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NAVAL POSTGRADUATE SCHOOL

Monterey, California



SKILL DETERIORATION AND ITS MANAGEMENT

by

James K. Arima

and

Douglas E. Neil

February 1978

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NAVAL POSTGRADUATE SCHOOL
Monterey, California

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definitive study. Data requirements are stressed in the long-range program.

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PREFACE

"Skill deterioration" has been an all-too-familiar problem for at least a generation of Naval officers who have participated in the management of the Navy's manpower and personnel. The examination of the problem documented in this report was sponsored by the Systems Analysis Division of the Navy's Program Planning Office. The monitor of the effort was Charles R. Hoshaw of the Enlisted Plans Branch, Bureau of Naval Personnel. Both Hoshaw and CDR Fred J. Breaux of the Mobilization Planning and Programming Branch, Office of the Deputy Chief of Naval Operations (Manpower), were most helpful in providing the initial guidance and direction for this effort.

Two thesis students of the authors, LT James E. Taylor and LT David M. Thalman, who participated in the project were most helpful in the literature search and review, contacting current research activities, and providing the "inside view" of the problems associated with skill deterioration and its management in the Navy. Their thesis on the topic and participation in this study is another example of the close working relationship between the faculty and students at the Naval Postgraduate School on topics of current concern to the Navy and the defense posture of the United States.

The addendum, which presents a formal model of the recommended study effort, was inserted at the suggestion of the study monitor after the initial review copy was circulated. It was prepared for a project briefing at the Naval Postgraduate School of RAMD C. A. Trost, the Director of the Systems Analysis Division (NOP-96), Office of the Chief of Naval Operations.

EXECUTIVE SUMMARY

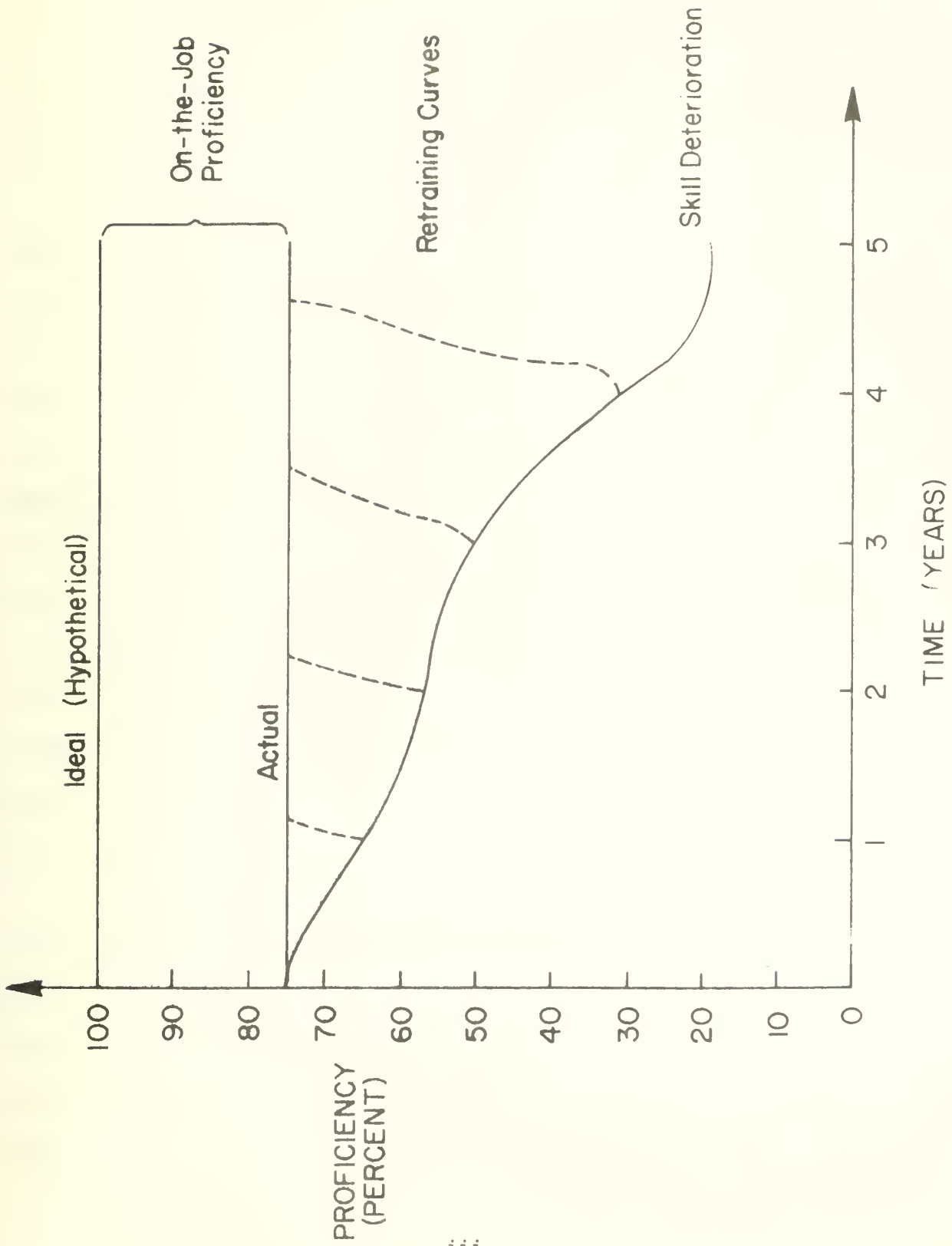
PURPOSE

The purpose of this study was to recommend a feasible research and study program to develop the knowledge and methods necessary to manage the problem of skill deterioration among Navy enlisted personnel due to the nonutilization of their learned skills.

PROBLEM

As the technology of Naval warfare has increased in its complexity and rate of change, so has the difficulty in maintaining a sailor's skills and proficiency in the occupation for which he or she is trained. A major factor contributing to this difficulty is the nonutilization of learned skills for extended periods of time. This situation could develop as a result of an assignment outside of the person's specialty or because of a break in service. The situation is typical of sailor's in the Reserve forces whose skill utilization periods are much shorter than the periods of nonutilization. Actually, skill deterioration, itself, is a symptom. The decision maker's problem lies in its cure--training. That is, the decision maker is concerned with skill deterioration because retraining may be required to rehabilitate skills that have deteriorated due to nonuse and because a given amount and frequency of training must be provided the Reserves to prevent skill deterioration through excessively long periods of nonutilization. The problem is depicted in the accompanying figure.

The elements of the problem are the current level of performance on the job, the skill deterioration curve, and the retraining curves at various periods of nonutilization. The level of performance on the job is the baseline from which the skill deterioration curve is derived and the criterion



Schematic Representation of the Skill Deterioration Problem.

to be attained in retraining. However, determining this level is no easy matter in practice. As shown in the figure, an ideal or hypothetical level can be logically created, but the actual performance of job incumbents has been found to be around 25 percent below such ideal levels. The skill deterioration curve is initially steep, but it should level off when the large decrement due to the immediate forgetting of poorly learned and practiced skills has passed. As the period of nonutilization continues, another factor enters the picture--a change in the job itself. This again leads to a rapid deterioration of skills due to their obsolescence. As the shape of the skill deterioration curve can be expected to reflect qualitatively different sources of skill deterioration, so can the retraining curves be expected to differ according to the place on the skill deterioration curve when retraining commences. If retraining must overcome obsolescence, for example, training will consist essentially of new learning.

There are many occupations in the Navy with quite specific skills being required in particular positions. These are reflected in the Navy Enlisted Occupation Standards and the Navy Enlisted Classification (NEC) system. The skill deterioration problem, in this context, is twofold. First, there is no way to determine what the skill deterioration curve may be for any one occupation and, consequently, the amount and type of retraining required. Second, the jobs and positions for which skill deterioration curves and rehabilitative training programs must be developed are very numerous. Thus, the skill deterioration problem has its qualitative and quantitative aspects.

