators. He has developed a modular training system for surface sonar operators utilizing self-paced instruction. This method is extremely effective in initial training of first tour sonar technicians (ST), but has proven less than adequate for those personnel returning to the fleet for second or subsequent tours. Like many other ratings, ST's have little chance of maintaining their operational skills while on shore duty, unless they are assigned as instructors at an ASW training center. The ensuing skill loss from disuse is difficult to measure *a posteriori* and nearly impossible to predict beforehand.

Mr. Asa-Dorian's problem is where to place personnel within the modular system upon their return from billets out of the sonar skill area. He believes some sort of performance measurement could prove beneficial in supplying data for the amount of retraining required within the modular system.

Naval Occupational Development and Analysis Center (NODAC)

Washington, D.C.

Mike Callahan, Navy Occupational Development Task Analysis Program (NOTAP) Department Head (AUTOVON 288-4621)

C. T. Marshall, NOTAP Analyst (AUTOVON 288-4621)

NOTAP was developed out of a requirement for task information data across all Navy enlisted billets. Collection of data commenced in 1967, and as of this year, approximately ninety percent of the enlisted rates and two officer categories have been processed and put into NOTAP data banks. The basic intent of this accumulation of job data is to identify what people do, not how well they do it. The development for each rating proceeds in the following manner:

1) Subject matter experts (SME) from NODAC familiarize themselves with background information such as NEC manuals, Occupational Standards, rate manuals and PQS.

2) The SME team then travels to a specified job site where an extensive use of the particular rating exists to obtain direct observations.

3) A task inventory suvery is then developed and administered to 18-23% of the rating population.

4) The results are reviewed, then placed on tapes and filed in a computer data bank.

The types of data collected consist of such things as job satisfaction; primary and collateral duties; job characteristics; and most importantly, task statements which may be as numerous as 600. Access to the NOTAP data is handled by over forty subprograms which can analyze the data in various ways.

Correlation, cluster analysis, and matrix reduction are but a few of the options available. In essence, NOTAP offers an initial start in developing task analysis for a particular rate, and additionally some rather useful data analysis tools.

Unfortunately, task criticality is not addressed as in the Air Force CODAP system. Also, user access must proceed via the Bureau of Naval Personnel, thus making any local real time response difficult, if not infeasible. However, the possibility exists of obtaining data tape copies on a specific rating for use at a local level. This would facilitate any in-depth analysis at any Navy facility having computer capability.

Naval Personnel Research and Development Center (NPRDC)

San Diego, California

Adolph Anderson, Code 302 (714/225-2371, AUTOVON 933-2371)

Mr. Anderson and his colleagues are in the process of developing a Performance Proficiency Assessment System for the Director of Naval Education and Training (DNET). The system will have, as its primary objective, the determination of personnel readiness throughout the Navy. To this end the system's foundation has the following structure:

1) Development of Job Performance Measures (JPM): Two prototype rates, the Internal Communication Electrician (IC) and the Surface Sonar Technician (ST), have been selected in conjunction with developing hands-on JPM's. These instruments will determine if the individual can accomplish the critical tasks within his job.

2) Use of the quality control concept and sampling techniques: Since it would be expensive to administer JPM's to the entire rating population, sampling techniques will be employed to determine the degree of readiness within any particular rating. The aggregate of all ratings would thus quantitively indicate personnel readiness fleetwide.

3) The prototype phase of the program will be completed in FY 1981, and at that time, other ratings will hopefully be considered for development.

It is of interest to note that great emphasis was placed on task analysis in initial development, and extensive use of the Navy Occupational Task Analysis Program (NOTAP) preceded identification of critical tasks. The Personnel Qualification Standard (PQS) material was also used, as was data on Navy Occupational Standards. The relevancy of this assessment system to this study lies in the mutual objective of determining proficiency, or said another way, how well an individual retains his skill. The target populations differ (active duty in skill area versus various components out of skill area), but the concept of a quantitative performance measure is quite amenable to ascertaining the degree of skill loss in populations both in and out of previously learned skill areas.

In discussing skill retention in a more general sense, Anderson emphasized the following:

1) The more rapid a person acquires a skill, the longer his retention.

2) Continuous skills (tracking) are retained longer than discrete (procedural) skills.

3) Obsolescence should be considered separate from skill deterioration. Skill deterioration usually takes place early on in the period of skill disuse while obsolescence is of longer term.

4) The longer the retention interval, the greater the skill loss. This especially applies to procedurally oriented skills.

In summary NPRDC and especially Anderson's group are studying areas of great mutual interest. Several contacts in other agencies were illicited, and continued exchange of information concerning job performance measures and assessment systems should prove to be quite beneficial. A good synopsis of the

NPRDC Performance Proficiency Assessment System was published by Pickering and Anderson [1976].

Naval Reserve Readiness Command, Region Nine

Memphis Tennessee

Captain D. A. Nystrom, Commanding Officer (AUTOVON 966-5550)

Because a large percentage of this study's target population is the reserve force, contact was made with a senior officer experienced in maintaining reserve readiness. The Selected Reserve of 104,000 is organized into sixteen Readiness Commands. These commands are structured under both functional and geographic guidelines. Captain Nystrom's command (CTF-9) of approximately 6000 men is basically surface ship oriented and stretches from Kentucky down through Florida.

Since the initiation of the total force concept in 1973, much effort has been made to increase reserve readiness and enhance the ability of the Selected Reserve to augment the active duty force. However, several deficiencies still exist in the area of training, specifically skills maintenance. The 48 drill periods and 2 weeks active duty per year are proving to be adequate in the area of general military training, but fell short of insuring a sufficient amount of skill proficiency. Some of the more serious shortcomings are:

1) No consistent funding for long range training programs.

2) Geographical location of training centers within any Readiness Command prevent 100% participation in specific skill maintenance.

3) Most equipment is obsolete. For example, communication components used in some training centers is of Korean War vintage.

4) Very little software or simulator systems to train weapons systems operators. In most cases, if personnel from the surface Selected Reserve were called up, they would have little or no knowledge of modern fleet systems.

Captain Nystrom discussed a new program, the Versatile Training System (VTS), which was initiated in 1972. Oriented towards enhancing enlisted aircraft maintenance training, VTS utilizes software simulation and self-paced instruction along with tailoring each individual's training by comprehensive performance tests (i.e., diagnostic, pre-tests, post-tests, PQS, etc.). Unfortunately, funding for remote terminal sites throughout Readiness Command Nine (pilot study) is unavailable at this time. Additionally, there is some disagreement as to VTS viability in the surface reserve, where many paygrades and rates are intermixed within any particular training center.

Naval Technical Training Center (NTTC)

Memphis, Tennessee

Bob Coolidge, Program Manager for Other Service Veteran (OSVETS) Retraining Program (AUTOVON 966-5955)

The OSVETS program is designed to indoctrinate newly enlisted veterans of other services, in lieu of basic recruit training, in the procedures, policies, regulations, and traditions of the United States Navy. The typical profile of the OSVET applicant is an E-4 with two years prior service, a "clean" record, and no deficiencies on the Basic Test Battery. The course length is three weeks and deals only with general military training such as firefighting, damage control, shipboard safety, and human resources management. The two OSVETS training sites, San Diego and Great Lakes, have a combined average annual input of 3500 to 4000 people.

The intent of OSVETS, that of recapturing personnel resources, is quite sound. Although no specific skills are retrained, efforts are made to place OSVETS graduates into appropriate technical schools, particularly those located within the NTTC complex at Memphis.

However, there are no quantitative methods to aid in screening OSVET applicants. In lieu of this, if the period of non or broken service exceeds two years, the individual is automatically sent back to recruit training. In addition, no performance measure is used to determine to what degree the OSVET graduate is qualified for technical training or retraining. Here again skill retention data and methods to measure performance would greatly enhance the quality of the OSVET program.

Seville Research Corporation

400 Plaza, Pensacola, Florida

Dr. Wallace W. Prophet, Director (904/434-5241)

Dr. Prophet was contacted because of his past work on retention of flying skills. Under the auspices of the Studies and Analysis Branch of USAF Headquarters, he authored an extensive literature review and annotated bibliography mentioned in the preceding section [Prophet, 1976]. Although his present research group is not working in this area, he had several relevant comments. First, any retraining program must take into account the problem of individual differences. There are many variables comprising each person's nonutilization period which can interact in various ways to produce numerous retraining needs. He felt skill decay may be significantly checked through the use of low fidelity rehearsal devices. This type of program would especially be amenable to practicing procedural skills which are the most rapidly lost. In order for this idea to be successful, it was stressed that the Navy must provide sufficient incentive to motivate each individual to keep current in his rate. Finally, Dr. Prophet agreed that performance assessment would be a useful approach to determine how much retraining was necessary provided a military agency developed the program to ensure its usefulness related to the operational environment.

U. S. Air Force Human Resources Laboratory

Brooks AFB, San Antonio, Texas

Dr. Raymond E. Christal, Occupation and Manpower Research Division (512/536-3648, AUTOVON 240-3648)

For many years Dr. Christal has been a leader in research concerning enlisted skill acquisition, classification, and performance. One of his major achievements was creation of the Comprehensive Occupational Data Analysis Programs (CODAP) which is a computerized system for organizing and analyzing Air Force occupational information. Among other things, the system is capable of storing component tasks for each technical rate along with the relative task criticality. Critical tasks are identified by examining three factors; a) consequences of bad performance, b) task delay tolerance, and c) task learning difficulty. Difficulty is defined as time to learn and is thought to be related to deterioration of the task. The primary data base is a task inventory conducted every six years. At this time Air Force jobs appear to be quite stable regarding the types of skills they require. Because of the CODAP system's proven usefulness, other services have adopted similar programs and the Navy system, NOTAP, will be discussed subsequently.

