

AD-A132 561

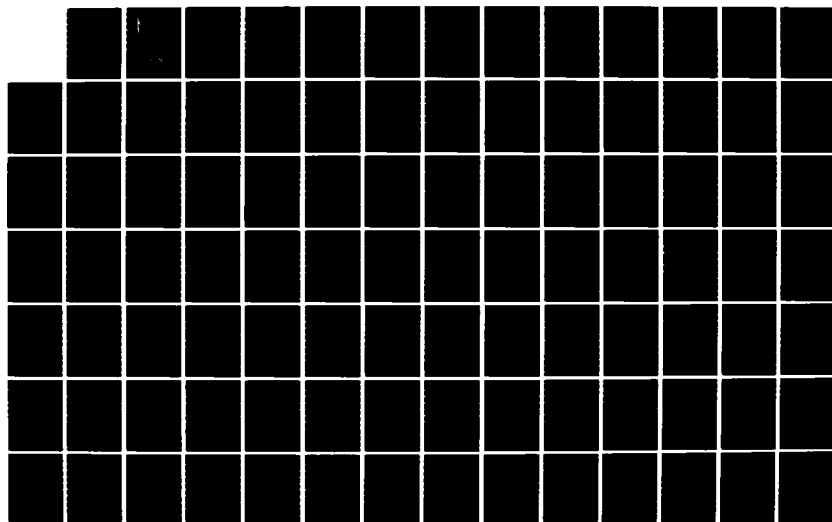
HUMAN FACTORS ENGINEERING A SELF-PACED TEXT LESSONS
26-30(U) HUMAN ENGINEERING LAB ABERDEEN PROVING GROUND
MD R BROGAN ET AL. AUG 81

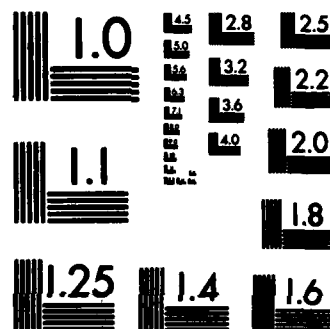
1/2

UNCLASSIFIED

F/G 5/5

NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD-A232 362

1



HUMAN FACTORS ENGINEERING

A Self-Paced Text Lessons 26-30

Approved for Public Release:
Distribution Unlimited

DTIC FILE COPY

DTIC
ELECTE
SEP 19 1983
S D E

Ruth Brogan

Jerry Hedge

Kevin McElory

Judah Katznelson

US ARMY HUMAN ENGINEERING LABORATORY
PACIFIC MISSILE TEST CENTER

83 09 16 107

HUMAN FACTORS ENGINEERING

A SELF-PACED TEXT

LESSONS 26-30

**Ruth Brogan
Jerry Hedge
Kevin McElroy
Judah Katznelson**

August 1981

**Approved for Public Release:
Distribution Unlimited**

**US ARMY HUMAN ENGINEERING LABORATORY
PACIFIC MISSILE TEST CENTER**

ACKNOWLEDGEMENT

We are grateful to the following personnel for their technical support:

**John Miles, U. S. Army Human Engineering Laboratory
LT. Alex Bory, Pacific Missile Test Center
Martha Kinney, Advanced Technology, Inc.
Paul Dumas, Advanced Technology, Inc.
Pamela Carpenter, Advanced Technology, Inc.**

TABLE OF CONTENTS:

LESSON 26:	Maintainability, or Can Anyone Fix This?	1
LESSON 27:	Hazard Analysis, or a Stitch in Time	17
LESSON 28:	Training the Right People	53
LESSON 29:	Does the Training Work? and	22
LESSON 30:	Psychophysical Methods, or Do I Detect a Signal?	29

Accession For	
NTIS GRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A	



HUMAN FACTORS ENGINEERING

LESSON 26: MAINTAINABILITY, OR CAN ANYONE FIX THIS?

Hello again, and welcome back to your course on Human Factors Engineering. If you'll think back a few lessons, you'll remember that since our hero I. M. Eager 'got his act together' and came under the tutelage of Professor Ed U. Kator, he has been exposed to a number of important human factors engineering topics. Along with Eager, you have studied the processes of systems acquisition, systems analysis, task analysis, and cost analysis and have learned some of the important terms and concepts related to each of these topics.

In this lesson you will learn about an additional area of concern to human factors engineering, namely, designing for maintainability. In order to get his students thinking about maintainability, why it's a human factors problem, and what variables contribute to maintainability, Professor Kator asked each student to think of a system, and to consider the problems that might arise if that system were designed without consideration for its maintainability. Eager naturally thought of his super chopper and focused on how designing for maintainability had been an important consideration in the final design of his super machine.

Kator then used this question and the resulting discussion as a vehicle to begin his lecture on maintainability. Kator began by asking his students if they knew for sure what maintainability is, and what types of activities are involved. Ed was not at all surprised to find that many of the students were unsure of the nature and scope of the topic they had been discussing for the last 15 minutes.

Once again Ed U. Kator used this outcome to expertly maneuver the class to the real starting point of this lesson. He laid out the exact plan for this lecture (and incidentally, we'll also follow Ed's structure in presenting the information to you). First, we will look at some of the basic concepts and definitions associated with this topic; namely, we will discuss the similarities, differences, and relationships between maintainability, maintenance, and reliability. If you are at all familiar with this area, we're sure you've heard some of these 'buzz words.' After we define each of these concepts, we'll discuss some of the typical maintainability design features. From there you'll deal with analysis and allocation of maintenance functions, looking at things such as the trade-off between costs, flexibility, reliability, speed, and available manpower.

(GO ON TO THE NEXT PAGE)

From Page 1

How does all of this sound so far? Pretty tantalizing, eh? Well, hold on to your replaceable parts because we're not through yet. Before we complete the lesson, we want you to become familiar with the concept of maintainability prediction. In addition, we want to show you how to increase operational efficiency by focusing on methods to improve the relationship between the design of a particular maintenance task and the skills involved in performing that task. Before we ramble on any further, let's get to the task at hand--so prepare yourself for the new best-seller, 'maintainability.'

The increasing complexity of modern-day equipment--both commercial and military--has resulted in new types of engineering problems. These problems have increased the importance of designing systems so as to enhance their maintainability, reliability, and high performance. Historically, design engineers have approached these problems by focusing on the equipment while ignoring the 'man' aspects of the man/machine interface. The primary concern of the engineer was to provide hardware that would accomplish the specified function of the system. This is not to say that the human was not considered at all, but, rather, that little attention was focused on his capabilities, his limitations, or other 'human factors' in the design.

In the preceding paragraph we mentioned terms such as maintainability and reliability. Are you familiar with these terms, what they mean, how they're related, and why they're important? If you're not now familiar with them, before this lesson's over you'll know them intimately. If you are familiar with them, we hope the following pages will introduce you to some new and important facets of these problems.