CURRENT STATE OF KNOWLEDGE

The first phase of this study was directed at determining what was available in the scientific literature, in ongoing research activities, and

in the institutionalized data and information management systems of the Navy that could be used to define the skill deterioration problem and as guidance for its management. Unfortunately, existing, extensive reviews of the literature covering a period of over 75 years could provide very little of direct application to the problem as stated. The emphasis in the literature is on skill acquisition, rather than retention; the basic research is more concerned with memory and forgetting processes rather than the results of the non-utilization of learned behaviors; and the experimental tasks that have been used have been simple and artificial. The literature on retraining is considerable, but it deals with the training in a new occupation of persons whose skills are no longer marketable, rather than the rehabilitative training of persons who have lost their capabilities and skills. Scientists within the present research scene quickly acknowledge the problem of skill deterioration, but there is very little experimentation designed specifically to investigate it. Concern is especially high in the area of flying skills because of the reduction in flying hours to conserve energy sources, but the emphasis is on developing substitute (simulator) training, rather than on measuring the loss of skills. There are, however, a few interesting efforts that may provide some insight into the skill deterioration problem, but the specificity of the studies merely serves to accentuate the extremely long course that a strictly experimental program would take.

The management information systems of the Navy were found to be organized in a way that could not provide data to be applied to the problem of skill deterioration. These systems do involve the collection of task and performance data, but each process--such as NEOCS, NOTAPS, and PQS--serves a different master and together they do not provide a quantitative assessment of skill levels as they exist in the fleet for tasks essential to the

performance of prescribed missions. Thus, if baseline performance cannot be established, neither can the skill deterioration function or the requirements for retraining.

RESEARCH AND STUDY ALTERNATIVES

These findings indicate the need for a very comprehensive program of data collection and research if answers to the skill deterioration problem are to be found. Three possible approaches were considered: a performance testing approach, a systematic job/task/skill analysis approach, and a synthetic, simulation-based approach.

Performance Testing

One deceptively simple and straightforward method recommended to us by many persons was a performance-testing approach. In essence, this method would test persons on the job and persons returning to the job to determine the skill loss due to nonutilization. The gap, if any, would be the retraining that must be accomplished. The concept is excellent, but its implementation is difficult. Performance testing that is criterion referenced embodies, in large part, a hands-on, job-sampling approach. Attempts to develop such tests for determining personnel readiness have met with much difficulty because the development and validation process necessarily intrudes into the duty cycle of persons on the job. Even if such tests could be developed for the entire range of Navy occupations, the costs of establishing, instrumenting, and operating testing facilities for evaluating the skill deterioration of persons who have been out of their occupational areas and are returning to them would be excessive.

Job/Task/Skill Analysis

The typical training approach to the problem of retraining lost or degraded skills would be to analyze jobs into tasks and subtasks and then

specify what skills and knowledge are required to perform the tasks. A criticality dimension may also be applied to the tasks to establish a priority of tasks to be trained. The argument put forth by this approach is that the skill deterioration and retraining problems cannot be diagnosed and remedied without a knowledge of the skills required to perform the tasks and their criticality. The problems associated with this approach are the difficulty in validating that the skills specified are those that are actually required--often a major experimental effort in itself, determining the level of skill necessary for satisfactory performance, determining the actual skill level of those on the job, and devising a method for measuring skill levels at a remote site in the case of those who have been out of the job and are returning to it. It is evident that this method involves all of the problems and costs of the performance testing method plus the time and costs in attempting to understand and control the underlying skill mechanisms. However, the understanding achieved in one task or job could conceivably be generalized to other tasks and jobs with a potential savings in effort. These methods would also provide a sounder base for prescribing retraining.

Synthetic, Simulation-Based Approach

In order to circumvent the costs and time involved in the preceding alternatives, a synthetic, simulation-based approach was considered. It is essentially a method for capturing the policy of those who make retraining decisions now and who prescribe training programs for the various categories of the Reserves. It systematizes what is being done by intuition and experience so that it can be applied by rule to any job or billet. Using personnel and training experts and experienced Navy supervisors, a list of job characteristics that would have a bearing on the skill deterioration and obsolescence rate for any and all would be created and statistically

manipulated to result in a smaller list of orthogonal or independent job characteristics or clusters. These characteristics would be used to describe synthetic jobs that have varying amounts of the characteristics. The experts would then rate the amount of skill deterioration that would occur for each of these synthetic jobs at various periods of nonutilization. Appropriate statistical methods would then be used to recapture the policy of the experts and supervisors so that the relative importance or weight of each of the "pure" job characteristics could be determined. The resulting vector of weights could then be applied to any job that could be scaled on the relevant characteristics to obtain its skill deterioration curve. Thus, the system would be efficient in that one set of weights could be applied to any job.

The validity of the method could be determined by using it to make retraining decisions or training programs for the Reserves. Feedback from these efforts would be used to reevaluate and, if necessary, adjust the weights of the skill deterioration vector. This approach deals directly with the skill deterioration problem and will provide an operational tool within a relatively short period of time that has the benefit of being self-correcting.

SUMMARY AND RECOMMENDATIONS

Skill deterioration among Navy personnel due to the nonutilization of learned skills is a serious problem with no easy solution. The available scientific literature does not provide much that can be used to solve the problem. Empirical approaches to determining skill loss for the entire range of Navy occupations would be an undertaking of considerable proportions that would have to be done on a continuing basis as jobs change. Without the long-range commitment of resources and continuing command support these

methods will not produce the desired results. A short-range approach that attacks the problem directly using expert opinion seems to be the only feasible solution. Along with the implementation of the short-range approach, the Navy's performance measurement system (PQS) should be improved to permit a scoring of individual performance that reflects the actual capabilities of the individual. The NOTAP program should be improved so that tasks are consistently described across all occupations to permit the analysis and derivation of important, composite skills using appropriate statistical procedures. Eventually, then, the short-range approach using personal judgments can be replaced with actual data in similar categories from the job environment itself. In the meanwhile, decisions made on the basis of the interim method should be validated by feedback from the training or job environment and a self-correcting cycle be established.

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INTRODUCTION

This report summarizes work carried out in accord with our proposal entitled "Deterioration of Skills." The report reviews, in part, literature related to the proposed topic and discusses programs designed to provide better insight into skill deterioration and approaches which have the potential to aid in the interim and long-range to the retraining question in the Navy.

Essentially, the task statement contained in the proposed study effort was as follows:

- (1) Establish a series of topics of interest which are of importance in skill deterioration.
- (2) Review the literature relevant to skill deterioration, job obsolescence, and nonutilization in the Navy's enlisted structure.
- (3) Define gaps and deficiencies in areas of interest established above.
- (4) Suggest research efforts which will aid in closure of observed gaps and deficiencies.

In the course of our activities we were exposed to a variety of views relevant to the topic of interest. These activities were the result of a literature review and discussions with individuals during travel. The discussions and activities of those visited are summarized in Appendix A. Later sections are devoted to a discussion of a proposed approach to the retraining problem and required study efforts.

PROBLEM OF SKILL DETERIORATION IN THE NAVY

In an organization as large as the Navy with its many diverse and unique operational activities coupled with the wide variety of operational

environments and complex of Naval systems, a premium is placed on the development and retention of a highly capable and skilled enlisted work force. One aspect of this total problem is the maintenance of an acceptable level of performance proficiency or skill in personnel necessary to fulfill wartime manpower requirements. The magnitude and significance of the problem becomes obvious when one considers that approximately 75 percent of the Navy occupational specialities requires the development and use of specially trained skills. The problem of availability of such personnel is compounded by the fact that at any given time approximately 25 percent of the skilled work force is assigned to responsibilities not involving skills and capabilities for which they were trained (Taylor and Thalman, 1977). Further, a significant component of the total work force in a wartime situation will consist of reservists, retired personnel, and prior service volunteers. As such, an emergency situation would find the Navy with a large element of its enlisted force experiencing various levels of skill deterioration and/or job obsolescence.