Although Dr. Christal is not currently working on any project directly related to this study, his past experience and future plans are worth mentioning. His main interest is exploring the usefulness of aptitude tests which he recently discussed in a paper presented to the Military Testing Association [Christal, 1976]. The main hypothesis is that aptitude is a measure of the speed of skill acquisition. A corollary is that aptitude is also, then, a measure of re-learning time. Although it is felt that skill deterioration may be unrelated to aptitude directly, there are indirect connections between skill acqusition and skill decay. In this regard, Dr. Christal is beginning work on what he calls "perishability of skills." Past work supports the belief that those who learn faster and therefore attain greater proficiency, lose their skill level less rapidly. A future study will attempt to measure learning and decay and relate these to the Air Force aptitude testing battery. The question to be answered is the following: Is aptitude a good differential for learning and decay rates?

U. S. Air Force Human Resources Laboratory

Williams AFB, Phoenix, Arizona

Dr. Edward E. Eddowes, Senior Technical Assistant
(602/988-2611, AUTOVON 474-6604)

Dr. Eddowes has devoted much of his energy toward proficiency of flying skills. After the basic psychomotor skills involving flying are acquired, the concentration of training is on procedural type skills, not unlike those associated with Navy technical enlisted rates. It is agreed by most authorities that procedural skills deteriorate much more rapidly than psychomotor skills. Dr. Eddowes has recently completed a proposal for research on maintenance of flying skills. His attack focuses of reacquiring lost skill and on the amount of training sufficient to do the job.

On the subject of performance assessment, Dr. Eddowes believes that the learning experience depends on viable performance evaluation to be successful. Because the system operator gets feedback from the system, the system output approach to assessment is often preferable to the control input approach. In other words the former approach measures final system behavior while the latter looks at what the operator does to the system. In essence an assessment program must first identify and define the skills involved, and then develop a means of measurement of those skills. This sequence of events will insure the relevancy of the performance measure to the task.

U. S. Army Research Institute (ARI)

Alexandria, Virginia

Dr. Joyce Shields (AUTOVON 284-8695)

Dr. Shields is working on a skill retention study involving Chaparral missile technicians. The Army has found this particular MOS is lacking in demonstrated job proficiency in an operational environment. In order to answer questions in this area, a study has been designed to accomplish the following:

1) Evaluate skill loss between training and utilization on the job.

2) Determine the most effective refresher training.

3) Provide data on forgetting over time for task performance.

The study design is longitudinal in nature, and utilizes comparisons between control and noncontrol groups over varying retention intervals of zero, one, two, and four months. The basic intent is to gain data on the effects of nonpractice of a previously learned skill, which closely parallels the present effort of this paper. The maximum retention interval of four months is somewhat less than what is desired here, but otherwise the similarity is quite significant.

U. S. Army Training Support Center

Fort Eustis, Virginia

Capt Harry Porthouse, Individual Training Evaluation Group (AUTOVON 927-3128)

The Training Support Center oversees and administers the Army's new Skill Qualification Test (SQT) program. The SQT replaces the former norm-referenced MOS test with a criteria-referenced performance battery. The program is essentially a quality assurance device designed to maximize combat effectiveness. It is also used to directly support training and the Enlisted Personnel Management System. SQT is based on the critical tasks identified in the Soldier's Manual and is administered in as many as three parts; written, hands-on, and performance certification. The program is very well organized and documented as demonstrated by the following sources: Ford, Campbell, and Harris [1976]; Maier, Young, and Hirshfeld [1976]; and Taylor and Vineburg [1975]. The Army seems to have the right idea by developing a comprehensive program capable of use for performance evaluation, readiness assessment, personnel management, training, and advancement.

D. RESEARCH GAPS

While investigating past literature and agency sources, several neglected areas of research as related to this study, have become apparent. In this light, the following points are presented:

1. In the area of skill research, very little effort has been devoted to the subject of skill retention.

2. Most retraining data, excluding flight skill retention studies, considers learning a new skill as opposed to relearning a previously acquired skill. Few reports exist on loss of skills due to the nonutilization of those skills.

3. Methods of assessing performance have only begun to be examined. There is little data on the selection of performance criteria, and on identifying critical tasks.

4. There has been insufficient consideration of individual differences in operator performance (e.g., individual aptitude in relation to retention). Research on general learning and relearning curves is not meaningful until the factors affected by individual differences are investigated.

5. Little work has been conducted concerning predictive measures of skill acquisition and retraining. An example is the relationship between aptitude and learning. There has been no specific study of aptitude and skill deterioration or retraining.

6. Many factors have been hypothesized to affect skill retention during a period of disuse; however, few studies have tried to quantify those variables. For example, interference from the activities conducted during the nonutilization

period is thought to be a major cause of skill decay. With the exception of a brief study on flying skills, this area remains relatively untouched.

7. The Navy currently has several job classification systems: Personnel Qualification System (PQS); Occupational Standards; Navy Enlisted Classification (NEC); Navy Occupational Task Analysis Program; the rating structure; etc. However, there exists no standardized operational taxonomy for fleet-wide use.

8. Finally, most of the research conducted to date has been in a laboratory setting. Few efforts have studied skill acquisition, retention, and retraining under actual complex operational environments. Herein may lie the most grave deficiency. Many authorities on applied research in these areas agree that much of the work done previously may not transfer to operational problems.

IV. CONCEPTUAL MODELS

A. MOTIVATION

The previous discussion of informational sources has suggested several areas related to skill deterioration and retraining that require initial or additional research effort. Answering the retraining question is infeasible while knowledge in these areas remains deficient. With this in mind, the topic remaining to be addressed is the development and organization of a retraining program in the Navy. In order to fully understand the total retraining problem, the approach taken must not only seek to close the above individual gaps, but also should strive to examine the relationships among these areas. Specifically, the interactions of the various factors which contribute to skill deterioration and influence retraining in the operational environment need to be investigated. For example, several interactive variables are individual differences, task type, length of the retention period, and retention interference factors.

Thus, one viable approach for discussing a retraining program is the development of conceptual models. The model, in this case, represents an advancement from the present state-of-the-art of enumerating past deficiencies to an organization of a plan describing future solutions. Conceptual models are efficient methods of presenting a problem comprised of several integrated parts. They include a sequential plan describing various stages of development, depict functional relationships between those stages, and provide an organized decision pathway for implementation. Finally, information which is required prior to, or during model development and data supplied after it becomes validated and operational, should be utilized for closing the research gaps and further defining their interrelationships.

B. THE MATRIX APPROACH

1. Background and Definition

The matrix, or grid concept, is used frequently in mathematics to correlate two or more variables which have specified value sets. In the social sciences, the matrix approach has been used to equate one set of behavior characteristics with another. Basically, the grid concept can be used wherever knowledge of classification, correlation, comparison, or interactions needs to be investigated. The matrix approach herein will be used as a decision-maker's tool for determining, or in some respects, predicting skill deterioration and retention across the broad spectrum of Navy ratings.

For simplicity, the matrix will be two-dimensional, and will equate job clusters with job characteristics/skills. Figure 2 serves as an example of clustering jobs and job characteristics. Along the vertical axis are the seventeen occupational categories as outlined in the Navy Recruiting Manual, which are functionally classified. The horizontal axis dimensions job characteristics which require various abilities, but are not single skills per se. The intersection of one job characteristic with one job cluster indicates the interactive effects. The cumulative effect of all job characteristics on any particular job cluster may be determined by observing the total row composition of the respective job cluster. Conversely, the column composition will indicate the effect of one particular job characteristic on all job clusters. The question of cell scaling now arises. Each individual cell may be thought of in one of two ways:

1) The degree of importance, on a percentage scale, a particular job characteristic has on a job cluster. The row total for any job cluster would then sum to 100 percent.

2) The severity of deterioration, on an ascending scale of one to ten, a particular job characteristic has on a job cluster. The row average could then represent a composite factor of skill deterioration for the respective job cluster.

Even though only two dimensions are used in the matrix, a third dimension depecting the level of individual experience could be helpful. However, instead of making the matrix three dimensional (and more complex), enlisted paygrades will be categorized into three groups: E1-E4; E5-E6; and E7-E9. A separate skill deterioration matrix as in Figure 2 will then be done for each group.

Finally, the length of the retention interval must be taken into account. Four years of non-use will produce more deterioration than will six months. Some multiplier

	COMPLEXITY	RESPONSIBILITY AND MANAGEMENT	FREQUENCY OF USE	TECHNOLOGICAL OBSOLESCENCE	TOUR LENGTH	JOB VERSATILITY (TRAINING TRANSFER)	DOCUMENTATION	TROUBLE SHOOTING
OA - OPERATIONS SPEC.; ANALYSIS								
OB - OPERATIONS SPEC,; CONTROL								
OC - GRAPHIC SPEC.								
OD - ADMINISTRATIVE SPEC.								
OE - SUPPLY AND ACCOUNTING SPEC.								
OF - FOOD PREPARATION/ SERVICE SPEC.								
OJ - ELECTRICAL SPEC.								
OK - ORDNANCE SPEC.								
ON - MECH. SPEC.; PRECISION EQUIP.								
OP - MECH. SPEC.; GENERAL								
OQ - AVIATION MAINT. HANDLING SPEC.								
OR - MECH. SPEC.; FABRICATION								
OV - AVIATION ELEC-TRICAL/ELECTRONICS								
OW - SECURITY GROUP SPEC.								
OZ - OCCUPATIONAL SPEC.; TECHNICAL								
CB - MECH./FABRICATION (CONSTRUCTION)								
OU - OCCUPATIONAL SPEC.; UNDECIDED								

Figure 2. Matrix Example

or scalar, perhaps derived in exponential fashion, can be used to differentiate cell values on a specified time basis (i.e., quarterly or yearly).