Now can you tell us your definition of maintainability? Which of the following would you say best defines maintainability?

- (1) A design characteristic which is the probability that an item will be retained in or restored to a specified operating condition within a given period of time, when maintenance is performed according to prescribed procedures and resources. Turn to Page 18.
- (2) All actions necessary for retaining an item in or restoring it to a specified operating condition. Turn to Page 89.
- (3) Both of these answers are correct. Turn to Page 71.
- (4) Neither of these answers is correct. Turn to Page 43.

From Page 68

(1) This answer is incorrect. There are a number of important maintainability areas that must be evaluated in terms of the trade-offs involved. Go back to Page 68.

From Page 52

(3) Nope, we fooled you. This answer does not refer to what we would do with reliability information. It gives you two ways of determining system complexity, and we would use these to decide on a course of action. It is the course of action itself that we need as a correct answer. Return to Page 52.

From Page 47

(4) Look back at your assignment. Only one of these answers describes precisely the objective of phase five. Return to Page 47.

From Page 62

(2) Only recently have computer programs been used as a technique to increase skill levels. Return to Page 62.

From Page 13

(2) This is only one source by which you could recognize the existence of a hazard. Go back to Page 13.

From Page 24

(4) Look a bit more closely. You're making some false assumptions. For instance, just because a methodology has been proven valuable in industry, this doesn't necessarily mean it will be available to the military. Return to Page 24.

From Page 31

(2) Maybe we confused you. In this situation the sonarman's responsibility is to detect subs. There was a signal (sub), but the response given was that there was no signal. That places this situation in the cell marked 'miss.' The stimulus was 'on' but the response was 'no.' Return to Page 31.

From Page 38

(2) Very good, you would be likely to give a large number of responses, and, because there was no penalty for false alarms, both these and the number of hits would increase.

In general, if the payoff is high and there are no penalties for incorrect judgments, you can expect an observer to have a high rate of hits and false alarms. You, as an experimenter, can change the proportion of responses which occur in Figure 30.1 by changing the payoff and penalty structure. An example of this takes us back to our dew line observer. Suppose that it is a peacetime situation and the observer really doesn't expect to find any enemy aircraft. In fact, his main concern is that he doesn't identify a TWA flight as an enemy plane. The enemy craft is the signal in this situation. There is the likelihood that the number of correct rejections will be the highest of all the cells in Figure 30.1. If the rate of presentation remains constant (the number of enemy craft), but the expectancy of presentation changes (war is declared) then the number of false alarms will increase.

So now you can see how signal detection takes into account the observer's biases and how these biases influence the observer's responses. The classical psychophysical methods assumed that with trained observers these biases were overcome and that responses were influenced only by changes in the stimulus.

Okay, so far we've discussed the classical methods and signal detection theory. These methods and their differences are nice to know, but we are primarily interested in how they impact upon the human factors specialist. Why would you use a classical method in your work?

- (1) To establish the observer's bias and, therefore, ensure easy detectability. Turn to Page 48.
 - (2) To ensure that stimuli are below the lower difference level and, therefore, would be readily detected. Turn to Page 64.
 - (3) To ensure that stimulus values are above the lower difference level and, therefore, will be readily detected. Turn to Page 41.
-

From Page 17

(1) Absolutely correct. Human error does account for the largest percentage of accidents.

As was mentioned in Lesson 3, today there is a concerted effort to use human factors engineers not only to correct faulty design, but as a part of the original design process as well. In this way, tragic errors and potential hazards and accidents can be prevented. Thus, in contributing to the design of a system, the human factors engineer should help to provide conditions which optimize operator performance and protect the health and safety of system operators. Of course, that effort must be done within the design-to-cost principles discussed in Lesson 25 (affordability).

As you have seen in your previous lessons, the scope of human factors engineering encompasses a wide range of system safety considerations. Areas of consideration include such variables as noise levels (Lesson 19), noxious fumes and gases (Lesson 18), shock and vibration (Lesson 15), warning devices and labels (Lesson 10 and 12), as well as extreme climatic environments (Lesson 17). In addition, human factors engineers evaluate system safety considerations in the areas of fire hazards, emergency escapes, and electrical and mechanical hazards. The military specifications you are already familiar with, such as MIL-HDBK-759, typically have a subsection on safety and tolerable limitations for each factor under consideration. MIL-STD-1472 has an additional subsection devoted to hazards and safety which can be found in section 5.13 on Page 189.

So, if the basic principles of human factors design are employed when devising a new system, the overall safety of the operator will be taken into account. Why then do you suppose that this lesson has been included in your human factors engineering course?

- (1) To fill in space. Turn to Page 20.
(2) To reemphasize the findings of previous lessons. Turn to Page 49.
(3) To introduce you to a method for evaluating safety conditions in an existing system. Turn to Page 12.
-

From Page 81

(3) While it's true that interchangeability is an important maintainability feature, it should not be concluded that it is always the most important design feature. Return to Page 81.

From Page 15

(3) You're incorrect. Initial concerns in the maintainability area rested on design improvements only. Return to Page 15.

From Page 98

(4) You're correct in saying the organizational differences must be considered, but this fact prohibits generalization to a great extent. Return to Page 98.

From Page 13

(3) This isn't the only source you can use to identify a hazard. Return to Page 13.

From Page 9

(1) In general, this is true. Given a good program and the right kind of training requirements, OJT is the most efficient type of training. But there are instances when OJT won't work very well (e. g., a jet pilot). Return to Page 9 and try again.

From Page 30

(4) Auditory threshold is only somewhat correct, since our example was about hearing. However, there is an answer that is correct without regard to the sensory modality in question. Return to Page 30.

(1) Very good. Since the military must always be prepared for wartime, in developing manpower data, you must assume this type of scenario.

The third source document of importance is the reliability analysis. This provides computations and statistical analyses compiled by reliability engineers. This document provides information on elements which are expected to fail prior to the scheduled time of replacement. Analysis of this data provides the human factors specialist with information regarding maintenance load and its effects on operators.

A final source of information is operating manuals for similar systems. By examining these documents and by talking with persons experienced in similar systems, the human factors specialist can get a good idea of the requirements of the system with which he is working.

If, after examining all these documents, you discover that individuals already exist to operate and maintain the system, then your job as a human factors engineer is much easier. But more often than not, with a new system, skilled people will not be available and training will be required in one form or another. While you as a human factors specialist will not be directly involved in training, an understanding of the training is important.

There are several techniques which can be used for training. We will examine four general methods. These are:

- (1) On-The-Job Training (OJT)
- (2) Classroom Training
- (3) Computer-Aided Instruction (CAI)
- (4) Team Training

On-the-job training (OJT) is one of the most widely used training methods found in the military. Its name is fairly descriptive, but its real advantages may be more difficult to understand. You've heard about OJT. What do you think is its greatest advantage?