Therefore, a significant problem for the modern technical Navy is one of assessing and analyzing the capability of naval personnel resources required to maintain operational capability at an acceptable level. A major aspect of the problem involves specification of the nature and extent of retraining required to offset anticipated reduction in performance capacity resulting from nonutilization of skills and job obsolescence.

RELEVANCY OF EXISTING DATA

As suggested earlier, our task was to involve, in part, a review of work related to the problem of skill retraining requirements following periods of nonutilization and/or job obsolescence. In terms of applicability to the stated objective, the literature review was disappointing. Current and past efforts devoted to the study of skill degradation have been rather fragmented and frequently simplistic. There does not appear to have been an organized research program designed for the purpose of providing research data necessary to establish and implement an effective diagnostic and implementation program in skill maintenance. In general, the present state of the art consists of appreciation of the complexities involved in performance rather than an understanding of the variables and their interaction, particularly as these variables relate to maintenance of performance proficiency. Fleishman, et al. (1973), for example, have concluded that it is virtually impossible to translate, let alone apply, many of the terms and concepts developed in learning laboratories to training programs applicable to real world situations. Too often, reports survey available literature and conclude with a categorization of those parameters considered to be of importance. Infrequently is there a discussion of possible interrelationships between parameters as they would apply in the real world.

LACK OF A SYSTEMATIC MILITARY PROGRAM

Paralleling the absence of research programs directed at the skill deterioration and retraining problems is the lack of an organized, systematic effort to obtain empirical evidence from ongoing Navy programs and activities to solve problems in these areas. The 3M programs, for example, are designed to provide data to improve the maintenance and readiness of Navy material, and aviation safety programs exist to provide information to improve the safety and performance of aircraft, flight personnel, and their associated systems. Such organized efforts do not exist among the manpower and personnel programs to determine how much training is required to maintain and/or rehabilitate requisite skills when they are not habitually used in a person's daily work activities.

At the present time, a program exists for rehabilitating other service veterans (OSVETS) who reenlist in the Navy after a period of broken service. There are two sites, San Diego and Great Lakes, where those with less than two years of broken service are given training in general military subjects peculiar to the Navy--such as fire-fighting, damage control, shipboard safety, and Navy human resources management. Those who have greater than two years of broken service are sent to a Recruit Training Center to start at the beginning with new recruits. In either case, the individual usually proceeds through an initial-training, specialty school following the first phase of rehabilitation training. Navy personnel on active duty returning to their specialties after a period of nonutilization and Navy reenlistees with broken service are usually sent through a rehabilitation program, often integrally located within the receiving command, prior to assignment to regular duty. These programs are designed to handle the retraining requirements of once-trained personnel entering or reentering a skilled

occupation in the active Navy, but there is not the necessary organization and planning of these activities to provide the information necessary for their improvement and for application of the findings to the Reserve component training of the Navy. However, personnel experienced in the operation of these programs should be able to provide qualitative insight into the parameters that seem to affect skill deterioration and retraining.

There is another area where several programs exist that are of direct relevance to the skill deterioration problem. The area is concerned with specifying and describing the occupations and jobs that make up the enlisted structure of the Navy. As in civilian industry and commerce, there are several approaches depending on the purpose and objectives of the various efforts. There is, first, the Navy Occupational Task Analysis Program (NOTAP) that is a computer-based, information system. It generates, maintains, and analyzes tasks performed within Navy occupations. The description is detailed and behavioral, and the prime user is the training community. Then there is the Navy Enlisted Occupational Classification System (NEOCS) that is stated in terms of the functions performed and the knowledge required for a particular occupation. The prime user is the personnel management community as it deals with the selection, classification, and assignment of individuals. There is also the Performance Qualification Standards (PQS) which are a combination of textbook-type knowledge requirements and a hands-on demonstration of proficiency by a job incumbent. The orientation is toward individual career development and advancement and unit readiness. Finally, there are the squadron, ship, and shore manning document programs that are based on job sampling methods and the 3M maintenance requirements to generate manpower requirements.

All of these programs have the common characteristic of defining and setting standards for Navy jobs and occupations, and yet none or any

combination of them will define precisely what degree of skill or what combination of capabilities are actually necessary to perform a job adequately in the Navy. Stated in another way, they cannot provide precise information as to how well incumbents actually perform their jobs. Unless there is a precise way for determining performance requirements that can be stated quantitatively, it is not possible to determine when and to what degree skill has deteriorated. Neither is it possible to determine when rehabilitative training has served its purpose. Perhaps the lack of integration of these many activities is a reflection of the excessive fragmentation, in the past, of the Navy's manpower requirements, training, and personnel management functions, which is currently being corrected (Salzer, 1976).

RESEARCH NEEDS

Emphasis in the Navy has consisted of the development of programs designed to impart skills and knowledge to the recruit which will enable him to reach a level of performance competency sufficient to maintain fleet readiness. The current problem consists of proficiency degradation as a result of nonutilization of learned skills and/or technological obsolescence. Therefore, the problem is one of maintenance or updating of a previously learned skill as opposed to initial skill acquisition or development.

Goldstein (1974) has suggested that there are three basic components in any attempt to assess retraining requirements--organization, job/task, and the recipient. In terms of the Navy, these components can be translated into (1) operational objectives of the Navy, (2) analysis of job/task/skill, and (3) analysis of the individual sailor.

Analysis of Navy needs and objectives is essential in the development of measures of effectiveness for eventual evaluation of a retraining

program. Organizational analysis will provide criteria by which the success or adequacy of any proficiency maintenance program can be judged and will ensure an understanding on the part of all units that can be expected to interact with the retraining program (Goldstein, 1974).

Therefore, from an organizational point of view, it is possible for the Navy to hypothesize a potential level of proficiency which is ideal and represents 100 percent effectiveness. However, in most man-machine systems the achievement of maximum proficiency is rarely observed. The influence of within and between subject variability, environmental, situational, social, and organismic stressors all tend to degrade potential proficiency to a level somewhat less than the hypothetical ideal. Hopefully, however, observed proficiency can be maintained at a level necessary for acceptable operational readiness. Figure 1 presents a graphical representation of the maintenance problem.

Organizational analysis is required to ensure that expectations on the part of the Navy are not unreasonable. In the absence of realistic proficiency requirements a potential conflict exists between objectives of the Navy and a retraining effort designed to maintain proficiency.

The job/task/skills analysis of Navy need assessment will provide information necessary to fully understand the requirements for satisfactory performance in the maintenance of operational readiness. This aspect of assessing retraining requirements would involve a series of steps designed to define and describe jobs/tasks in terms of criticality, frequency, and susceptibility to obsolescence. As such, a distinction must be made between job analysis, task analysis, and skill analysis. The Navy must develop a program which will identify the what (i.e., job and task) and allow for determination of how an operator achieves satisfactory performance