2. Model Description

The skill retention matrix, by itself, is of little value. It must be made an integral part of the operational personnel cycle. Figure 3 shows the functional relationship of the matrix within the cycle. The following is a brief description of how the model works.

a. Selection: The present recruiting system, using occupational specialties as depicted in Figure 3, represents a substantial effort to match aptitude with training. However, the selection process itself is beyond the scope of this study, and the only reason for mentioning the occupational specialties was their use as a potential matrix dimension.

b. Initial Training: This includes all training prior to operational assignment: recruit, "A" school, and fleet replacement training. The only time personnel will pass through this phase more than once is to acquire a new skill, or, in rare instances, for complete retraining. In the former case, the cost would be prohibitive, unless the individual showed unusually high aptitude for the respective training.

c. Duty Tours: The three duty tour categories encompass almost the entire target population. Only those personnel on short periods of temporary duty would not be considered. An associated tour would be in the skill area of initial training, and every effort should be made to place first tour personnel within their operational rating. A

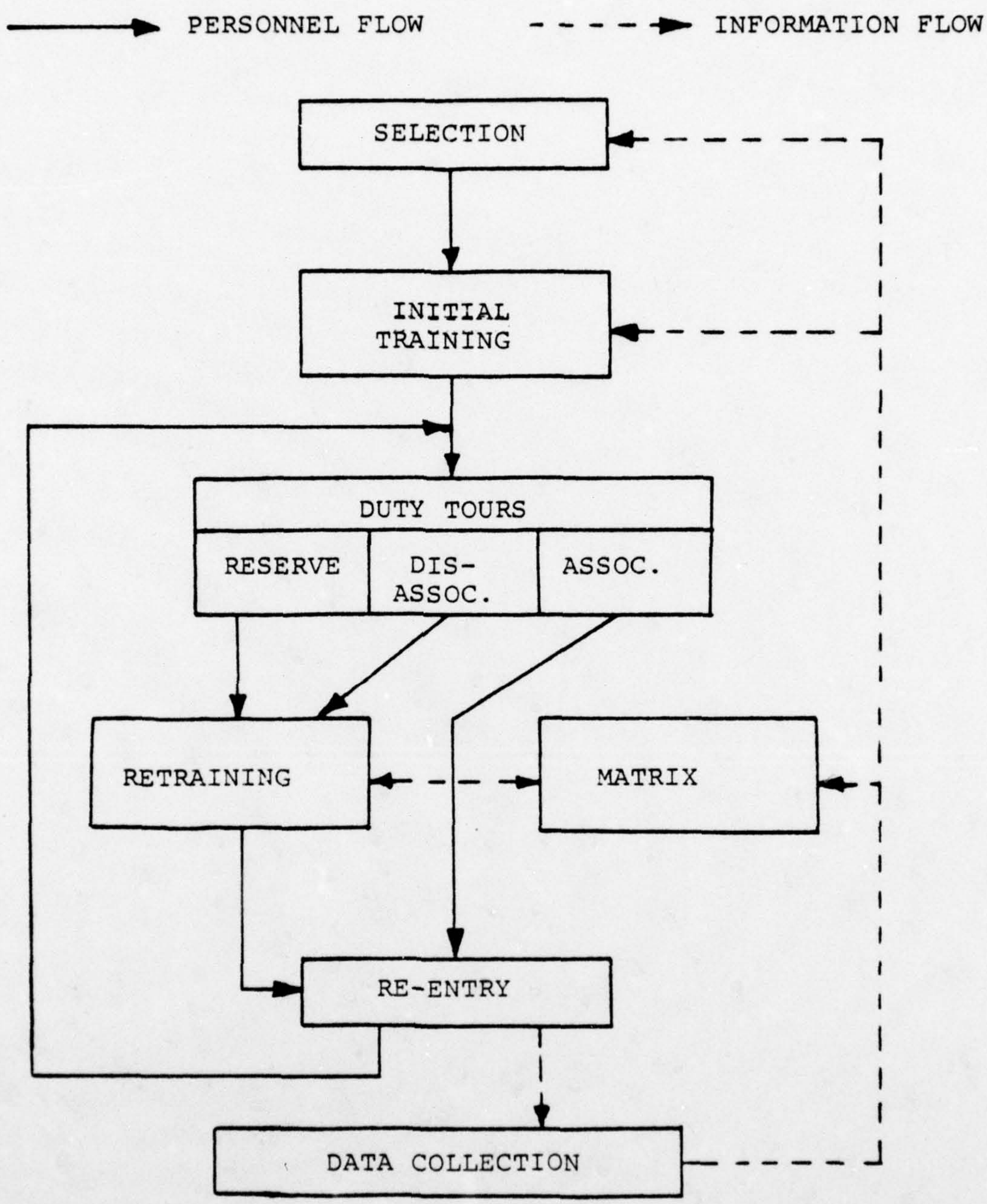

Figure 3. Matrix Model Description

disassociated tour would be out of the primary skill area, as often happens to individuals rotating from sea to shore tours. The reserve category is actually an extended disassociated tour, but is considered separately because of the inherently longer periods of retention.

d. Skill Retention Matrix: The entire model is intended for Bureau of Naval Personnel (BUPERS) use, where large amounts of manpower are constantly shifted throughout the Navy structure. It is at the BUPERS level where the skill retention matrix will be most effective, since personnel are detailed from one tour to another here. The matrix will reflect previously learned skill areas, length of non-use intervals (if any), and experience level, to ascertain the amount of retraining necessary to facilitate re-entry. Those personnel having just completed an associated tour would be directly detailed without use of the matrix, unless a record of inadequate performance is noted on periodic evaluations. The matrix will be especially useful in dealing with large groups, such as reservists coming back into active service to augment the regular force. The intent of the matrix is to provide the Navy with a method by which skill deterioration can be predicted without the prior necessity of extensive longitudinal studies. Admittedly, the initial iteration of the matrix scheme will represent a "gross cut" at the problem, but later evolutions should prove more and more accurate.

e. Retraining: After the retention matrix has indicated the gross level of skill loss incurred, BUPERS can detail the individual to the appropriate retraining level. Presently, there exists on-the-job training, fleet replacement training, technical training (A, B, and C schools), and recruit training. Inherently, this represents a hierarchy of training levels, and could be modified to incorporate retraining as well. However, besides the costs ensuing from program modifications to facilitate retraining, the logistical costs must also be considered. To use existing sites for retraining would require vastly increased amounts of temporary personnel movement, billeting requirements, and temporary additional duty funding. One alternative to this is establishing retraining sites in close proximity to areas of large personnel concentration, such as San Diego and Norfolk. Procurement costs for these remote sites would be expensive, and before any decision can be made on the method of retraining, a cost analysis must certainly be undertaken.

f. Re-entry: This is the juncture where the individual re-enters his previously learned skill area, presumably retrained and again proficient in his specialty. It is also during the first few months after re-entry where data on job performance should be collected.

g. Data Collection: To prevent confounding the effectiveness of retraining (and the retention matrix) with the benefit of being on the job any more than a few months, data collection on job performance should be done soon after reentry. At present, the enlisted performance evaluation is the only method, and it is a subjective measure not free from bias. Some measurement methodology need be developed to offer an objective quantifiable indication of job performance, such as hands-on performance tasks, or criteria based paper and pencil testing. In any case, the information gained from data collection will have the following implications on the entire model: proper aptitude criteria for selection of personnel; amounts and types of initial training required; updating the matrix dimensions and cell scalars; and determining the effectiveness of various retraining levels.

3. Matrix Implementation

As was mentioned before, the initial matrix will serve only as an estimate of skill loss, with improvements certainly to be made as feedback dictates. The following discussion will supplement the implementation diagram in Figure 4.

a. Documentation Survey: The Navy has several personnel classification systems. The Navy Enlisted Classifications (NEC), Occupational Specialties, and the Rate Manuals are primarily requirements and qualifications documents, while the Personnel Qualification Standard (PQS) is a procedural instruction system for actual operational use. The Navy Occupational Task Analysis Program (NOTAP) deals with job content and maintains an occupational data bank on all Navy ratings. The intent in reviewing these systems is to develop sufficient background in support of proposing alternatives for the matrix dimensions.

b. Matrix Dimension Alternatives: As was mentioned in the definition of the matrix approach, Figure 2 serves as an example set of dimensions. There are other conceivable alternatives: NOTAP job cluster analysis versus Fleishman's