- (1) Since it is done 'on-the-job' it is always more efficient. Turn to Page 8.
- (2) The trainee has little problem transferring what he learns from the training situation to the real job. Turn to Page 24.
- (3) It requires less effort putting together OJT programs, since those conducting the training do the work every day. Turn to Page 47.
- (4) All of the answers presented here. Turn to Page 75.

From Page 37

(2) Good show, you've done it again. General hazard analysis does consist of these three phases.

Generally, systems, by their very nature, possess hazards. For example, temperature extremes occur in the engine and boiler rooms of a naval vessel. Power sources necessary for computer facilities, as well as nuclear reactors on some types of vessels, are also sources of hazards. Add to these things the fact that the ship is moving back and forth and/or up and down in the middle of the sea, and you can see that there are plenty of reasons why hazard analysis is a necessity. People are always a part of any system and they are not infallible. Because of this, you can never expect to eliminate all hazards and prevent all accidents. Therefore, as a human factors specialist, you will want to eliminate as many hazards as possible and concentrate on those conditions which are most severe. It is necessary, therefore, not only to identify the existence of hazards but to evaluate the hazards found.

This evaluation will involve estimating the probable seriousness of a potential accident as well as estimating the probability of occurrence of the accident. For example, if a heat source is located close to flammable material, there is a high probability that an accident will occur. On the other hand, if the flammable material is placed in a metal container away from the heat source, there is a low probability that an accident will occur.

In addition to estimating the probability of an accident, the evaluation of hazards should also include an estimate of the severity of any damage or loss which would result if the hazard led to an accident. In the heat sources example, tremendous losses might occur if the flammable material caught fire in a heavily populated area. This evaluation will allow you to compare one hazard with another in order to determine which potentially hazardous condition should be corrected first. It will also allow you to establish a priority scheme to use in deciding whether or not it would be cost-effective to try to correct existing conditions.

(GO ON TO THE NEXT PAGE)

From Page 10

Now you are ready to look at the evaluation phase in detail. Remember that the purpose of hazard analysis is to suggest or establish a plan of action which will lead to hazard elimination or reduction. Without a method of distinguishing among various hazards, your plan of action may not be appropriate. Figure 27.3 in your supplement is an example of a data form which shows four types of evaluation that can be conducted for each hazard. The four evaluation factors are severity, probability, cost, and action. The categories under each factor are arbitrary, but the ones you choose should cover the range shown in Figure 27.3. By using a recording method such as this one, you can help reduce the individual pieces of information gathered into groups of similar types of information. Of the groupings shown, which is the most important?

- (1) Cost. Turn to Page 93.
 - (2) Probability. Turn to Page 99.
 - (3) Severity. Turn to Page 92.
 - (4) Action. Turn to Page 40.
-

From Page 22

(3) This is a tough one. A job analysis is required, but, although funding is a consideration, it is not a formal part of this phase. Return to Page 22.

From Page 6

(3) Right, we will review a method of safety analysis, more accurately hazard analysis, of the entire system.

It is hard to give an adequate definition of an accident, but we, as human factors specialists, are concerned with the problem of accidents. Generally speaking, an accident is an event or occurrence which is both undesirable and unexpected. It results from faulty equipment or human performance errors. When an accident occurs, there may or may not be injury to either the person or the equipment, but there usually is a disruption of the normal work routine. Accidents almost always result in time delays and reduced production.

In this lesson we will look at accidents as events that occur when either the people, machines, or materials are out of control. In so doing, we can look at the system in terms of control. By analyzing the system, we should be able to determine which part is deficient so that improvements can be made. Let us emphasize the idea that human performance errors may largely (not entirely) be 'designed out' of hardware; also, lots of them may be 'designed in.' By using the systems approach, it is possible to plan ahead so that a good deal of the potentially hazardous situations will be eliminated in the design of the system. Therefore, costs for breakdowns, change, and reinstallation will be saved.

One way of analyzing the system is by conducting a hazard analysis. Hazard analysis consists of three parts: (1) identifying the hazard, (2) evaluating the hazard, (3) selecting the best countermeasures for the particular situation.

The first step in eliminating a hazard is recognizing that there is one; that is, to identify the existence of the hazard. This can be done in several ways. Many sources of potential danger can be pinpointed just by looking at the system itself. For example, the more typical design aspects which are involved in accidents can often be found in the accident prevention manual for industrial operations. This manual is published by the National Safety Council and contains a machine safety checklist, which you should become familiar with. As an example of one item on the checklist, notice the corners of the table or desk at which you usually work. Are the corners sharp or rounded? If they are sharp, then they are a potential source of accidents, to say nothing of pain when you come into rapid contact with them, huh? Which of the following do you think is also a general source used to recognize a hazard?

(GO ON TO THE NEXT PAGE)

From Page 12

- (1) Tripping over a raised piece of rug. Turn to Page 82.
 - (2) Historical evidence that shows that accidents occur at a particular location. Turn to Page 4.
 - (3) Experienced craftsmen telling you about hazards in their work area. Turn to Page 8.
 - (4) All of these are ways to recognize and identify hazards. Turn to Page 16.
-

From Page 88

- (2) You're correct when you say that this answer is important for designing for ease of replacement, but there is a more correct response. Return to Page 88.
-

From Page 72

- (3) Determining whether or not a given job can be performed is the ultimate goal of this series of analyses, but it is not the main goal of a job analysis. Return to Page 72 and try again.
-

From Page 62

(1) Good show. Through the 1950s, intensive training was promoted as a method of increasing maintainability effectiveness.

With the increased complexity of equipment and the realization that training-to-improve-maintainability had certain limitations, other methods of improving maintainability were examined.

Technical manuals were devised to provide quite explicit equipment operation procedures, including where possible trouble spots could occur. These technical manuals have proven helpful, but equipment can fail in many ways, and a good deal of 'logical troubleshooting' is also called for when using the technical manual maintenance procedures. Logical troubleshooting combines a 'high degree of problem-solving ability' and 'a game of probabilities.'

Computer programs for maintenance were also proposed and used to aid maintainability. The problems found here were much the same as with the technical manuals; namely, the practical impossibility of dealing with all possible combinations of faulty connections. Currently, all these techniques are being used to increase maintainability. In addition, maintainability prediction is considered to be an important method of increasing maintainability, and can predict the likelihood of a certain fault occurring at a particular point and a particular time.

An example of using computer programs to judge the readability of technical manuals can be found in HEL TM 4-80. This manual presents a computer program which will analyze the text in a number of ways, such as:

- (1) Number of words with three or more syllables.
- (2) Number and average length of sentences.
- (3) Average syllables per word.

Finally, this program provides a reading grade level score. Now, if you know that the average maintenance technician has a reading level of X and the tech manual which must be used is written at level X + 5, then you know you need to redo the tech manual.