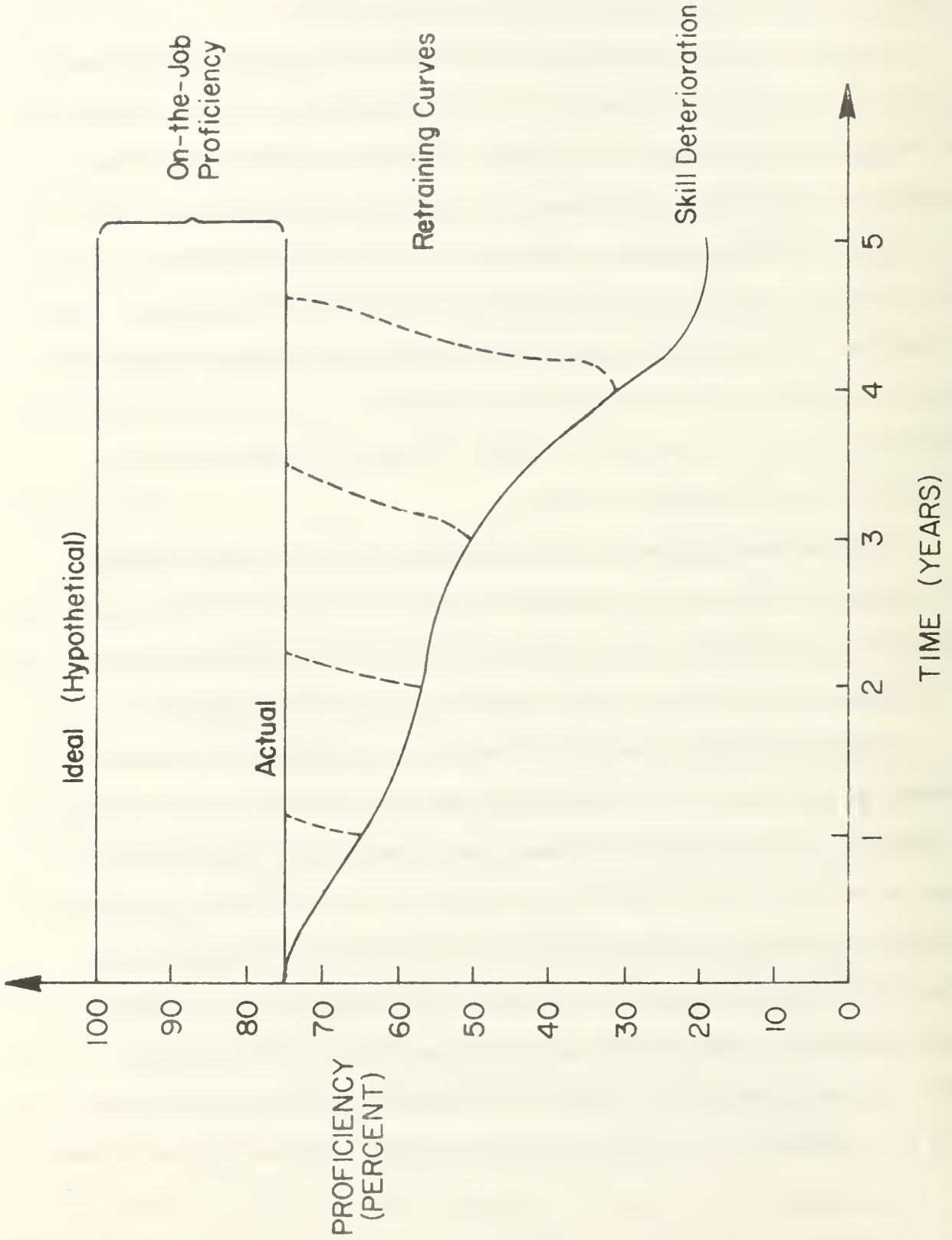


Figure 1. Schematic Representation of the Skill Deterioration Problem.

(skill)(Salvendy & Seymour, 1973). The problem of maintaining proficiency becomes one of integrating the "what and how" under different times, places and jurisdictions (Silvern, 1970).

The third component in assessing retraining requirements is the most difficult and most formidable. The Navy must develop a program that will examine performance standards and capabilities of the target population for use in the assessment of retraining/proficiency maintenance requirements. The primary objective of this portion of the analysis is to determine behavioral characteristics which have been learned and retained by individual performers (Goldstein, 1974). The objective of a retraining program is to return individual performers who are now or have been operators in the system to full duty. This portion of the need assessment analysis will provide data essential for the design of a retraining effort which considers behavioral characteristics and proficiency levels of groups and individuals and provides the basis for tailoring retraining requirements to the individual.

The systematic research program suggested above requires a major commitment of resources that is sustained over a long period of time. Research and development in the Navy, as in the other services, tends to be spasmodic with the recurring sacrifice--temporarily or permanently--of long-term programs to short-term needs. A long-term skill deterioration research program could well meet such an eventuality. One underlying cause for these disruptions is that decision makers must provide immediate answers, if not solutions, to current problems. Thus, in the fact of real-world demands on decision makers, it would be appropriate to consider the possibility of short-term research that is designed, primarily, to help decision-making and planning with respect to the skill deterioration and obsolescence issue without, necessarily, providing any great understanding of the problem.

This study, therefore, also examines what could be done in the area of research into the skill deterioration problem with immediacy as the motivation, rather than understanding.

SKILL DETERIORATION LITERATURE

SKILL RETRAINING

A number of problems present themselves upon examination of studies dealing with the general subject of skill. As suggested above, data purported to deal with the question frequently does not have a clear-cut application to the "real-world." Data collected in sterile laboratory settings are frequently too simplistic and lack application to problems in the fleet. Further, the literature tends to use the terms skill, proficiency, aptitude, task, job ability and performance interchangeably. This situation results in considerable confusion and prevents the development of an organized set of research data on the subject of skill specifically. Fleishman, et al. (1973) have defined this problem earlier; however, the present effort would suggest that the problem remains and represents an area in which a solution is required if meaningful data applicable to the operational Navy is to be forthcoming.

Considerable effort has been devoted to the study of acquisition of skill. One of the most notable collection of papers on this subject is Bilodeau (1965). However, as the purpose of the current effort was on the retention or maintenance of skill, a comprehensive review of skill learning research will not be included here.

Perhaps the first major effort was a review by Naylor and Briggs (1961) on the retention of flight skills conducted for the Air Force. Naylor and Briggs categorized variables of interest into task, learning, retention interval, and recall. While their effort was comprehensive, the emphasis was on laboratory research as opposed to operational application. This emphasis combined with the report's verbal learning and memory orientation limits its utility to the present effort.

A second major effort involved the investigation of skill loss in Navy personnel when assigned to non-rating related billets (Rose & Turner, 1967). This study represents an attempt to examine the retention or maintenance of technical skills in the operational Navy. One important aspect of the report was the authors' differentiation between "skill loss" and obsolescence. They suggest that a distinction be made between the inability of Navy personnel to perform on a job through lack of practice (non-utilization) and inability resulting from technological changes (obsolescence).

As a result of their review, Rose and Turner concluded:

- (1) Discrete tasks involving sequential steps incurred considerable loss of skill over time, while continuous tasks suffered little decrease in retention.
- (2) Job skill research has been predominantly oriented toward operational skills and not maintenance skills.
- (3) Few reports exist on skill loss due to nonpractice of those skills.

Gardlin and Sitterley (1972) conducted a review of skill retention literature and concluded that retention variables should be separated into four major categories: (1) amount of training, (2) duration of retention interval, (3) task organization, and (4) task environment.

Gardlin and Sitterley suggest that skill retention would appear to be functionally proportional to amount of original training, extent of task organization, and degree of similarity between simulation and operational setting. Further, skill retention is most likely inversely proportional to duration of the nonutilization period. The primary factor in the prediction of skill retention, according to Gardlin and Sitterley, is the final level of skill acquisition prior to nonutilization.

Gardin and Sitterley make an important point when they suggest that training/retraining programs should be based on previously identified critical performance dimensions. Silvern (1970) made a similar suggestion in a discussion of maintaining trained proficiency. Therefore, essential task elements which determine success or failure of a mission must be identified and stressed in proficiency analysis, training and/or retraining. Performance measures should be designed to analyze an operator's capacity to perform those aspects identified as being critical.

Prophet (1976) has conducted a comprehensive literature review of long-term retention of flying skills. The Prophet effort was oriented around the following categories of subject matter: (1) general retention factors, (2) task or skill factors, and (3) retraining factors.

In agreement with Gardlin and Sitterley (1972), Prophet has suggested the best predictor of performance following nonutilization of skills is the highest level of skill acquired prior to that interval. However, no precise statement can be made relative to the duration of retention. At best, one can conclude from available data that the longer the period of nonutilization the greater the decrement in proficiency. However, the question of proactive and retroactive inhibition on retention has not been examined sufficiently to allow for the drawing of conclusions as they relate to technical skills.

RETRAINING AND OBSOLESCENCE

The majority of work completed on the subject of retraining is not generally applicable to the present task. The primary emphasis in what has been called retraining research has been directed toward preparing an individual for entry into a new job specialty subsequent to job displacement.