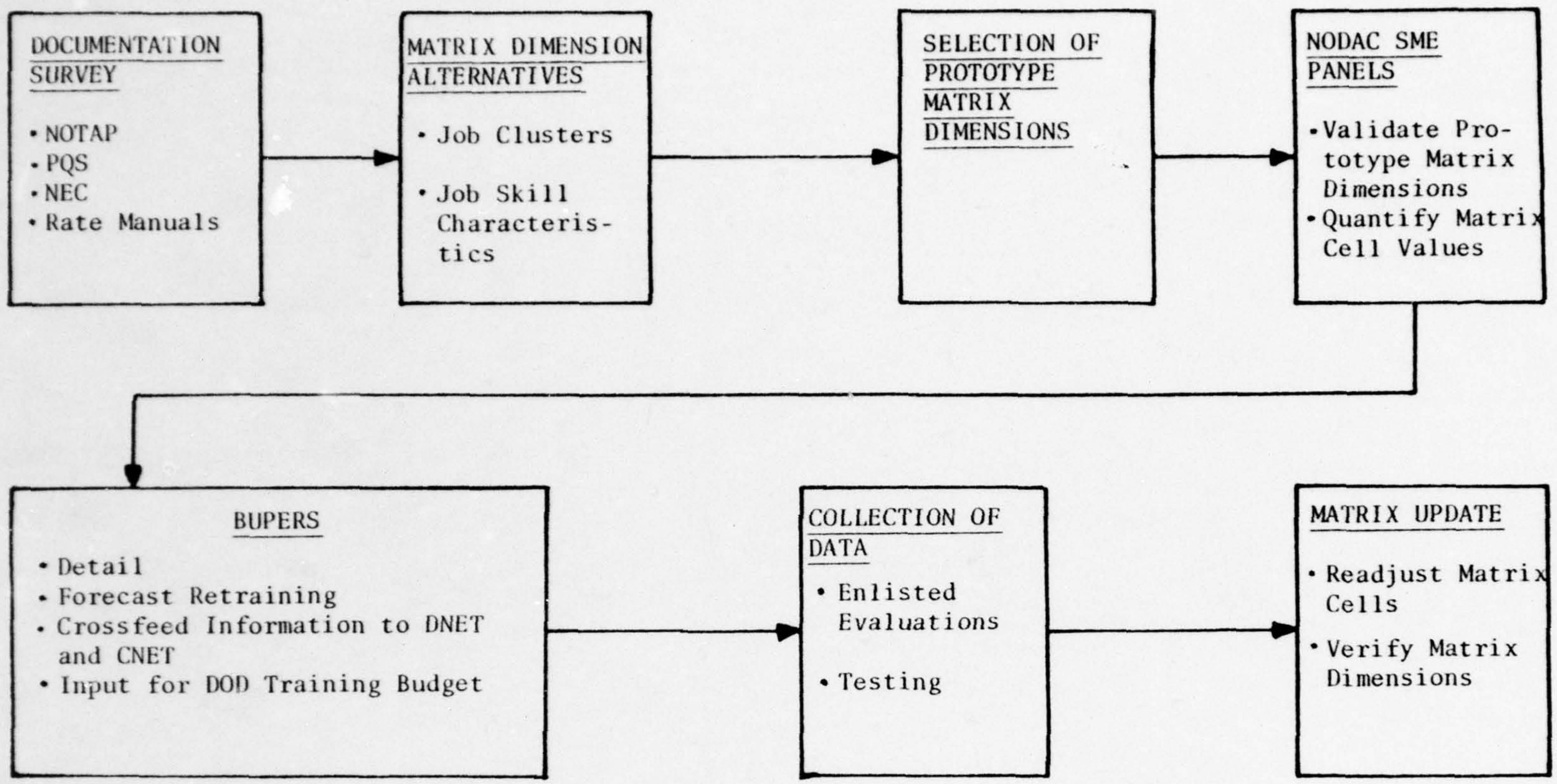

Figure 4. Matrix Implementation

[1967] psychomotor and physical performance factors; or clustering of Navy ratings contrasted with categories of perceptual, mediational, and response processes. Again, the possibilities are numerous, but the dimensions selected should reflect operational experience, and not merely empirical laboratory results. Also, the dimensions should be of workable size, with a tractable number of categories per dimension. A specific figure would be difficult to assign currently, but perhaps bounding the range between ten and fifty would be sufficient.

c. Navy Occupational Development and Analysis Center (NODAC) Panels: this is the key step in matrix implementation. Subject Matter Experts (SME) will either confirm or modify the matrix dimensions, and assign scalar quantities to the matrix cells. Since the SME's will be experienced senior enlisted members, their inputs will greatly affect the implementation of the matrix. Furthermore, their experience in task analysis should be of use in validating the construction of the matrix, especially if the dimensions previously selected are job clusters and job characteristics as depicted in Figure 2.

d. BUPERS: the first iteration of the matrix will then be sent to BUPERS for approval and dissemination to the detailing section and other departments. Of course, primary use of the matrix will be to include retraining considerations in the detailing process. BUPERS will also coordinate with the Chief of the Naval Reserve when reserve units are tasked with active force augmentation. As consequent iterations of the matrix cycle evolve, BUPERS will act as a central contact point for the Chief of Naval Education and Training, the Chief of Navy Recruiting, and other agencies to insure the matrix is in alignment with the personnel cycle from the recruiting through retraining stages. BUPERS can also use matrix generated data as inputs for the Navy and the DOD training budget.

e. Collection of Data and Matrix Update: the success of the matrix depends upon, among other things, feedback information to insure flexibility and continuity. The data collected on personnel after re-entry into their skill areas will serve to adjust the matrix cell quantities, and also verify the previously selected and validated matrix dimensions. As mentioned before in the model description, either enlisted performance evaluations or some form of testing procedure will be the source of such data collection.

4. Summary

It is important to again mention that the initial matrix is an estimate or "gross cut" prediction of skill loss. However, it represents a potential approach to the skill degradation problem, which has to date been largely neglected. In essence, the matrix will supply numerical values which indicate approximations of occupational skill loss. These matrix values will be sensitive to both experience level and length of nonutilization period, and subsequent iterations will serve to refine the net approximation. Thus, the matrix will provide the BUPERS level decision-maker with a skill degradation estimate as the initial step in determining retraining requirements.

The matrix is the foundation of the model depicted in Figure 3. The other functional blocks presently exist in varying degrees of effectiveness. No attempt has been made to critique them since that is not an objective of this study. Because of this, only the matrix portion of the model is carried through development of the implementation plan.

Also not fully developed was the testing methodology for data collection after re-entry. It is perhaps hazardous to rely solely on enlisted evaluations to gather such information; and thus,effort to construct an adequate performance measurement is indicated.

C. PERFORMANCE ASSESSMENT APPROACH

1. Background

After perusing the preceding sections of this paper, it is hoped that the reader has gained an appreciation for the usefulness of job performance measures (JPMs). Modern criterion referenced performance tests can directly evaluate individual proficiency. Since job performance is the output of training, JPMs should be capable of assessing the training process as well. In other words, the capability of JPMs to evaluate proficiency means they can also identify areas of weakness. These areas can then be translated into inputs for training. Thus, the relevancy of job performance measures to both proficiency assessment and training requirements, provides the basis for this conceptual approach.

Since the ultimate question to be answered concerns the amount of retraining necessary after a period of skill deterioration, it would prove useful to examine the advantages that job performance measures could offer. A JPM system measures current proficiency, and therefore can identify current training needs. By administering an up-to-date JPM to an individual prior to his return to a previously learned skill area, specific training units can be prescribed for any deficiencies. This capability reduces the need to be concerned about the nonutilization period and the retention variables involved. The most relevant question for retraining is one of how well the individual can perform his tasks at the present time. Additionally, obsolescence is another variable of the retraining problem which would be minimized by a JPM approach. Provided the JPM is updated as technology advances, it would always evaluate performance at the current state-of-the-art regardless of the amount of obsolescence that had occurred. A JPM program would also provide standardization for evaluation of instructional objectives and operational performance. It would force the two communities of training and readiness assessment to adopt the same criteria for measurement. It is intended that this model give the decision-maker a tool that will aid in answering the retraining requirements question. A major portion of this tool is the JPM itself which provides a direct, objective measure of proficiency. This type of conceptual approach combines readiness assessment and retraining assessment into one system. Additionally, it provides feedback as well as data for training programs and future research respectively. A widespread performance measurement system is especially useful

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as a manpower management tool in the areas of selection, placement, and advancement. In essence, with this model, the decision-maker can receive the information necessary to insure that the proper numbers of qualified personnel are assigned to the fleet.

In the sections to follow, the conceptual model will be treated in detail and a recommended implementation sequence will be presented. The model is designed primarily to describe a career training/duty cycle which may be interspersed with periods of nonutilization. The JPM approach can be applied to active duty or reserve personnel. Additional discussion concerning the implications for reservists will be contained at the end of this section.

2. Model Description

The basic JPM model is composed of two sites: a training site and a duty site. An assumption of the model is that the same JPM be given at both sites. This approach is not viable if differing criteria, hence, differing proficiency measures are used. Also, the JPM utilized must be technologically current. The training site cannot produce competent personnel for the duty site if obsolescence is allowed to come between them.