(GO ON TO THE NEXT PAGE)

From Page 25

(1) This answer does require an estimation procedure, but not an interval estimation. Return to Page 25.

From Page 14

We hope this discussion of maintainability has shown the strong relationship that exists between system design characteristics and technician skill level. Which of the following phrases would be most descriptive of this relationship?

- (1) The designer must take into consideration the skill level of the person who will be charged with the task of maintaining the equipment. It would be ludicrous to make all maintenance steps incomprehensible to the maintainers. Turn to Page 52.
- (2) The designers need simply to worry about the electronic or mechanical aspects of their machinery; technicians at all maintenance levels will possess the same skills. Turn to Page 32.
- (3) Maintainability has, in the past, always been largely concerned with the technician's skill level. Turn to Page 7.
- (4) All of these statements are accurate. Turn to Page 45.

From Page 51

- (2) You're only partially right. Individualized training and immediate feedback are two aspects of CAI, but, unfortunately, cost is sometimes a prohibitive factor. Return to Page 51.

From Page 69

- (4) This is a tough one. But if you examine the answer closely, you'll see that only one term really answers the question. Return to Page 69.

From Page 13

(4) Very good. In addition to looking at the system itself, there are other sources by which you could identify a hazard. These are historical records, safety checklists, and other information obtained from general investigations.

Historical data may indicate that accidents are common at a given location, but a trained systems analyst can also use his or her judgment to identify additional sources of hazard locations.

Now, we have mentioned historical records, but what do they consist of? Private-sector industries are required by regulation of OSHA (Occupational Safety and Health Act) to maintain accident reports. OSHA regulations require that the type of accident, its location, and its result (in the form of measures of such things as the number of days lost from work) be recorded. Of course, in the military setting, OSHA regulations are not binding. However, do you think our military services are more or less stringent in their safety programs than that required of private sector industries?

- (1) More. Turn to Page 79.
- (2) Less. Turn to Page 70.
- (3) In between. Turn to Page 87.

From Page 83

(3) These discussions are important, but what about the other techniques listed? Return to Page 83 and try again.

HUMAN FACTORS ENGINEERING

LESSON 27: HAZARD ANALYSIS, OR A STITCH IN TIME

Hello, this is Lesson 27 of your Human Factors Engineering Course. In this lesson you will learn about analyzing for safety by investigating the hazards which may be present in a system. You also will be referred to a summary of safety design principles in MIL-STD 1742.

Before we get into hazard analysis, let's recap a bit so that this aspect of Human Factors Engineering is put into perspective. Remember that the central focus of human factors is the concern for the operator in the design of machines and environments. With this consideration in mind, our objectives are to enhance the effectiveness of an individual's performance. Our primary objective is, of course, to enhance human values. Values such as health and safety are important in and of themselves, but, they are also important from a pragmatic point of view. If the people working and living in a system lack these human values, then their effective functioning will be diminished. Therefore, a fair part of the human factors engineer's job is to ensure that the system is safe for its operators.

Everything you have learned so far in this course has been aimed at these objectives. Even our oft-repeated statement about relating the human's capabilities and limitations to the requirements of the task has these objectives in mind. After all, if the task requirements overreach the person's capabilities, the desired outcome will not be accomplished and an unsafe situation may develop. If you recall, this was what Lesson 3, 'Tragic Mistakes and Positive Consequences,' was all about.

In that lesson we discussed the major cause of most accidents. Do you recall what factor was identified as the cause of most accidents?

- (1) Human error. Turn to Page 6.
 - (2) Equipment malfunction. Turn to Page 92.
 - (3) Gremlins in the system. Turn to Page 78.
-

From Page 2

(1) Very good, you're absolutely right. Maintainability is concerned with implementing principles basic to future equipment repair.

Well, that wasn't exactly the easiest question to answer, was it? We hope you didn't think we were trying to trick you with the other definition, which seems equally plausible. Rather, we were trying to make a strong point for demonstrating the difference between maintainability and maintenance. There is a distinction between the two words as each term is used in engineering design. While 'maintainability engineering' is concerned with equipment design fabrication, or development so as to facilitate future equipment repair, 'maintenance engineering' is concerned with the technical problems of keeping a system in an operational state or repairing a malfunctioning unit once the equipment is in use. The maintainability engineer directly influences the effectiveness of the maintenance engineer. Conversely, the maintenance engineer will affect the future maintainability principles derived and implemented by the designer.

You should be aware that these terms, as well as others related to the whole area of maintainability, are defined in MIL-STD-721. In addition, the whole topic of maintainability is discussed in MIL-STD-1472, so keep these in mind as good reference sources. Also, your supplement has two sources which apply to maintenance. One is a DID and the other is LSAR which you saw in Lesson 24. After the lesson is over, we suggest you look at these two documents.

An important concept to be considered in designing for maintainability is 'equipment reliability.' Based on what you've learned about maintainability and maintenance already, what would you think reliability refers to?

- (1) The numerical probability of failure-free system (or equipment) operation during a prescribed time period under certain specified conditions of performance and environment. Turn to Page 76.
- (2) The probability that an item will be retained or restored to a specified condition within a given period of time, when maintenance is performed under prescribed conditions. Turn to Page 64.
- (3) All actions necessary for retaining an item in or restoring it to a specified condition after a breakdown has occurred. Turn to Page 80.
-

From Page 61

(4) You're exactly right. All the answers presented here are incorrect. They make generalizations which are too broad. Simulation is the preferred choice when we talk about some sophisticated equipment, but not for more simple tasks. There are times when cost will prohibit the use by simulators. As far as realistic replication, don't forget OJT.

To conclude these two lessons on training, we will review some key concepts of which you must be aware. In the course of your job, you will hear certain terms, and this brief overview will allow you to understand better the topics being discussed.

Perhaps the most critical issue is that of fidelity. There are two types of fidelity that are important in the realm of simulators: physical and psychological (or functional). Physical fidelity is the degree of which a simulator represents the real world of the operational equipment. Psychological or functional fidelity is the degree to which a simulator reproduces in the training tasks the behavioral processes that are necessary to perform a job. With this introduction to fidelity, try your hand at the following. As a training analyst concerned with teaching decision-making abilities, which is more important?

- (1) Psychological or functional fidelity. Turn to Page 63.
 - (2) Physical fidelity. Turn to Page 78.
 - (3) Psychological fidelity is more important, but you cannot have psychological fidelity unless you have a high degree of physical fidelity. Turn to Page 50.
 - (4) None of these is correct. You cannot use simulators when dealing with decision making abilities. Turn to Page 56.
-

From Page 52

(4) Boo! Sure is a lot of pie in the sky around here. In the best of all possible worlds we might have a system comprised of replaceable units. But even then, there are bound to be human errors and you just made one. Try again. Return to Page 52.