As such, research has concentrated on development of skills and knowledge in what is essentially a new worker rather than updating or maintaining proficiency of that worker for the existing job function. Therefore, "retraining" research might better be described as "training" where the primary interest is in development of new skills and imparting new knowledge.

However, the subjects of proficiency maintenance, technical obsolescence, and nonutilization have been recognized as crucial problems in the area of personnel training and development in industry (Landy & Trumbo, 1976; Dubin, 1972; Siefert, 1964; Dubin, Shelton, & McConnell, 1974). These efforts have shown that performance/proficiency degradation can result from (a) rapid changes in technology and knowledge making current skills insufficient, and/or (b) loss of effectiveness can result from nonuse. Both forms of proficiency decrement exist in the modern Navy and can be defined as obsolescence resulting from accelerated technical change and nonutilization of learned skills.

Zelikoff (1969) has suggested that a major need in the area of obsolescence and retraining is the development of a method of quantifying the problem. Mali (1969) has proposed an obsolescence index (OI) for engineers:

$$OI = \frac{\text{current knowledge understood by engineers}}{\text{current knowledge in the field}}$$

However, employment of such an index requires assessment techniques capable of specifying current knowledge. Solution of this problem will require the development of research efforts designed to identify and classify the nature and cause of obsolescence in Navy job specialities and situations, e.g. reservists, personnel temporarily assigned outside their billets, etc.

SUMMARY

In summary, existing literature concerned with proficiency maintenance rarely exists in a form readily usable by the Navy. The literature

fails to provide what Glaser (1960) has considered required information for performance measurement and proficiency maintenance. Applied to the Navy's retraining effort, literature is deficient in the following fundamental categories (Glaser, 1960):

(1) Definition of performance to be evaluated

As a result of the fragmentation of research data, available information does not allow for the integration required for measurement and analysis of performance characteristics of interest to the Navy in a proficiency maintenance effort. On the basis of existing literature it is not possible to specify levels of proficiency. Rather, the concentration has been on measurement prior to and following training and as such is frequently not applicable to the current problem.

One major problem in performance evaluation is the absence of acceptable standards in many Navy job specialities. Industry frequently employs an "experienced worker standard" (EWS) in personnel evaluation. It is necessary that performance standards and methods of measurement be developed which are applicable to specifying retraining requirements following periods of nonutilization or technological obsolescence. Available literature does not provide a basis for developing such an "EWS" for the Navy.

(2) Determination of performance aspects to measure

Performance proficiency can be measured in terms of final product or behaviors involved in performance proficiency. The literature does not provide a basis for determining those aspects of performance which are most relevant and therefore enable discrimination between effective and ineffective workers. Information is lacking which will allow for specifying those aspects which are representative and critical and therefore worthy of measurement and evaluation. That is, in some job specialities the important

aspect may be the end product, while in other situations or jobs, ongoing behaviors may represent the critical aspect of proficiency.

(3) Measurement methods

Existing literature does not specify techniques required to measure observable behaviors and/or end products which need to be identified, recorded, and measured for subsequent ordering along an evaluative scale. Information is needed which will specify performance features to be evaluated and specify standards against which it will be compared.

(4) Reliability of measurement

Existing literature with its concentration on "skill acquisition" has not provided a basis for measuring proficiency degradation resulting from nonutilization and/or job obsolescence. Measures must be examined in terms of their ability to measure and assess degradation following nonutilization or resulting from obsolescence, and not the ability of a training program to impart new knowledge to the uninitiated.

(5) Validity of measurement

The literature would suggest that research has concentrated on developing measures which are frequently ends in themselves. As suggested in category (1), development of standards and criteria in terms of system performance in the "real world" as opposed to evaluation of training or retraining programs is required if measurements are going to be valid indicants of system efficiency. Measures based on evaluation of a training program are of little utility in assessing retraining problems as they apply to the operational readiness of the fleet.

CURRENT RESEARCH EFFORTS

OVERVIEW

Given the status of the extant scientific literature, described above, an effort was made to determine whether any current research programs might be applicable to the skill deterioration problem. The search was limited to Defense activities with the expectation that ongoing research in the civilian sector would not differ significantly from the findings of the literature survey. Program summaries of research and development activities of the services provided one source of information. Personal contact with research personnel in the laboratories and study organizations was another important source. Finally, the two graduate students working on this project with the authors were sent on a site visit to the many contacts that were established. Their record of these visits is presented in Appendix A to this report.

In general, ongoing research is oriented towards developing training techniques, equipment, and training systems. The emphasis continues to be on the acquisition of skill, as this is the training mission, rather than on its retention.

ARMY FIELD STUDY OF ANTIAIRCRAFT MISSILEMEN

There is, however one current research effort that deals specifically with skill loss and the role of refresher training in the maintenance of skill. A large field experiment has been designed and is already in the data collection stage at the time of this writing. The program was initiated because the Army has found that trainees forget much between the time they finish a school, take leave, and then report to their unit assignments. The project is in the individual training and performance evaluation area of the research effort of the Army Research Institute (ARI)

for the Behavioral and Social Sciences. Dr. Milton Katz is the overall program director for individual training and performance evaluation, and Dr. Joyce Shields is the project leader.

The ARI study has an ingenious design utilizing soldiers trained in the 16P and 16R military occupational specialty (MOS) fields. Soldiers with one designation fire the Chaparral missile, and the other, the Red-Eye missile. Both MOS are trained in the same course at the Army's Antiaircraft Artillery School at Ft. Bliss, Texas. Accordingly, this permits a direct comparison within the same individual of skill loss due to nonutilization of learned skills, proficiency level in the assigned duty vs. proficiency at the completion of training, and the retraining necessary to achieve a required proficiency level as evidenced by the performance on the missile that he fires on duty. The nonutilization periods are relatively short, being 0, 1, 2, and 4 months after completion of training because the emphasis is on refresher training and the maintenance of skills, rather than on the problem of extended periods of nonutilization. The findings of the study will, however have direct relevance to the question of skill deterioration and retraining, especially as it may be generalized to skill maintenance in the Reserve.

One aspect of this ARI study has been considerably facilitated because the individual training research program includes a major effort on the study, analysis, and creation of criterion-referenced tests in training. Criterion referenced means that the trainee is tested by performing essential, job-related tasks, rather than being normatively scored on a paper-and-pencil test of knowledge about the subject. But here again, it should be noted that to test a trainee on his ability to perform as a missileman at the conclusion of training is not the same as testing his ability to do

the job, since he will be required to fire only one of the missiles. While a great deal has been done on creating and applying criterion-referenced tests, these tests serve, primarily, as terminal objectives for training, rather than a definition of required job performance.

PERFORMANCE TESTING RESEARCH

An area closely related to criterion-referenced testing in the training environment is the new interest in performance measurement and evaluation in the operational environment. Several behavioral scientists engaged originally in developing criterion-referenced testing were used by the Army to develop its Skill Qualification Test (SQT), which plays essentially the same role as the PQS in the Navy. The SQT program, which is supported through the Army's Training Support Center--as the PQS is similarly supported by Navy Training Support detachments--may have batteries of tests that are more psychometrically sophisticated than the PQS. The Navy, however, has a performance evaluation, research program at the Navy Personnel Research and Development Center (NPRDC) that is designed to provide a more precise evaluation of the performance capabilities of duty sailors than the PQS (Laabs, Main, Abrams, & Steinman, 1975) in order to create and prescribe the type of training that will lead to increased personnel readiness. The program has demonstrated how difficult it is to develop a prototype test for a single rating that truly reflects the incumbent's job demands (Laabs and Panell, 1976). It has also demonstrated the need for adequate equipment that is representative of the duty environment if a true hands-on evaluation is to be conducted at a testing site other than the duty station itself. The NPRDC program has also indicated the large number of sailor-hours that would be required to develop and validate a test battery for a particular rating, and by inference, the large number of sailor-hours that would be required in an operational performance-testing program. In fact, on one of

its field studies, the NPRDC research team was not permitted to use duty personnel for performance testing owing to the encroachment on duty time (Laabs, Harris, and Pickering, 1977). The research team had to settle for a pencil-and-paper test with much smaller demands on duty hours and organizational equipment. The implications of this research and development program are that a positive command decision would be required at a very high level if evaluative, performance-testing programs are desired for determining the on-the-job proficiency of the Navy enlisted force because the costs are very high. And yet, an obvious and simple answer to the skill deterioration problem that is often proposed is to test the individual to determine whether he or she could be sent directly to a duty assignment or whether a period of rehabilitative training is necessary.