The model is depicted in Figure 5. A description of the model is organized into the following four phases: initial training, the JPM, retraining, and duty site.

a. Initial Training

The initial training block is where the individual obtains basic and advanced training for his particular

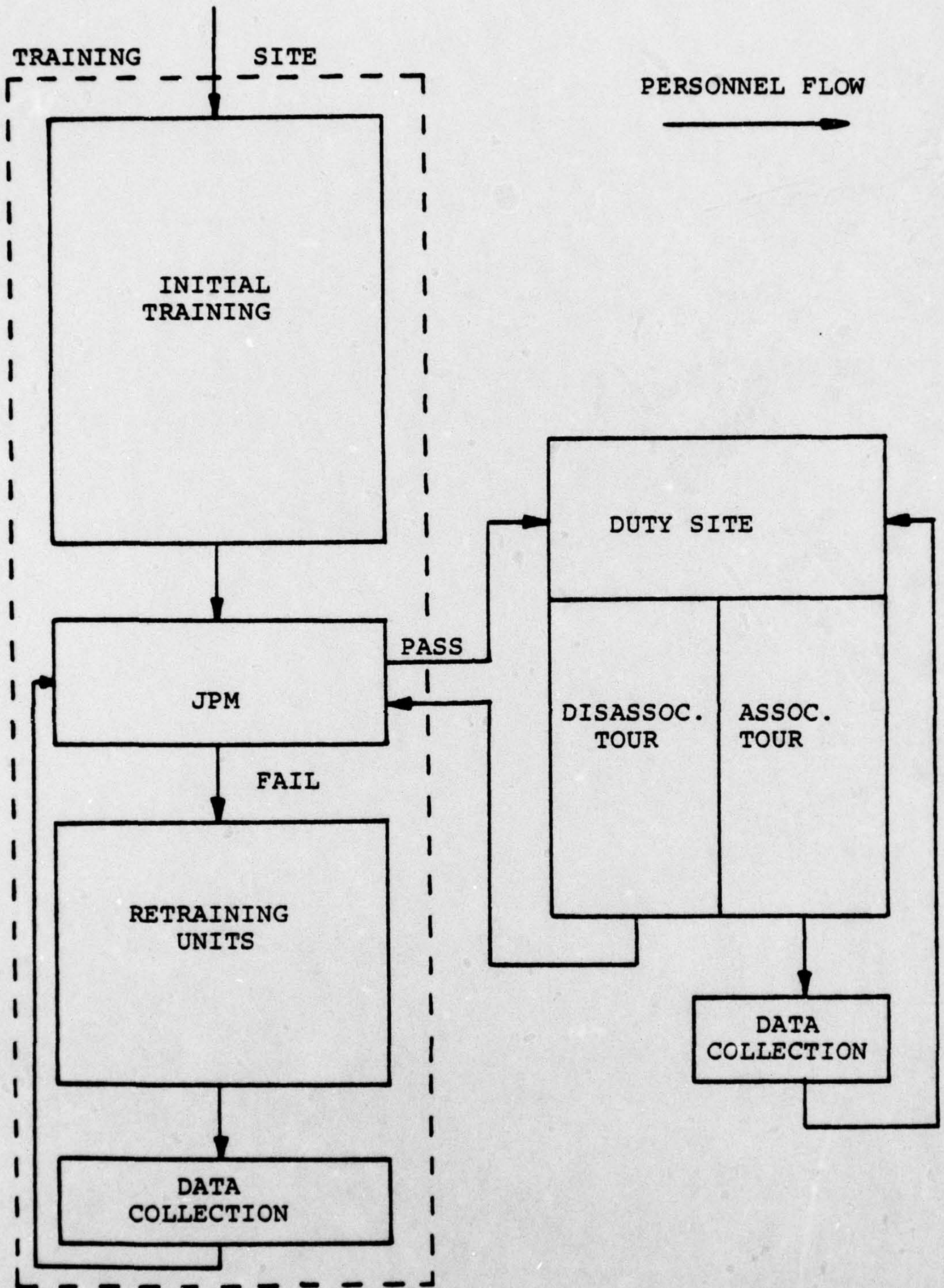

Figure 5. JPM Model Description

rate. The model operates under the assumption that each person is initially trained only once for each rate or skill area. If for any reason the individual changed rates or is taught a completely new set of skills, he must enter the model through the initial training block again. The training program should use the same criteria for construction of instructional objectives as are used to develop the JPM program. The output of the initial training section goes to the JPM section.

b. Job Performance Measures (JPM)

The JPM section is the focal point of the entire model. Development of adequate performance assessment tools is receiving much attention throughout the military, as was mentioned in previous portions of this paper. Although it is beyond the scope of this study to construct a prototype JPM, the following ideas are contributed in order to aid future efforts and to emphasize crucial assumptions of this model:

1) The JPM battery should be developed from criteria based on task analysis at the operational level. In addition, supervisory personnel can help identify critical tasks. The final set of proficiency criteria must make sense to the worker himself.

2) At the risk of being redundant, it is reemphasized that the criteria developed for performance measurement must also be used as a basis for constructing instructional objectives for the training portion of the model. It is essential for the individual to be trained in the same skills that he will use operationally in order for this approach to work

efficiently. A separate JPM battery should be developed to evaluate the particular skills of each rate.

3) The JPM can utilize both written and hands-on methods of assessment techniques, depending on the types of skills involved in the particular job.

4) The types of skills utilized also determine whether a process or product method of assessment is preferable. The former approach monitors the operator's actions while the latter method evaluates the results of his actions. In most military settings the task is complex (i.e., sonar operator, radar operator, etc.) which necessitates evaluating the product. Reference 34 contains a thorough discussion of this topic (p. 8-11).

5) To be effective, each JPM should be as objective as possible. Objectivity is the ability of the test to perform consistently under various evaluators or under one examiner for various subjects.

6) Finally, every JPM must be kept current with operational requirements. The JPM will need to be updated when significant technological or procedural advancements occur. This implies that the training sites must keep abreast of operational changes also. Ideally, the training sites should be the first to receive new innovations in order to ensure the fleet is provided with highly qualified personnel.

As depicted in Figure 5, the JPM block provides an interface between the initial training, retraining, and duty site sections. Inputs coming from both initial training and retraining are utilized for a comprehensive, practical assessment of performance upon completion of an instructional period. Also, a diagnostic job performance evaluation is conducted on personnel coming from disassociated duty sites. Personnel with substandard performance from the above three sources are sent to the retraining section along with a breakdown of specific deficiencies. Upon satisfactory completion of the particular JPM battery(s) for the applicable rate, the individual is detailed to his next duty assignment. Additional specifics concerning JPMs will be presented in the implementation section.

c. Retraining

The retraining block is the third portion of the training site. It receives its inputs entirely from the JPM block. The retraining program consists of many separate training modules or units. These units are comprised of related skills required for specific rates. Since one of the assets of a JPM system is its capability to identify deficient performance areas, each trainee can be assigned to complete only those units where retraining is deemed necessary. Simulation and self-paced instruction techniques would seem to lend themselves well to this type of training situation.

Upon completion of the required number of retraining units, training data will be collected and a JPM battery will be administered once again. The types of data that may prove useful include information on the type and length of the nonutilization period (if applicable), initial training scores, JPM scores, types of retraining units given, etc. A JPM reexamination would insure attainment of minimum proficiency standards as well as provide feedback for the retraining system.

d. Duty Site

The duty site section of the model represents all permanent duty assignments an individual might receive during his naval career. The duty site is divided into associated and disassociated tour types. These terms differentiate respectively between assignments related to the rate for which the individual was initially trained and assignments where the skills of his rate are not used. Thus, a disassociated tour can be equated with a period of nonutilization as defined and discussed in earlier portions of this paper.

Inputs to the duty site can come from successful completion of training evolutions via the JPM block or from previous associated tours. During associated tours, personnel will periodically be given a JPM battery with OJT to correct any inadequate job proficiency. The individuals' training records will also be kept current. An individual completing a disassociated tour will need to be given a JPM evaluation to determine the type of retraining necessary, if any. In order to administer this approach, BUPERS must be able to distinguish between associated and disassociated tours of duty.

3. Communication Channels

The magnitude and complexity of the retraining problem dictates that communication channels be briefly discussed. Figure 6 is one proposal for establishing lines of communication. It is necessary there be an interface between the training site and the duty site for exchange of information and feedback. Thus, a Training Coordinator was inserted between the two major sites. This coordinator will receive, assimilate, store, and disseminate data from all other sections of the model. Thus, it is hoped that each site will receive timely information regarding changing performance requirements. An educational system must receive constant feedback from the users of its product in order to fine-tune its instructional methods. Training and performance data is collected at both sites and sent to the Training Coordinator where it is compiled for informational and research purposes. For example, JPM data could have implications for establishing future selection criteria for technical enlisted rates. Manpower management information is also sent to BUPERS where decisions are made regarding personnel placement at the duty site.

4. <u>Implementation</u>

This section will outline a possible implementation plan for the JPM model. The plan is depicted in Figure 7 and is discussed below.

a. Task Analysis

To begin, all tasks for each rate must be identified. This can be accomplished by using the Navy Occupational Task Analysis Program (NOTAP), the Personnel Qualification Standards (PQS) Program, and specific job manuals. The list of tasks must then be ranked according to criticality. Several factors to be considered when identifying critical