From Page 6

(1) Really! By selecting this answer you've cut us to the quick. We will forgive you, however, because we are really nice people and we know you couldn't mean it. Could you? Return to Page 6 and try again.

From Page 22

(1) You're partially right. A job analysis must take place during this phase, but course outlines are not developed until later in the cycle. Return to Page 22.

From Page 30

(2) Very good. This was an example of an absolute threshold.

An absolute threshold is the upper or lower value of the stimulus range which can be detected 50 percent of the time. You may see it referred to in research studies as an absolute limen (AL) or reiz limen (RL; from the German).

Another type of threshold value which is important for human factors specialists is the difference threshold (DL). The DL can also be referred to as a just noticeable difference (JND). It is the minimum amount of stimulus that needs to be added or subtracted in order for an individual to detect the fact that the stimulus has changed. While there is a technical difference between the two terms, it won't be necessary for us to be concerned with it in this lesson. For example, suppose a series of tones is to be presented: you need to determine how much the frequency of a given tone must be increased or decreased before the individual will be able to notice a change in pitch. This amount of change (measured in Hz in this case) is called a DL.

There are three classical measurement procedures that may be used to determine an individual's threshold. These are the method of limits, the method of adjustment, and the method of constant stimuli.

The method of limits or just noticeable differences provides the most direct method of determining a threshold. This method can be used to determine both RL and DL; however, it is primarily used in determining an RL. In order to determine an RL, the experimenter should present several series of trials to each observer. In these trials different stimulus values will be presented in alternating ascending and descending order. On each series of trials there is a point at which the observer's responses change. For example, in an ascending series of 500 Hz auditory stimuli, the observer may indicate, 'no I can't hear the tone' when it is presented at 10, 11, 12, and 13 Hz; but, 'yes I can hear it' at 14 Hz and up. By presenting ascending and descending series of trials, the experimenter is able to take into account the variability of the subject's responses. Finally, the RL is determined to be the average stimulus values at which this change in response occurs.

(TURN TO PAGE 67)

HUMAN FACTORS ENGINEERING

LESSON 29: DOES THE TRAINING WORK?

Welcome back to your Human Factors Engineering Course. As you recall, we're in the middle of reviewing a course which Lt. I. M. Eager attended. The professor, Ed U. Kator, was involved in a discussion of personnel selection and training. If you recall, at the end of the last class both you and Eager were given an assignment. The reading dealt with the instructional systems development (ISD) technique for training course development. As a review of this reading and an introduction to the material to be presented in this lesson, answer the following questions.

The ISD system consists of five separate phases. The first phase is called 'analyze.' What are the main functions of this phase?

- (1) To analyze the job in question and develop a course outline for required training. Turn to Page 20.
- (2) To analyze the job under consideration and decide what training is required. Turn to Page 47.
- (3) To analyze job requirements and ascertain funding requirements. Turn to Page 11.

From Page 81

- (1) Ease to accessibility cannot be noted as the most important design feature without other information on the type of design the HFE specialist is dealing with. Return to Page 81.

From Page 53

- (3) Reliability was considered briefly in Lesson 26, remember? Return to Page 53 and try again.

From Page 74

(3) This may have been a problem, but not a safety hazard. Flush this one down and try again. Return to Page 74.

From Page 55

(3) You'd better review the definitions again. Internal validity concerns itself with the training environment only. Return to Page 55.

From Page 67

(2) When the observer is adjusting a light source to where he/she 'feels' it is equal to another source, he/she cannot be said to be making an objective judgment. Return to Page 67.

From Page 9

(2) Very good. The problem of transferring knowledge from one environment to another is definitely minimized when OJT is conducted properly.

With OJT you have to be careful. Too often it is used as the only training program. As with any successful program, effort must be put forth to obtain successful results. Merely having one worker show the other the ropes is not a comprehensive OJT program. Most often OJT is supplemented, or it is used to supplement other training methods. This is not to say that OJT in itself cannot be used, but with most major military systems, classroom training is also required.

Training with simulators may be considered an extension of the OJT method, even though it is not, strictly speaking, 'on-the-job.' The simulator provides a realistic training environment which is often less expensive than the real thing and safer in case the student makes an error. Aircraft simulators are excellent examples. More often than not, military training combines simulator training with formal classroom presentations.

There is another method the military uses to teach equipment operation and maintenance which uses the OJT philosophy. In the Army it's called skilled performance aids (SPAS); in the Navy, job performance aids (JPAS). SPAS and JPAS are documents, devices, guides, or tools which supply information and guidance to aid the job incumbent in performing a task while on the job. While JPAS and SPAS are similar, SPAS are a bit more comprehensive at this time, so we'll emphasize them. As time goes by, both programs will more nearly reflect each other.

The skill performance aids package is a change from the traditional teaching of theory to a 'hands on' form of training. As a program, SPAS provide for the simultaneous development of the hardware item, the organization, and the training, with each element supporting and supplementing the other.

Why do you think the Army is so excited about SPAS?

- (1) Since today's soldier is highly motivated to classroom training, the Army feels the SPAS will meet with the same enthusiasm. Turn to Page 80.
- (2) Since the SPAS methodology has proven itself in industry, the Army feels certain it will work for the military. Turn to Page 63.
- (3) Because this method concerns itself with the hardware system, the soldier, and the cost. Turn to Page 51.
- (4) All of the answers listed here. Turn to Page 4.

From Page 41

(1) Very good. The production procedures require that the observer actually manipulate the stimulus (as in the classical method of adjustment) until he produces a value requested by the experimenter.

So you can see that one way of classifying these scaling methods is by what they require of the subject. Estimation procedures require verbal responses that estimate stimulus values, and the production procedures require an action on the part of the subject to produce specified stimulus values.

A second way to classify the scaling methods is by the types of judgments required of the subject. He may be required to judge the difference in sensations or the absolute magnitude of sensation. In some cases relative judgment of magnitude will be required. We will now discuss four types of estimation scales. But remember that similar types of scales are based on production methods as well.

(1) Category estimation (or production) - in this method the subject is asked to indicate which stimuli belong in which categories.

(2) Interval estimation (or production) - this method requires the subject to judge the intervals of sensation which separate stimuli.

Before we continue with the last two methods, let's create a situation and ask a question. You, as a human factors specialist, are designing a backpack to be worn during field maneuvers. You have four different packs which have already been developed, and each of these packs has a different weight and a different design. You want the users to have the pack which feels the best and you suspect that this might not necessarily be the pack which weighs the least. You ask a group of users to try on each pack. After they have done this, you ask them to indicate which design is poor, good, okay, or great. Which of the methods presented in this lesson have you used?

- (1) Interval estimation. Turn to Page 14.
- (2) Category estimation. Turn to Page 42.
- (3) Method of limits. Turn to Page 75.
- (4) Signal detection. Turn to Page 90.