The performance testing research at NPRDC has also shown that duty personnel cannot perform once-learned tasks if they are not required to perform them on the job (Laabs, Pannell, and Pickering, 1977). For example, certain technicians on nuclear submarines learn to test and maintain missile test and readiness equipment. Some of the equipment is so reliable, however, that they are never required to troubleshoot and repair the equipment. Tested on the procedures required to do so, they inevitably fail. A self-instructional, remedial study guide, on the other hand, that was designed to be used during a cruise was sufficient to enable those who had used it to perform the repair functions adequately upon subsequent testing. These findings have very significant relevance to this study. First, as mentioned early in this report, there is an ideal and an actual performance level for duty billets. The former may be used for developing training documents, but the latter is a more realistic baseline for determining skill deterioration and a retraining criterion. There is, apparently, considerable distance between the two

curves depicted in Figure 1. Of 305 BTs who were given a diagnostic test on job related behaviors, only 10 percent passed all modules of the test at a minimally acceptable cutoff score. Of those who did not pass all 14 modules, the score on the basic mechanical procedures test of the modules was only 70 to 75 percent correct. These findings, if replicated in other situations, would suggest that the actual performance capability of duty sailors is only about 75 percent of the tasks that may be included in, say, the NOTAP description of the job. The second significant point to be made from the results of the NPRDC studies is that once-learned skills of a procedural nature can be rapidly reactivated with appropriate job-performance aids or self-study materials. Accordingly, the retraining requirement is also dependent on factors other than skill deterioration, such as the availability of documentation and job-performance aids at the duty site.

TWO AIR FORCE PROGRAMS

There is concern in all of the services regarding the maintenance of flying skills with the serious reduction in flying hours as a result of the high cost and scarcity of fuel. The general approach to the problem is toward ever more sophisticated simulators for individual and team training. Simulators are also expensive in terms of procurement and operation, but there is limited, although generally positive, data on their ability to maintain flying skills, particularly of a procedural nature. What is needed is a better understanding of the more critical component skills involved in flying and their perishability and retrainability. The USAF Human Resources Laboratory (HRL) on flight training at Williams AFB, Phoenix, Arizona, is attempting to investigate these areas with a special interest in skill-maintenance training (Eddowes, 1977). While there are no enlisted skills in

the Navy that are strictly comparable with those among Air Force pilots, general principles with reasonable generality are expected to appear as a result of a systematic investigation of flying skills.

At the USAF HRL at Brooks AFB, San Antonio, Texas, where research is conducted in the area of Air Force personnel, a research program is being conceived to investigate systematically the perishability of skills as a function of specific parameters (Christal, 1977). For example, there may be a relationship between the shape of the learning (skill acquisition) curve and the retention (perishability) curve. Since the rate of learning and the terminal level of skill acquisition is closely related to aptitude, so must aptitude have a strong influence on the retention of learned skills. The potential benefit of research following this approach is that broadly applicable functions could be discovered that would be of considerable utility in managing the skill deterioration and retraining problem areas. At the time of this writing, data were being generated for the acquisition curve at the USAF HRL, Lowry Field, Colorado (Ward, 1977).

SUMMARY

In summary, many training activities express a concern with the retention of training, but research and development continues to emphasize the acquisition of skills. There are a few, individual projects at the personnel research laboratories of the Army, Navy, and Air Force that deal directly with skill deterioration and retraining. In the Navy, the performance testing research at NPRDC has provided insight into the difficult problems associated with a testing approach, shown that personnel who are apparently performing acceptably in their jobs do not, and cannot, perform many of the skills they were taught and tested on in training, and have

indicated that once-learned, nonutilized, and forgotten skills can be effectively rehabilitated with self-study materials.

REQUIRED STUDY EFFORT

REQUIREMENT FOR A LONG-RANGE PROGRAM

The preceding sections have shown the scope and magnitude of the problem the Navy faces in attempting to manage the problem of skill deterioration. Essentially, the question is as broad as "How much and at what intervals is training necessary to maintain the requisite skills for a ready Navy?" Unfortunately the research on skill retention, training, and performance measurement was found to be quite fragmented and parochial and only relevant to specific problems and programs at very low levels of aggregation. At the highest levels of aggregation, an occupation could be the object of attention; at lower and more prevalent levels, the object of study would more likely be the acquisition and/or retention of skill in a particular task. Similarly, ongoing occupational programs in the Navy's manpower and personnel areas are fragmented and are designed to serve the immediate needs of the sponsoring activity. Thus, there is no link between the Navy's NOTAP program and the PQS program when, in actuality, they both deal with the activities and functions of a sailor in a particular occupational category. In order to make inroads into reducing the skill deterioration problem to a manageable state, a long-range orientation that attempts to direct and integrate research, plans, and programs towards its solution is necessary. A long-range program could, however, include short-range goals that attempt to gain better insight into the skill deterioration problem and, hopefully, to find interim solutions that can be used in the routine management and operation of the Navy's manpower and personnel systems.

ELEMENTS OF THE LONG-RANGE PROGRAM

The study program should attempt to make use of the many ongoing activities that could contribute to an understanding and management of skill deterioration with respect to the Navy's entire enlisted structure. Eventually, the various parts of the operating programs should be incorporated into an aggregated model of the manpower/personnel system, such as the NAMPS program. But in order to achieve this end, the long-range program should have some hierarchical goals in a time dimension. Called phases, the time-oriented goals might take on the following form.

Phase I. As stated above, an immediate, ad hoc, interim solution is desired to provide a framework or model for the overall program, to facilitate understanding and progress, and, at the same time, to provide guidance for the decision maker who must manage and operate the force on a continuing basis. The only way that this can be done is to use the judgments of experienced professional and military personnel as the basic data from which to build this short-term solution. A specific aim of the short-term effort should be the development of a method for estimating skill deterioration as a function of the duration of nonutilization and the original skill level of the individual. The objective of this study is to make specific recommendations for such an effort. When the derivation of the skill deterioration curve has been accomplished, the same general methodology could be used to estimate the amount and kind of retraining that would be necessary to re-establish the original skill level at any point in the skill deterioration curve. At an early point in the skill deterioration curve, the problem could be restated as the amount and type of training necessary to maintain the desired level of skill.

Phase II. The objective of Phase II would be to develop and institutionalize a system for measuring and scoring performance that could be used to set a standard for required job performance. The PQS exists and should be used as the starting point. The PQS must be scored on a Guttman scale (Edwards, 1957) in which the performance items are sequenced according to their importance or necessity for adequate job performance. In such a scale, a particular score can be obtained in only one way and represents an individual's point on the scale. One point on the scale could represent an entry level of proficiency, another a minimally adequate level of proficiency, and another an acceptable level of proficiency. Without a quantified standard, there would be no basis for estimating deterioration. The administration and scoring of the PQS should be better standardized to increase its reliability and, particularly, its validity with respect to performance that is actually required on the job (Laabs, Panell, and Pickering, 1977). The many recent studies on criterion-referenced measurement should be consulted in this regard.

Phase III. The objective of this phase would be to upgrade the task analysis and occupational analysis systems of the Navy so that more sophisticated analyses are possible, such as those required to make inferences across occupations. The NOTAP system should incorporate a method for determining the relative importance of the tasks in the inventory, and the method should be further refined so that occupations can be clustered according to their similarities and important job dimensions can be determined across many or all occupational fields. At the present time, clustering programs are appropriate only within an occupation. The reason for establishing these capabilities is to provide a framework for determining skill deterioration functions using the PQS scores as the criterion measure. (The

concept of determining skill deterioration functions in this manner is developed below in the section dealing with the short-range program.) Phase III can be pursued concurrently with Phase II, and there should be liaison between the two efforts to establish a consistent framework. For example, the scaling of the PQS items should be consistent with the relative importance of tasks determined by the NOTAPS method.