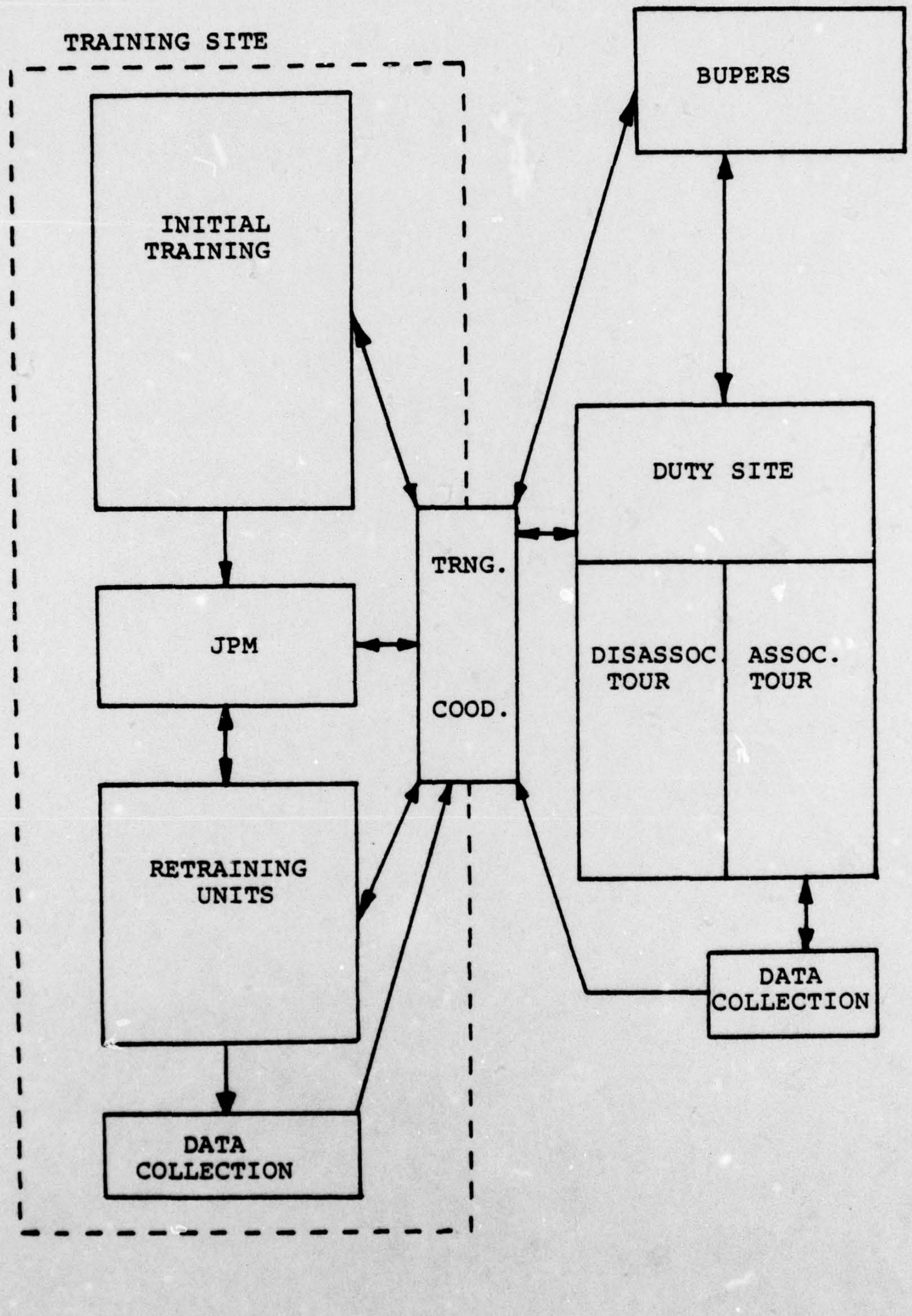

Figure 6. JPM Communication Channels

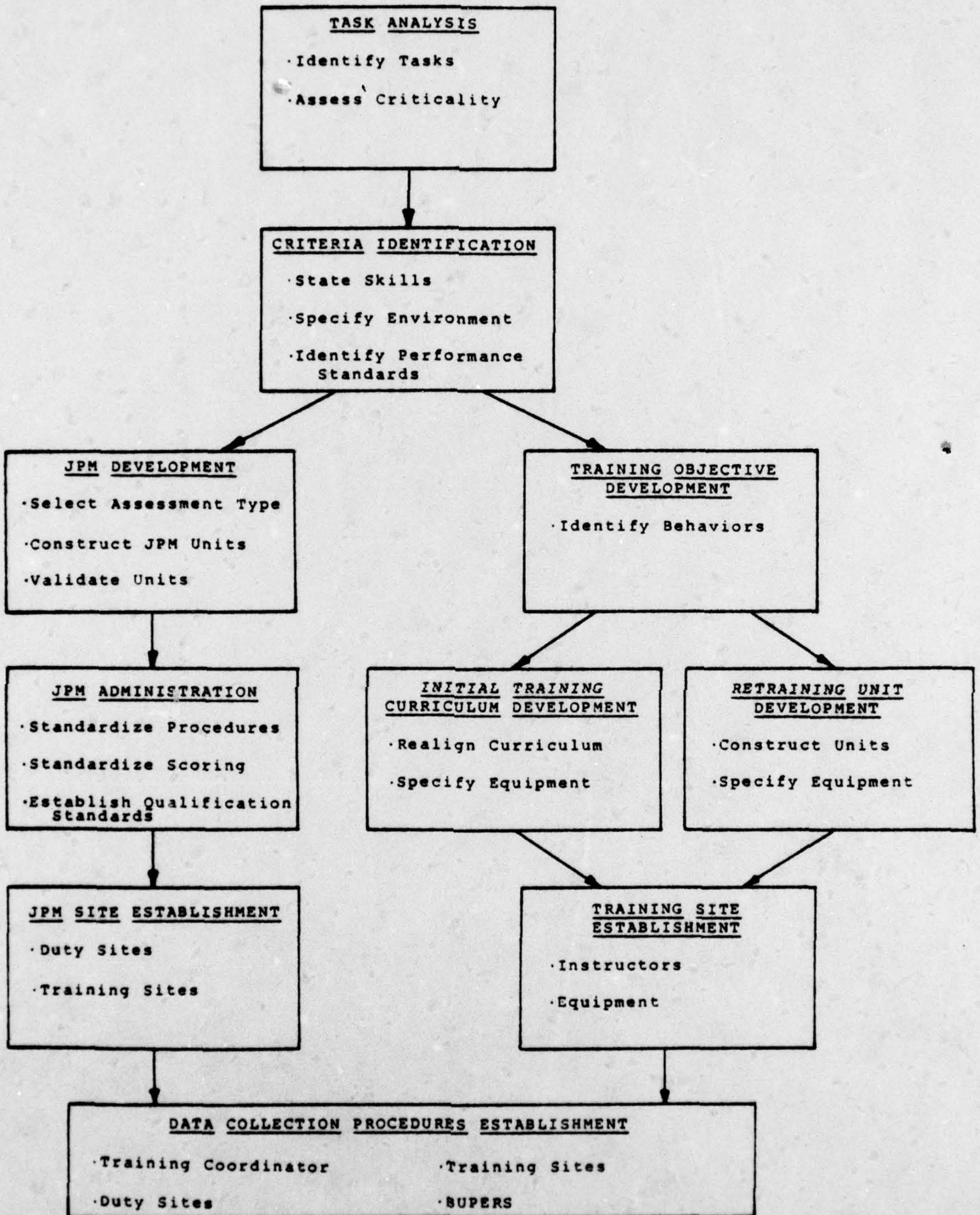

Figure 7. JPM Implementation Plan

tasks are the following:

1) Consequences of poor performance
2) Visibility of poor performance
3) Task delay tolerance
4) Task difficulty
5) Frequency of performance

A panel of subject matter experts or experienced supervisors can aid in selecting and ranking critical tasks for performance evaluation.

b. Criterion Identification

Criteria, or standards of performance, are derived from the critical tasks identified in the preceding stage. These measures of effectiveness must relate directly to the actual job tasks they are designed to evaluate. Developing performance criteria early insures common use by both training and job proficiency experts.

Three areas must be included in each set of complete criteria. First, the skills or knowledge required to successfully complete the task must be specified. This is basically a statement of what the individual must do. Second, the environmental conditions should be identified. For example, servicing an aircraft oxygen system is a critical task for the AME rate, and the criterion must delineate whether the task is to be performed indoors or out, day or night, on shore or at sea, etc. Third, the standards against which performance will be measured need to be defined. This portion of the criterion specifies quality standards and time constraints.

c. JPM Development

Once the criteria have been established, a set of JPMs can be constructed. The best method of evaluation also needs to be decided. For example, physical maintenance tasks may lend themselves well to simulation or hands-on-measurement while cognitive type tasks would be better scored by written methods. Another developmental suggestion is to design each component JPM to evaluate only one critical task. Proficiency demonstrated for each task could then be given simply a PASS/FAIL score. Additionally, it is recommended that several JPMs for a given task be designed both to add flexibility in constructing total test batteries and to provide a broader base for evaluation and selection of the best JPM units. In constructing the JPM modules, constraints such as manpower and equipment availability, costs, and time, need to be considered.

Following creation of a JPM battery for each technical rate, the tests must be validated. Checking exam reliability encompasses assurance of consistent JPM information output. Validity is the degree of job assessment accuracy. Finally, proficiency standards must be established relative to the resulting JPM score. In other words, the performance scores must be ranked on a qualitative scale.

d. JPM Administration

In this stage of implementation, procedures for administering and grading JPMs must be established. Since many sites could conceivably administer JPM batteries, a set of standardized procedures for using JPMs must be employed at all locations. This will ensure system continuity and the production of useful training data. Testing personnel must also be provided with guidelines for scoring and reporting the results of each JPM battery. To facilitate grading, a cut-off performance score for each unit should be established. Performance at or above the required level would receive a PASS score. Admittedly, fixing qualification standards is rather arbitrary;however, factors affecting the decision are task criticality and required manpower levels. A numerical grade for the total battery can be derived by simply forming the ratio of passed units to failed units.

e. JPM Site Establishment

As the JPM batteries are completed, implementation sites must be identified and manned. Optimistically, it is hoped that JPM sites can be established at or near all associated duty sites for routine, periodic performance assessment. Additionally, sites are required at the related training establishments for retraining placement. In this case variables such as location of existing training facilities and the availability of needed hands-on equipment must be considered.

f. Training Objective Development

Coincident with the development of the JPMs, educational specialists can take the performance criteria and write instructional objectives. These objectives are usually behavioral in nature which means they identify desired responses by the trainee under given situations. Essentially, they define the behavior desired upon completion of training. Behavioral objectives form the basis for curricula development.

g. Initial Training Curriculum Development

In a majority of cases, curricula for technical rating programs of instruction are already developed and in use. However, the training programs must be examined and realigned to reflect the newly constructed criteria-based instructional objectives.

h. Retraining Unit Development

Constructing retraining modules is a large, but necessary task. Since the JPM batteries will be designed to evaluate proficiency levels of specific critical tasks, each retraining unit must also cater to a critical task or group of associated tasks. Trainees will be assigned to complete only the specific retraining units identified by deficient performance. Unlike initial training programs where basic theory and general knowledge must be taught, the retraining program need only concentrate on refreshing motor skills and rehearsing procedural skills. The retraining units can also serve to modernize skill levels that have become degraded due to technical obsolescence.

i. Training and Retraining Site Establishment

Training sites for all rates are well established. The placement of retraining sites will depend upon the location of related JPM and duty sites. A major constraint in location planning is the type of equipment required for training and evaluation. Ideally, the retraining unit should be flexible and compact enough to be utilized at the training site and the duty site if necessary. Like JPMs, retraining modules should be capable of moving with personnel and equipment in the fleet.

j. Data Collection Procedures

In order to process all of the information made available by the various components of this JPM model, several points of data collection, as well as a central data bank, should be established. As shown in Figure 5, data collection occurs at both the training site and the duty site. The Training Coordinator depicted in Figure 6 could serve as the central data depository as explained earlier. Also, individual training jackets need to be maintained and carried between sites.