From Page 71

(4) Exactly right. Although the second stimulus was actually one half the first, before we can determine assigned values, we need to know how this signal was perceived by the individuals.

In the estimation procedures, a large number of trials would be given so that all the stimulus values would be presented several times. The average response of each subject would be taken for each stimulus value. In this way, a scale could be derived for each individual. Eventually, the average of all of a group of individuals' responses for each value would be taken. We recommend that you take a look at any introductory text which deals with psychophysical scaling methods. They can be an invaluable aid when making decisions as to design features which require sensory judgments on the part of the users. They can help you make decisions as to how bright, loud, soft, etc. a stimulus must be to be differentiated from other values.

Well, you've learned a great deal in this lesson, as did I. M. Eager when he took the course. In fact, after this particular lesson, Eager used the magnitude estimation method to find out which wattage his emergency light had to be in order for it to be perceived as twice as bright as other lights on the instrument panel. He also used the scaling methods to evaluate how well people like the food in the cafeteria, but we'd rather not go into that, if you don't mind.

So long for now, but see you in our next two exciting lessons on designing experiments. Ta, Ta.

From Page 51

(1) Exactly right. In addition to the individualized, immediate feedback aspects described previously, the fact that the instructor is freed to concentrate on specific problems makes CAI an often-preferred method. Perhaps the best advantage of all is being able to avoid having to get all the students together at one time and place. This course is, of course, an outstanding example of CAI. Right? Right!

The final method of training we will examine is team training. Quite simply, team training can be defined as training a group of personnel to perform related or integrated functions as a team. Since most highly complex systems require a number of people to work together, the need for team training is obvious. However, research has shown that to be successful, team training must be integrated with the individual instruction.

Well, you've completed a very brief review of personnel selection and training. Some of the information presented will be used by you directly as a human factors specialist. Other material will serve as background data. From what you've studied thus far, what would you say is/are the important factor(s) for the human factors specialist?

(1) The human factors specialist must assure himself that the proper method of training is used so that the military gets the best trained personnel possible. Turn to Page 69.

(2) Both of these answers are important to the human factors specialist. Turn to Page 43.

(3) When developing a system, the impact of personnel selection and training in regard to cost and time must be evaluated. Turn to Page 39.

From Page 81

(2) While it's true that modularization is an important design feature, we cannot say that it will always be the most important feature in every design. Return to Page 81.

From Page 63

(3) Exactly right. You may not need training in every aspect of certain operations and, therefore, you do not want to simulate the entire system. The use of part-simulation allows you to accomplish your objectives at a lower cost.

To summarize much of the content of the past two lessons, the following selection from an article by Alice M. Crawford and Kent S. Crawford of the U. S. Navy Personnel Research and Development Center (NPRDC), San Diego is presented. It indicates that we do not have all the answers. Maybe you can help provide some of them.

'Individual training is a very large enterprise in the military services. Unlike civilian industry, the military must train most of its personnel in required skills rather than select people who are already proficient. Also, given the trend toward more sophisticated equipment and weapons systems, the military must rely even more in the future on educational and training programs to keep pace with technological developments.

'For these reasons, issues pertaining to the design and implementation of training efforts, which are of interest to educators in all sectors of society, are of particular importance to the armed services. Training technologies must be effective while keeping the expenditure of dollars and time to a minimum. Considerable research will have to be done before such an objective can be realized.'

There is one aspect of training which has not been addressed in these lessons. We have talked about various design features and prototypes which are used to assess the adequacy of the man-machine interface. Think about this. How do we assess the effectiveness of a new piece of equipment? In Lesson 37 you will learn about test and evaluation, but for the moment, you need to be aware that often it is necessary to apply our training knowledge and skills to training test subjects or participants. In order to assess the man-machine interface, we often need trained subjects. One practical approach to evaluating whether or not your test participants are adequately trained is suggested in DI-H-7058: give the trainer a comprehension test right after his training, but before his test performance on the system. A more detailed explanation of test participant training is given in TM 29-76 on Pages 33-34. Please read these references after this lesson ends. By the way, this lesson ends here. Your next lesson is coming soon and is the first of a series of lessons which deal with experimental or test study design. Lesson 30 (Psychophysical Methods) begins this series and we will see you there. Bye.

HUMAN FACTORS ENGINEERING

LESSON 30: PSYCHOPHYSICAL METHODS, OR DO I DETECT A SIGNAL?

Hi, glad to see you back. This is Lesson 30 of your course in Human Factors Engineering. This lesson is the first of five lessons which deal with experimental methodology and statistical techniques. When I. M. Eager took this course from Professor Ed U. Kator, he was glad that the lessons had finally come to this point. After all, he had learned a lot about human capabilities and limitations, but, up to this point, he had had to rely on already established information, such as that found in the reference documents you have been using. Eager's perfect helicopter was so new that often some of the needed information was not contained in these reference sources.

Eager (being eager to be correct) knew that data had to be gathered and analyzed in order to evaluate adequately the design of his new machine. However, he wasn't sure exactly how to go about collecting the necessary data or, once collected, how to analyze it. Now he would find out, and so will you.

This lesson is concerned with methods that are used to determine the relationship between stimulus intensity and sensation or the perceived level of stimulation. This area of concern is called psychophysics and deals with the connection between physical stimuli and the psychological responses they produce. Do you always detect a stimulus? If a red light appears on the control panel of Eager's helicopter to signal that his engine was overheating, what is the likelihood that he will see that light in the excitement and the workload imposed during initial takeoff? Can motivation influence the way you respond to a stimulus? Can you judge two equipment stimuli as being equal? These are the sorts of questions that psychophysical methods may be used to answer.

The basic purpose of the classical psychophysical methods is to provide procedures for determining thresholds. In other lessons we discussed the detection of signals and the concept of thresholds. For example, a definition of thresholds was presented in Lesson 10, but we will repeat it for you here. A threshold is a stimulus value that separates the stimuli which elicit one response from those which elicit another or no response. For example, a tone of 25 Hz presented at 60 dB may be the lowest frequency a particular individual can detect. He cannot hear a 24 Hz tone at 60 dB, but can hear tones above 25 Hz at 60 dB. We would then say that his frequency threshold for auditory signals presented at 60 dB is 25 Hz.

(GO ON TO THE NEXT PAGE)

From Page 29

Now, there are different types of thresholds with which we are concerned. Which type of threshold do you think was described in the example just given?

- (1) Different threshold. Turn to Page 92.
 - (2) Absolute threshold. Turn to Page 21.
 - (3) Wedding threshold. Turn to Page 48.
 - (4) Auditory threshold. Turn to Page 8.
-

From Page 67

(1) Very good. This is correct. The average of all the adjustments made by the subject represents the stimulus value that the observer feels is equal to the standard stimulus. This value is called the point of subjective equality.