Phase IV. The purpose of Phase IV would be to gather empirical data through the PQS system in such a manner that the skill deterioration functions can be updated and refined on the basis of experience. Depending on how individuals are handled on their return to a specialty area after a period of nonuse, empirical evidence could be generated as to the efficacy and necessity of various retraining decisions. An adequate management information system would be required to integrate, develop, and store this information. Since this phase is far removed from the limited objectives of this study, it will not be further explored at this time.

OUTLINE FOR A SHORT-RANGE STUDY EFFORT

The purpose of the short-range study effort is to develop a schema for determining a skill deterioration function that could be applied to the entire array of skills in the Navy's enlisted classification system. This section will detail the steps that could be taken, using expert judgment, to arrive at such a skill deterioration function. The skill deterioration function, once obtained, could be used as a basis for determining retraining requirements using similar methods of eliciting and processing expert judgment. The steps in the process are outlined in Figure 2 and described below.

<u>Step</u>	<u>Objective</u>	<u>Method</u>	<u>Product</u>
1.	Determine what job characteristics affect skill deterioration.	Group interviews with panels of expert judges in training, manpower, and personnel.	List of characteristics that affect skill deterioration rate.
2.	Determine amount of redundancy in the list of skill deterioration characteristics.	Have judge panel estimate dependencies among the skill deterioration characteristics.	A proximity matrix of the skill deterioration characteristics.
3.	Develop a smaller number of independent skill deterioration characteristics.	Use appropriate multidimensional scaling procedures to reduce proximity matrix to a few orthogonal factors.	Set of skill deterioration factors.
4.	Prepare materials for policy capturing simulation.	Create hypothetical jobs by random assignment of possible values to the skill deterioration factors.	Set of hypothetical jobs, each described by a value for each skill deterioration factor.
5.	Obtain expert judges' evaluation of jobs for skill deterioration.	Have judge panel make 5-yr. skill deterioration curves for each hypothetical job by 2 levels of experience.	5-yr. skill deterioration curves for each job at 2 experience levels by each judge.
6.	Capture judges' policy.	Using multiple regression, obtain weights for each skill deterioration factor at each year point by experience level.	A vector of coefficients to predict skill deterioration at each year point by original skill level.
7.	Evaluate model (1)	Select several NECs and convene panel of experts in each. Each judge scales the skill deterioration factors for his/her NEC and provides skill deterioration curves by skill level.	Scaled values for the skill deterioration factors and overall assessment of skill deterioration for each NEC by 5-yr. periods and experience level.

<u>Step</u>	<u>Objective</u>	<u>Method</u>	<u>Product</u>
8.	Evaluate model (2)	Using appropriate vectors from the model, predict skill deterioration curves from judges' factor scores.	Evaluation of the model to predict within its standard error of estimate at a specified confidence level.

Figure __2__. Outline of Steps to Create and Validate an Interim Model to Predict Skill Deterioration.

Model Development

Step 1. Convene professional and military personnel who can be considered experts in the areas of training, manpower, and personnel to develop a candidate list of characteristics that affect the degree to which a particular job would be subject to skill deterioration with nonutilization of the acquired skills. Various techniques could be used to elicit such characteristics. For example, critical incidents might be obtained and retranslated into a list of characteristics. The requirement for a quick reaction or turn-around time might be one basis on which jobs could be differentiated for skill deterioration potential. The presence of job performance aids, check-out lists, and manuals would also affect skill deterioration by negating small amounts of forgetting. Hopefully, a list of some 20 or 30 characteristics would be obtained.

Step 2. Step 1 was designed to be overly inclusive to prevent the loss of leaving out potentially important characteristics. The task is now to reduce the redundancy and create maximally independent (orthogonal) characteristics that would be much fewer in number. The first step in accomplishing this objective is to obtain a proximity matrix for the many characteristics. This could be done by having the panel scale the relatedness (say, from -1 to 1) between any pair of characteristics.

Step 3. Multidimensional scaling or factor analytic procedures could be used to reduce the proximity matrix to clusters or groups of characteristics that have much in common. If the groupings are complex, the judges could be asked to help identify and interpret them. The product will be a set of relatively orthogonal characteristics that will be called skill deterioration factors for convenience.

Step 4. This step begins the process of obtaining the "policy" that expert judges would use in evaluating jobs for their skill deterioration potential on the basis of the obtained set of skill deterioration factors. To do this, a large number of hypothetical jobs would be created by randomly assigning scaled values (say, from 1 to 10) to each of the skill deterioration factors. The overall methodology is explained in a paper by Christal (1967), and the use of hypothetical cases is similar to the hypothetical ships created by Borman and Dunnette (1974) to determine the personnel readiness status of ships.

Step 5. The hypothetical jobs are given to a panel of expert judges whose only task is to evaluate each job for the skill deterioration that would occur with nonutilization of learned skills. They will be asked, however, to make judgments based on whether the incumbent was in paygrade E4 or lower or in paygrades E5, E6, and E7. These correspond to the apprentice and journeyman/supervisor levels recommended by the Navy Enlisted Occupational Classification System (NEOCS) Study Group (1974). In accordance with the recommendations of the NEOCS Study Group, the enlisted supergrades, E8 and E9, will be considered as managers with competence in managing broad occupational areas. Because of their overlap with many specific job areas and their relatively small absolute numbers, they will not be considered in the recommended study effort. Additionally, within each of these classifications, hereafter referred to as experience levels, the judges will be asked to determine the amount of expected skill deterioration at periods of 1, 2, 3, 4, and 5 years of complete nonutilization of job skills. Thus, each judge would evaluate each hypothetical job by two experience levels and 5 yearly periods. The degradation could be in terms of percentage loss in skills from an original level of 100 percent.

Step 6. Using multiple regression and a least squares criterion, the judges' evaluations of the hypothetical jobs in Step 5 will be regressed on the skill deterioration factors generated in Step 4 for the jobs. A model will be fitted that accounts for the greatest amount of variation in the judges' evaluations. If sufficient numbers of cases are available, interactive effects and quadratic forms of the independent variables could be included in the initial set of predictor variables. The initial set of variables would be reduced using a stepwise or other appropriate procedure (Draper and Smith, 1966). An equation will be fitted for each year point at each level of experience. The coefficients of the fitted equations will provide a vector of weights for determining the two skill deterioration curves for any occupational classification or rating for which values of the pertinent skill deterioration factors can be determined. Thus, the resulting models are completely generalizable.

Step 7. In order to evaluate the model and its weights, several unrelated NECs should be used for a trial application. Again, experienced, senior personnel in the NECs will serve as judges. They will assign values to the skill deterioration factors in a step that is comparable to the operation in constructing the hypothetical jobs (Step 4). Then, they will estimate the 5-year skill deterioration curves for the two experience levels, as was done in Step 5. Perhaps two or more methods should be used to aggregate the judgments. One would be a simple average of initial judgments, and another could be a consensus agreement arrived at, perhaps, using a Delphi technique. This recommendation is made since it may not be obvious as to what the best form of aggregating the responses might be in this exercise (Einhorn, Hogarth, & Klempner, 1977). Whatever the methods used, the model weights would be applied to the aggregated skill deterioration factors to predict the aggregated skill deterioration curves. The model will be

validated to the extent that the predicted values fall no further from the given values than would be expected from the model's error estimate at a specific confidence level, say at the 95 percent level. If the values fall outside of the confidence band, the validation procedures and the original model development will have to be reexamined to adjust the weight vectors.