5. <u>Summary</u>

Since one of the largest potential consumers of a retraining system is the Naval Reserve, it is beneficial to discuss this model as it applies to their use. A major reserve problem is the lack of modern operational equipment. This means, unless equipment funding is substantially increased, many of the proficiency criteria developed for the active duty forces will not adapt to reserve training programs. Thus, reserve training and JPMs must be aligned with applicable criteria. Because the reserve system is totally dedicated to training, the training and duty sites, in terms of the JPM model, are merged at the same location. Therefore, when developed, the JPM batteries and retraining units can easily be administered at the Naval Reserve Training Units (NARTU). Obviously, data collection and individual training jackets can also be managed at individual NARTU locations.

Also, there are several agencies contacted during this study effort which contain expertise in specific areas relative to the implementation or further definition of this conceptual model. The following is a list of possible future study areas with the agencies which may be of assistance for each:

1) Task analysis - Chief of Naval Education and Training (CNET)

   Navy Personnel Research and Development Center (NPRDC)

   Naval Occupational Development and Analysis Center (NODAC)

2) Performance criteria - CNET

   NPRDC

3) Job performance measures - Director of Naval Education and Training (DNET)

   CNET

   NPRDC

   U. S. Army Training Support Center

4) Retraining unit development - CNET

   Reserve Readiness Command, Versatile Training System (VTS)

In conclusion, a Navywide JPM system would be difficult and expensive to implement; however, the long-term advantages would seem to far outweigh the initial investment. From this model the decision-maker receives information concerning both fleet proficiency and retraining requirements. Readiness data is obtained from the quantitative JPM scores at the duty sites and can be used to compare or contrast a number of variables throughout the Navy. For example, similar commands can be evaluated in terms of total proficiency and personnel of the same rate can be ranked for advancement purposes. In addition to a numerical score, the JPM indicates exactly which skills of a particular rate need retraining. Also, since the JPM is administered individually, the decision-maker is assured that the model will not have to be extrapolated to meet population differences. Essentially, this approach provides an empirically based tool for manpower management. Once established, the JPM system will be administered by local training and duty sites. The decision-maker can control personnel selection and placement by adjusting the qualification standards. For example, if feedback is received from a duty site which indicates that the proficiency of incoming personnel is not sufficient to maintain operational effectiveness, then tightening the qualification standards will increase that proficiency. Since the decision-maker can examine JPM data from both training and duty sites, he is in a competent position to make judgements concerning the alternatives between increased retraining time and decreased manpower in the fleet.

V. RECOMMENDATIONS AND CONCLUSIONS

1. It has been more than sixteen years since Naylor and Briggs [1961] published the first concerted review on skill retention. Their suggestions for further research, especially in the area of measurement methodology, have not been seriously studied. It appears the immensity of the problem and the apparent requirement for lengthy longitudinal research has prevented potential solutions from becoming more than just proposals. To overcome this situation it is necessary to develop a method which produces a viable short-term answer qualitatively, with a longitudinally constructed quantitative follow-up. Such a method may be realized by incorporating the matrix and performance assessment models discussed in the previous section. The approaches can be contrasted in the following manner:

MATRIX	JPM
a. Short-term qualitative solution	a. Longitudinal quantitative solution
b. General estimate of skill loss	b. Specific measurement of skill loss
c. Applicable to large populations	c. Considers individual differences
d. Is a predictive device	d. Is an assessment device
e. Utilized at BUPERS (high level)	e. Utilized at training/duty site (low level)

With these complementing features in mind, concurrent implementation of the two approaches would produce results both in the short and long term. The matrix, with its somewhat qualitative foundation, would soon provide the Navy with a BUPERS level instrument for determining retraining requirements for large groups. The JPM, with its ability to gather data quantitatively, would supply feedback information to improve the matrix, and also establish specific individual retraining needs. As an end product, the Navy would have a skill retention program which operates on two levels (BUPERS and training site) with both predictive and assessment capabilities. The system would be closed looped with a built-in pathway for modification since JPM collected data will continually supply feedback information to improve the matrix. In essence, the incorporation of matrix and JPM approaches will provide positive action now, while allowing sufficient time for data base development.

2. The use of training devices has been shown to enhance learning in both hardware and software intensive environments. Unfortunately, such devices are prohibitively expensive and are becoming difficult to procure in sufficient quantity and quality. For example, the SQQ-5 sonar system trainer used in ASW training costs in excess of $2 million, while the P-3C weapons system trainer costs over $13 million. Also, these and most other present generation systems are used for active duty personnel only. The reserve components, as was mentioned before, are forced to train on equipment developed as long ago as the Korean War period.

To facilitate training equipment procurement for both active and reserve forces, lower cost low-fidelity training devices should be utilized whenever possible. Because of diffuse geographic locations of personnel, especially reservists, these devices should be mobile and fully self-sufficient. In conjunction with software/hardware increases for the reserves, a restructuring of the drill period and active duty period mix is necessary. This revised plan should optimize the utilization of training devices throughout the year in preparation for operation of the actual system during the active duty period, and take precedence over general military training areas. The final product would be increased retention of fleet skills.

3. Additional research in the area of complex procedural skill deterioration is necessary. Future studies must either be conducted under actual operational conditions or in simulated operational environments where the researcher can ensure the transferability of the data and the results. The time has long past when basic research should give way to applied efforts to answer specific military skill retention questions.

4. Any program developed to address the retraining problem must be dynamic. Many shortcomings of the reserve system and training systems in general stem from their lack of ability to keep abreast of changing fleet requirements. Approaches such as those conceived in the preceding section will also be less effective unless they are allowed to keep pace with progressing technology.

5. The skill retention area has attracted the attention of several individuals and agencies, in both civilian and military sectors, resulting in a tremendous increase in

investigative efforts. Some method of collating this information on a continuous basis is required. Literature reviews at random intervals are not the solution. The Air Force, with its system of Human Resource Laboratories, adequately covers studies within their service, but falls short of covering external sources. The Navy has several levels of research facilities, from the Office of Naval Research (ONR) to the Naval Personnel Research and Development Center (NPRDC); but apparently has no effective means of centralizing information. Contact with the Army was minimal, but it would not be pretentious to assume that they face similar circumstances.

It is thus suggested that each service set up a liaison office to cross feed skill retention information on a continuous basis. For the Navy, such an office could be established within the office of Director of Naval Education and Training. Skill retention data could then be disseminated down the chain of command. In addition, this liaison officer could advise DNET on work assignments within military agencies to prevent unnecessary and more costly funding for civilian contracting.

6. Performance assessment has been shown to have wide applicability. The Job Performance Measure (JPM) discussed in the previous conceptual models section can be used to take advantage of the commonalities of personnel training, readiness, and advancement. These three areas all use different forms of measurement based on individual and group performance, but seek to achieve the same goal. Readiness is ascertained by Operational Readiness Exercises (ORE).

Training effectiveness currently has no cohesive assessment procedure, while advancement relies on enlisted evaluations and rating exams. The JPM could be used to measure proficiency in all these areas, thereby reducing costs and providing continuity within the total personnel cycle.

7. Regardless of the type of program conceived to answer retraining questions, the criteria established for performance assessment must match the criteria used for training programs. A performance measure is not useful as a diagnostic tool for a retraining program if the skills evaluated are not part of the program's goals. It is recommended that the desired job performance criteria be identified before developing performance measures and instructional objectives.

LIST OF CITED REFERENCES

1. Alliusi. E. A.. A Review and Analysis of Defense-supported Research and Development on Human Performance, Institute for Defense Research Paper, 1970.

2. Alliusi, E. A. and others, Summary Report of the Task Force on Training Technology, Office of the Director of Defense Research and Engineering, February 1976.

3. Armstrong, J. S. and others, Flying Skill Retention and Proficiency Flying, Air Command and Staff College, Air University Report 95-75, May 1975.

4. Bilodeau, E. A. (Ed.), Acquisition of Skill, Academic Press, 1966.

5. Briggs, G. E., and Naylor, J. C., Long Term Retention of Learned Skills: A Review of the Literature, U. S. Air Force Aeronautical Systems Division Technical Report 61-390, August 1961.

6. Christal, R. E., What is the Value of Aptitude Tests?, paper presented at the 18th Annual Conference of the Military Testing Association, Gulf Shores, Alabama, 18-22 October 1976.

7. Christensen, J. M., and Mills, R. G., What Does the Operator Do in Complex Systems?, Human Factors, pp. 329-340, 1967.

8. Craig, R. L., and Bittel, L. R., (Eds.), Training and Development Handbook, McGraw-Hill, 1967.

9. Daniels, R.W., and Allen, D. G., The Feasibility of Generalized Acoustic Sensor Operator Training, Naval Training Equipment Center Report 74-C-0067-1, May 1975.