Using the method of adjustment, you can also determine the magnitude of the constant error of perception that is made in judging the size of a stimulus. This information is helpful in the design of a variety of equipment. For example, if an operator is going to be required to adjust controls to match a standard, knowing the constant error for a representative group of operators will allow you to 'build in' the necessary control factor to compensate for the expected constant error.

The third classical psychophysical method is called the method of constant stimuli. In this method a range of stimulus values is selected and a set of stimulus values are used as comparison stimuli (CO). The COs are then presented in a random order and are each judged against a standard value. This procedure is repeated a number of times and the observer is asked to judge whether the CO is greater or less than the standard. This method may be used to obtain an absolute threshold (RL), a difference level (DL), or a point of subjective equality (PSE).

(GO ON TO THE NEXT PAGE)

From Page 30

So, now you know what the three classical methods of psychophysics are. It is also important for you to know some of the assumptions which underlie the use of these techniques and which limit their usefulness to certain prescribed situations.

In the classical use of these methods, only highly trained observers were employed. This was based on the assumption that:

(1) Response biases were controlled (i.e. subjects would not anticipate which stimulus value would be presented next and respond accordingly); and

(2) The observers were only influenced by the stimulus magnitude. No observer-strategy or decision-strategy was felt to be influencing the observers' responses.

The theory of signal detection was originally developed to deal with problems in radar and in radio and telephone communication. Its major contribution has been to show that the assumptions underlying classical psychophysics are false. Signal detection theory places a great emphasis on the judgmental aspects, as well as the sensory aspects, of the psychophysical experiment. In a typical signal detection experiment an observer will be asked whether or not he can detect a signal. Unlike the classical methods which always present a signal or stimulus, the signal detection experiments look at the observer's responses both when a signal is present and when it is not. Figure 30.1 in your supplement shows the four possible events in a signal detection experiment. Please use that figure to answer the next question.

Which of the following situations best describes a correct rejection?

- (1) Indicating that the patient's heart has stopped functioning when there is a straight-line indicator on the electric monitor. Turn to Page 49.
 - (2) Indicating that a sounding on sonar was caused by a moderate size whale, when in fact it was produced by a small submarine. Turn to Page 4.
 - (3) Indicating that an aircraft picked up on a dew line observation is not an enemy aircraft, if in fact, it is a scheduled TWA Flight. Turn to Page 58.
 - (4) All of these are correct. Turn to Page 84.
-

From Page 53

(1) Personnel selection and training is absolutely right. That's why this lesson is entitled 'training the right people.' Personnel selection and training play an important role in the overall system design. You will see that a fine balance must be maintained between these two important concepts.

Several years ago the U. S. was involved in a race for the moon. As has been mentioned previously, this race proved to be a real blessing for human factors engineering. From what you know about selection and training, which of the following statements would you deduce to be true regarding the space program?

- (1) Since training was extensive, little emphasis had to be placed on selection. Turn to Page 70.
- (2) Since operating procedures and equipment design were extremely complex, great emphasis had to be placed on both selection and training. Turn to Page 34.
- (3) Since there was so much emphasis on selection, the importance of training was minimal. Turn to Page 87.

From Page 15

(2) Totally ignoring the skill levels of maintainers can drastically alter the findings, because maintenance technicians do not have equal skill levels. Return to Page 15.

From Page 58

(4) Do you really think this is the right answer? It's way too simplistic. Try again. Return to Page 58.

From Page 37

(3) Work repair is someone else's domain, not yours. As a human factors specialist, you make recommendations for improvement. You do not make the repairs themselves. Return to Page 37.

From Page 47

(3) Revising the course does fall under phase five, but the requirement is not necessarily an annual one. Return to Page 47.

From Page 66

(4) Do you really think this is the right answer? It's way too simplistic, try again. Return to Page 66.

From Page 32

(2) Good deduction, and exactly right.

The space program, indeed, did involve a highly complex and sophisticated system, so complex that it required highly detailed operating procedures, stringent selection criteria, and years of training for its personnel. But this is one extreme. Not all systems are so complex. Some allow the designers less rigorous options in terms of selection and training. Recall, however, that OMB A-109 seeks to establish framework for all acquisition programs. And if the system exceeds \$75 million (research) or \$300 million (procurement) the 5000 series of DOD directives provide acquisition policies which impact on the designers' options. Recently TRADOC was advised to begin stating skill constraints and training base constraints in requirements documents. Therefore, system designers will soon have to understand design constraints stated in terms of intelligence and training time. Many military systems fall into this category. Take, for example, a communications system. The designer may have some latitude as far as the complexity of the system and, therefore, the level of personnel selection criteria and training requirements. In this example, let's assume that the designer either selects someone who 'knows the system' and needs little training, or one who is trainable, or he can simplify operating procedures so that just about any operator can be successful. This may sound quite simple at first, but there are many questions which must first be asked and answered before the designer gets to this point. It will be your job, as a human factors specialist, to pose these questions and help answer them. Before you can do this, you'll need some more training, so let's get some more details on personnel selection and training requirements.

As a human factors specialist, you will be most concerned with the personnel selection and training process as it occurs during design. In other words, it's good for you to know the mechanics of picking the best man for the job. But more importantly, you need to know how the equipment determines who that man is, whether or not he exists, and whether or not a man can be trained to operate and maintain the equipment. This means that if the human factors specialist doesn't get involved early in the concept exploration phase, his main job will become one of solving problems. Let's look back at one of the problems Lt. Eager might have had with his helicopter. If you recall, one of the many 'features' of this helicopter was its endurance capability. What if Eager had only allowed for one operator? Can you imagine how long it would take to find an operator capable of flying for 48 hours (selection) or training one to do that? The point is that Eager should have considered the availability of capable or trainable operators.

(GO ON TO THE NEXT PAGE)

From Page 34

Now that you know how not to do it, let's examine the way it's supposed to be done.

During the concept exploration of development a series of top level requirements will be presented--the helicopter must have certain endurance capabilities, be capable of supersonic speed, etc. As these requirements are converted to man-machine responsibilities, questions will be asked, such as (1) how many people will be required to operate the system? (2) what skills will they need? and (3) are skilled people available? What happens if the answer to this last question is, 'no, skilled people are not available'? What do you do?

- (1) Investigate the possibility of training. Turn to Page 60.
 - (2) Reallocate some man functions to machines. Turn to Page 90.
 - (3) Both of these should be examined. Turn to Page 83.
-

From Page 55

(4) That is a tricky question (or at least a tricky answer). It is rare, but you could have performance validity without training validity. For example, in some jobs, such as troubleshooting, making decisions between alternative possibilities of failure is an important job component. It may be that a training course which emphasized decision-making strategies would result in improved on-the-job troubleshooting performance. This result could have occurred even if the decision-making strategies had nothing to do with actual troubleshooting examples. In this case, you would have a training component with little training validity (no troubleshooting content) and good performance validity (improved job performance). Now you can see why this answer is not totally correct, so reread the selections and try again. Return to Page 55.