Application of the Model

Once the weights have been validated, implementation of the model requires a set of occupational fields within the Navy's enlisted structure that is considerably less than the total number of ratings or NECs. Each occupational field within the set should encompass a group of occupations that is homogeneous so that the skill deterioration curves for any one of the occupations should be highly likely to reflect those of the other occupations within the category. Once the occupational fields are selected, an $m \times n$ matrix should be constructed in which the i rows ($i = 1$ to m) are the occupational fields, and the j columns ($j = 1$ to n) are the skill deterioration factors of the model. The problem, now, is to determine the scale values for each $i \times j$ cell of the matrix. This could be done following the procedures that were used in the model validation (Step 7). The occupation that is most representative of the field, either by reason of being the largest in number or qualitatively most encompassing of the other occupations or a combination of both of these considerations, should be used to obtain the scale values. In fact, the NECs that were used in the model validation could be transferred directly to the matrix within the appropriate occupational fields. Once the matrix has been completed, the skill deterioration curves for any rating or NEC in the Navy can be computed for the two levels of experience--apprentice and journeyman/supervisor.

An important consideration in the implementation is the choice of a taxonomy for the rows of the matrix. The research literature emphasized task taxonomies, which are at too microscopic a level for this application. The Dictionary of Occupational Titles prepared by the Department of Labor would be more appropriate, since it is a classification of occupations. However, the classification is based on the universe of civilian occupations in the United States and may not be appropriate for the usage envisaged here. Probably the most appropriate classification would be the 23 occupational fields devised by the NEOCS Study Group (1974). Each of the 23 fields represents a functionally related set of ratings that could eventually be converted to one rating in the apprentice stage. The purpose and philosophy behind the classification fits well with the purposes of the skill deterioration effort. A similar, but slightly more compact taxonomy, is the 17-area, occupational specialty (OccSpec) system used by the Navy Recruiting Command for enlisting first term accessions into an occupational area without promising them a specific Class A School (Commander, Navy Recruiting Command, 1974). The groupings of occupations in this system is dictated by the need to facilitate an even flow of recruits into the Class A Schools (Arima, 1976). As a consequence of this objective, the classification may not be as broadly conceived or appropriate as the NEOCS Study Group classification.

Discussion

This short-term approach is an interim framework for an eventual empirically based system. As stated in the discussion of the long-range program, the interim model cannot be validated or improved without a quantitative measure of job performance that will enable a measure of skill loss. Similarly, the skill deterioration factors cannot be improved

without data so organized that task and relative importance data can be analyzed over all occupations simultaneously. While the long-range goals are sought, the interim method can be used as the best extant tool with the resulting experience in its application providing feedback for improving it.

Nothing has been said so far in this section regarding the real decision problem, which is the timing and quantity of skill maintenance training or retraining to be provided. As shown in Figure 1, it is desirable to have a function that would predict the amount of retraining necessary to achieve the baseline performance from any point on the skill deterioration curve. Initially, this function could be derived using expert judges to capture their retraining policy. Eventually, the obtained functions would have to be supplanted with real-world data. To do this, the same impasse is reached: a quantitative measure of performance level is required and the variables to predict the required training should be based on an analysis of the actual characteristics of the training environment, whether it be on-the-job, self-study, or formal schooling. In the meanwhile, retraining decisions could be made on the basis of the skill-deterioration curves generated by the interim method and followed up to obtain feedback regarding the appropriateness of the decisions. If a cybernetic cycle can be established, the method will be self-correcting and will tend to reach an equilibrium (optimal) level, especially with the improvement in the data base that is envisaged.

SUMMARY AND RECOMMENDATIONS

Skill deterioration among Navy personnel due to the nonutilization of learned skills is a serious problem with no easy solution. The available scientific literature does not provide much that can be used to solve the problem. Empirical approaches to determining skill loss for the entire range of Navy occupations would be an undertaking of considerable proportions that would have to be done on a continuing basis as jobs change. Without the long-range commitment of resources and continuing command support, these methods will not produce the desired results. A short-range approach that attacks the problem directly using expert opinion seems to be the only feasible solution at this time. Along with the implementation of the short-range approach, the Navy's performance measurement system (PQS) should be improved to permit a scoring of individual performance that reflects the actual capabilities of the individual. The NOTAP program should be improved so that tasks are consistently described across all occupations to permit the analysis and derivation of important, composite skills using appropriate statistical procedures. Eventually, then, the short-range approach using personal judgments can be replaced with actual data in similar categories. In the meanwhile, training and re-training decisions should be made on the basis of the interim method and followed up so that a feedback cycle is established to ensure self-correction of decisions.

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APPENDIX A

AGENCIES CURRENTLY ENGAGED IN RESEARCH ON VARIOUS ASPECTS
OF SKILL DETERIORATION AND RETRAINING

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.

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 professional 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 survey 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 quantitatively 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 illicitated, 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, ship-board 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 acquisition 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.

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ADDENDUM: FORMAL MODEL

ASSUMPTIONS

1. For all occupations, there is a limited number of independent factors that determine the skill deterioration rate with the nonutilization of skills.
2. These skill deterioration factors have weights that determine their relative effects independent of any occupation.
3. The weights will differ according to the initial skill level of the person and the period of nonutilization of skills.
4. All occupations can be scaled as to the degree of presence or relative importance of each skill deterioration factor.

MODEL

The skill deterioration that can be expected for a set of occupations after a period of nonutilization and an initial skill level can be expressed as:

$$\begin{matrix} A & B & = & C \\ i \times j & j \times k & & i \times k \end{matrix} \quad (1)$$

where A is a matrix of occupations by values for their skill deterioration factors, B is a matrix of weights for the skill deterioration factors by a particular initial skill level and period of nonutilization, and C is a matrix of expected skill deterioration for each occupation by initial skill level and period of nonutilization. Figures A-1a through A-1c show a schematic representation of the model.

j
Skill Deterioration Factors

i Occupations					

Figure A-1a. Matrix (A) of Values for the Skill Deterioration Factors by Occupations

ESTIMATION

The problem is to determine the skill deterioration weights. This can be accomplished by creating synthetic (hypothetical) occupations portraying the values in the $A(i \times j)$ matrix and having a number (n) of experts estimate the skill deterioration of those occupations in the $C(i \times k)$ matrix. The weights for the $B(j \times k)$ matrix will then be obtained by linear regression of the following form:

$$\hat{C}_{ik} = a_0 + b_{jk}X_{ij} + u_{ik} \quad (2)$$

where

k

Level of Initial Skill and Period of Nonutilization

		1		2		k	
j	1	2	k	1	2	k	k
	Skill Deterioration Factors						

Figure A-1b. Matrix (B) of Skill Deterioration Weights by Level of Initial Skill and Period of Nonutilization. The levels can be apprentice and journeyman; the periods, years.

k

Level of Initial Skill and Periods of Nonutilization

		1		k		1		2		k						
		1	2	-	-	1	2	-	-	1	2	-	-	k		
i	Occupations															

Figure A-1c. Matrix (C) of Skill Deterioration by Occupation for Each Level of Initial Skill and Period of Nonutilization.

$i = 1, 2, \dots, i$ synthetic occupations

$j = 1, 2, \dots, j$ skill deterioration factors

$k = 1, 2$ skill levels and $1, 2, \dots, k$ years of nonutilization
nested within each level of initial skill

\hat{C} = estimate of the judges' skill deterioration judgments

a = constant to be estimated from the data of judgments

b = the $j \times k$ skill deterioration weights to be estimated from the data

X = synthetic value for occupation i of skill deterioration factor j

u = residual error for occupation i at skill level 1 or 2 and non-
utilization period k due to the unsystematic variation in judgments of C by the n judges

The best-fitting equation can be determined by an examination of the residuals and the standard error of estimate of the prediction equation.

APPLICATION

Once the skill deterioration weights of the B matrix have been determined, expert judges can be used to scale the presence or relative importance of the skill deterioration factors for real occupations or occupational groups, thus completing matrix A . Matrix C , skill deterioration, is then given by the model.

The model provides the framework for updating and refining the judgmentally derived functions with empirically derived data as it becomes available through improved and integrated NOTAP and PQS systems.

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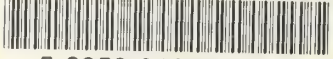
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