10. Drever, J., A Dictionary of Psychology, Penguin Reference Books, 1965.

11. Dubin, S. S., Shelton, N., and McConnell, J. (Eds.), Maintaining Professional and Technical Competence of the Older Engineer-Engineering and Psychological Aspects, American Society for Engineering Education, 1974.

12. Fleishman, E.A., Comments on Professor Jones' Paper in E. A. Bilodeau (Ed.), Acquisition of Skill, Academic Press, 1966.

13. Fleishman, E.A., On the Retention Between Abilities, Learning, and Human Performance, American Psychologist, pp. 1017-1032, 1972.

14. Fleishman, E. A., Performance Assessment Based on an Empirically Derived Task Taxonomy, Human Factors, pp. 349-366, 1967.

15. Fleishman, E.A., and others, A Program for Research on Human Performance, American Institute for Research Technical Report 6-73, June 1973.

16. Ford, J. D., Campbell, R.C., and Harris, J.H., Development of Guidelines for Administration of Skill Qualification Tests, Human Resources Research Organization Technical Report 76-9, July 1976.

17. Gardlin, G.R., and Sitterley, T.E., Degradation of Learned Skills: A Review and Annotated Bibliography, The Boeing Company Report D180-15080-1, June 1972.

18. Grimsley, D.L., Acquisition, Retention, and Retraining: Group Studies on Using Low Fidelity Training Devices, Human Resources Research Organization Technical Report 69-4, March, 1969.

19. Grimsley, D.L., Acquisition, Retention, and Retraining: Training Category IV Personnel With Low Fidelity Devices, Human Resources Research Organization Technical Report 69-12, June 1969.

20. Guthrie, E.R., The Psychology of Learning, Harper and Row, 1952.

21. Haber, S. E., Occupational Structure in the Military and Civilian Sectors of the Economy, George Washington University Report TR-1224, September 1974.

22. Heimstra, N.W., and Ellingstad, V.S., Human Behavior: A Systems Approach, Brooks/Cole, 1972.

23. Holt, H.O., Programmed Instruction, Bell Telephone Magazine, Spring 1963.

24. Hoos, I.R., Retraining in the United States: Problems and Progress, The International Labor Review, p. 414, 1965.

25. Irion, A.L., A Brief History of Research on the Acquisition of Skill in E.A. Bilodeau (Ed.), Acquisition of Skill, Academic Press, 1966.

26. Jones, M.B., Individual Differences in E.A. Bilodeau (Ed.), Acquisition of Skill, Academic Press, 1966.

27. Leon, G.A., Total Force Concept: Reality or Myth, U. S. Army War College, November 1975.

28. Lukosiewics, J., The Dynamics of Science and Engineering Education, Engineering Education, 61, 880-882, 1971.

29. Mailer, M.K., and others, Implementing the Skill Qualification Testing System, U. S. Army Research Institute for the Behavioral and Social Sciences Report 76-1, April 1976.

30. Mali, P., Measurement of Obsolescence in Engineering Practioners, Manage, pp. 48-52, 1969.

31. Mangum, G.L., and Walsh, J., A Decade of Manpower Development and Training, Olympus, 1973.

32. Navy Enlisted Occupational Classification System Study Volume II: The Study Effort, Chief of Naval Personnel, January 1974.

33. Parker, J.F., and Fleishman, E.A., Use of Analytical Information Concerning Task Requirements to Increase the Effectiveness of Skill Training, Journal of Applied Psychology, 45, 1961.

34. Pickering, E.J., and Anderson, A.V., Measurement of Job Performance Capabilities, Navy Personnel Research and Development Center Report 77-6, December 1976.

35. Prophet, W.W., Long Term Retention of Flying Skills: A Review of the Literature, Human Resources Research Organization Report 76-35, October 1976.

36. Prophet, W.W., Long Term Retention of Flying Skills: An Annotated Bibliography, Human Resources Research Organization Report 76-36, October 1976.

37. Rose, A.J., and Turner, T.B., Skill Loss: An Assessment of Evaluation Techniques Used by Other Services and Their Application to Navy Technical Ratings, Personnel Research Laboratory Report WRM 67-24, January 1967.

38. Salvendy, G., and Seymour, W.D., Prediction and Development of Industrial Work Performance, John Wiley and Sons, 1973.

39. Seymour, D.W., Re-training for Technological Change, paper presented at the Institute for Professional Management Conference, October 1966.

40. Somers, G.G., Re-training the Unemployed, The University of Wisconsin Press, 1968.

41. Swezey, R.W., and Pearlstein, R.B., Guidebook for Developing Criterion-Referenced Tests, U. S. Army Research Institute for the Behavioral and Social Sciences, August 1975.

42. Taylor, L., Occupational Sociology, Oxford University Press, 1968.

43. Taylor, E.N., and Vineberg, R., Performance Test Development for Skill Qualification Testing, Human Resources Organization Technical Report 75-16, July 1975.

44. Wright, R.H., Retention of Flying Skills and Refresher Training Requirements: Effects of Non-flying and Proficiency Flying, Human Resources Research Organization Technical Report 73-32, December 1973.

BIBLIOGRAPHY

1. American Society for Engineering Education, Maintaining Professional and Technical Competence of the Older Engineer, July 1973.

2. Ammons, R.B., and others, Long Term Retention of Perceptual Motor Skills, Journal of Experimental Psychology, 55, 318-328, 1958.

3. Barsby, S.L., Cost Benefit Analysis and Manpower Programs, Lexington Books, 1972.

4. Bienvenu, B.J., New Priorities In Training, American Management Association, 1969.

5. Bilodeau, E.A., and Levy, M.C., Long-term Memory as a Function of Retention Time and Other Conditions of Training and Recall, Psychological Review, 71, 1974.

6. Bilodeau, E.A. (Ed.), Principles of Skill Acquisition, Academic Press, 1969.

7. Bugelski, B.R., Psychology of Learning, Holt, Rinehart, and Winston, 1963.

8. Clough, D.J., Lewis, C.G., and Oliver, A.L., (Eds.), Manpower Planning Models, The English Universities Press, 1974.

9. Farrell, W.T., Hierarchical Clustering: A Bibliography, California State University Report No. 1, July 1975.

10. Fleishman, E.A., and Hempel, W.E., Factorial Analysis of Complex Psychomotor Performance and Related Skills, The Journal of Applied Psychology, 40, 1956.

11. Fine, S.A., Functional Job Analysis Scales, Upjohn Institute for Employment Research, 1973.

12. Frederickson, E.W., Hermann, P.W., and Kubala, A.L., Assessment Alternatives for a High Skill MOS, Human Resources Research Organization Technical Report 75-25, December 1975.

13. Gardlin, G.R., Judgement of Skill Retention, University of Washington, Department of Psychology Report 71-1-8, October 1971.

14. Goody, K., Task Factor Benchmark Scales for Training Priority Analysis: Overview and Developmental Phase for Administrative/General Aptitude Area, Air Force Human Resources Laboratory Report 76-15, June 1971.

15. Hollister, W.M., and others, Identifying and Determining Skill Degradations of Private and Commercial Pilots, Department of Transportation, Federal Aviation Administration Report 73-91, June 1973.

16. Koch, D.L., Constant Growth: Final Report, Military Airlift Command Project 15-5-75.

17. Laabs, G.J., Danell, R.C., and Pickering, E.J., A Personnel Readiness Training Program: Maintenance of the Missile Test and Readiness Equipment, Navy Personnel Research and Development Center Report 77-19, March 1977.

18. Legere, C.L., Job Analysis Handbook and Guide, Office of Training Systems Development, U.S. Army Security Agency Training Center and School, 1968.

19. List of Critical Military Skills for Use in Screening the Ready Reserve, Office of Deputy Assistant Secretary of Defense (Reserve Affairs), January 1974.

20. Navy Occupational Analysis in the 1970's, Navy Occupational Development and Analysis Center, May 1977.

21. Naylor, J.C., Briggs, G.E., and Reed, W.G., Task Coherence Training Time, and Retention Interval Effects on Skill Retention, Journal of Applied Psychology, 52, 1968.

22. Official Reserve Manpower Strengths and Statistics, Part II, Department of Defense, March 1975.

23. Orend, R.J., and Kriner, R.E., Assessing Reenlistment Eligibility: A Preliminary Examination of Some New Reenlistment Criteria, Human Resources Research Organization Report 75-11, May 1965.

24. Personnel Managment, Defense Documentation Center Report AO-785-350, September 1974.

25. Siegal, A.I., and Federman, P.J., Development of Performance Evaluative Measures, Applied Psychological Services, 1970.

26. Singleton, W.T., Easterby, R.S., and Whitfield, D.C. (Eds.), The Human Operator in Complex Systems, Taylor and Francis, 1967.

27. Smith, J.E., and Matheny, W.G., Continuation Versus Recurrent Pilot Training, Air Force Human Resources Laboratory, Flying Training Division Report 76-4, May 1974.

28. Vineberg, R., A Study of the Retention of Skills and Knowledge Acquired in Basic Training, Human Resources Research Organization Report 75-10, June 1975.

29. Walker, C.R., Technology, Industry, and Man: The Age of Acceleration, McGraw-Hill, 1968.

30. Winchell, J.D., Panell, R.C., and Pickering, E.J., A Personnel Readiness Training Program: Operation of the AN/BQR-20A, Navy Personnel Research and Development Center Report 77-4, December 1976.

31. Wool, H., The Military Specialist: Skilled Manpower for the Armed Forces, The John Hopkins Press, 1969.

32. Zelikoff, S.B., On the Obsolescence and Retraining of Engineering Personnel, Training and Development Journal, 25, 1969.

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