From Page 83

(1) These discussions are important, but what about the other techniques listed? Return to Page 83 and try again.

From Page 87

(1) Safety is an important factor. In fact, it was one of those previously mentioned. But there are other factors which also must be considered. Return to Page 87.

From Page 53

(2) You don't think cost has been considered yet? What about Lessons 21 and 25? Return to Page 53 for another answer.

From Page 79

(4) Very good, you are correct. These are all sources of information that may indicate a potential accident.

The answers to the last question are all indicators of potential accidents. Figure 27.1 in your supplement shows how these intermediate indicators may be used to help prevent accidents before they occur. For example, if the workers complain about the functioning of a particular piece of equipment, the safety specialists should investigate to see whether the equipment is about to malfunction and thereby cause an accident. Infantrymen who complain about a gun jamming are professionals who should be attended to when their complaints are made. After all, who knows the equipment better than its user. The experienced worker or user can often detect an out of control situation before the safety inspector.

Another avenue used to identify critical areas in the system is a general investigation. All information about the system in question can be obtained through some type of investigation. Basically, there are two types of safety investigations: preaccident and postaccident. Preaccident investigations can be initiated by a variety of factors, such as user complaints, normal rounds of the safety inspector, etc. Because the accident has actually occurred, the postaccident investigator is usually able to isolate the cause of the accident. With the information, corrective action can be suggested to eliminate or reduce the severity of future occurrences. Both types of investigations have the same purpose: to eliminate or extenuate future accidents.

Figure 27.2 shows you the various sources of information used in an accident investigation. In this figure the node labeled 'accident' represents the postaccident investigation, while the node labelled intermediate indicators impinge upon the internal or preaccident node, which, in turn, leads to the investigations and information nodes.

Well, let's review in the form of a question. What does general hazard analysis consist of?

- (1) Identification, evaluation, corrective action. Turn to Page 48.
 - (2) Identification, evaluation, corrective suggestions. Turn to Page 10.
 - (3) Identification, corrective suggestion, work repair. Turn to Page 33.
-

From Page 58

(1) Yes indeed, this answer is correct. The more often the signals are presented, and the observer expects a high presentation rate, the more 'hits' the observer will have.

So, part of the detection rate of signals depends upon the observer's expectancy about the rate of presentation. Take the dew line observer as an example. In peacetime there are few aircraft, and the observer doesn't really expect any. In wartime, however, there is a different expectancy concerning the possibility of enemy aircraft. Now, perhaps you can see how the detection rate will change as a function of the presentation rate.

Another bias which affects the detection of an observer is the payoff or outcome associated with the observer's responses. In essence, this is concerned with the effect of motivation on psychophysical judgements. Imagine the situation in which you were to be paid \$10 every time you correctly identified the presence of a specified signal; there would be no penalty for incorrect responses. How would this set of outcomes or payoffs affect your responses?

- (1) There would be an increase in the number of misses and false alarms. Turn to Page 93.
- (2) There would be an increase in both hits and false alarms. Turn to Page 5.
- (3) There would be an increase in the number of hits, but a decrease in false alarms. Turn to Page 55.
- (4) Two of these answers are correct. Turn to Page 57.

From Page 95

(3) This might be true of some systems, but think about the consequences of this philosophy in a military system. Return to Page 95 and try again.

From Page 27

(3) Exactly right. What concerns the human factors specialist most in personnel selection and training is its impact on the cost and the time frame required to implement the selection or training program.

In Lesson 37, you will learn about HFE test and evaluation. But we think it is a good idea to explain that the HF specialist is likely, frequently, to have to analyze HFE test data (DI-H-7058). He likely will be called on to 'recommend solutions,' two of which are personnel and training changes. For example, in one tech memo it was found that a function (fire control) was allocated to humans. Test soldiers did poorly on the algebra problems required to perform this task. So, the following alternatives were suggested:

(1) Reallocate fire control function to machine (and build a new black box to do it).

(2) Keep same function allocation, but provide computational device to do algebra.

(3) Get smarter operator.

(4) One present operator, lots of extra training.

The HFE specialist doesn't actually decide which alternative to select, but he is part of the design team which will have to make that decision.

And so went Professor Kator's first lesson on training. Lt. Eager was briskly jotting down notes and figuring how he would begin the selection and training process for his super helicopter. Ed U. Kator then passed out a reading assignment for the next class. You'll find it on Pages 82-84 of your supplement. Before you begin the next lesson, read through it. We think you'll find it quite interesting. Our next lesson will be concerned with methods to evaluate the training process. See you then!

From Page 92

(2) Cost effectiveness is not the next item on the hazard analysis agenda. Return to Page 92.

From Page 91

(1) The bottom line is success, but the other answers presented here also make some 'valid' points. Return to Page 91 and try again.

From Page 61

(2) You're correct if we're talking about highly complex systems, but what about simple systems? Return to Page 61.

From Page 11

(4) You don't take any action until you've done more work than this. The first grouping should be done on the basis of importance. Return to Page 11.

From Page 5

(3) Very good, you are correct. We must design equipment with the lower difference level (AL) in mind. We want all critical signals to be detected. Therefore, we try to use stimulus values that are above the AL.

This lesson so far has dealt with methods for determining the acuteness of our senses. Now we will present a few scaling methods that are used to help us measure the range of sensation. For example, if you wanted to present two sounds and you wanted your observers to experience one as being twice as loud as the other, would you make the physical intensity (in dB) of one sound twice as intense as the other (i.e., 40 dB and 80 dB)? The answer is no. That probably wouldn't result in a sensation of loudness that is twice that of the original sound. You would have to manipulate frequency as well as dB.

In the remainder of this lesson we will present scaling methods which are often called 'direct' methods. They are called 'direct' because they assume that the individual making the judgements is capable of describing his observations directly on interval or ratio scales. Using the direct scaling methods, you have available to you two response procedures. One of these broad classes of procedures is called estimation procedures, because the observer is asked to estimate directly the magnitude of the stimulus presented. The other class of procedures is called production procedures. What do you think the production methods require of the individual?

(1) The individual must vary the stimulus to create the asked for value. Turn to Page 25.

(2) The observer must judge an asked for stimulus value. Turn to Page 100.

(3) The observer must indicate when his difference level has been established. Turn to Page 95.

From Page 25

(2) Very good, you're correct. You have asked the users to estimate the categories that they feel the stimuli belong in.

(3) Ratio estimation (or production) - in this method the subject's job is to judge the apparent ratios that hold between two or more stimuli that are presented. For example, two tones might be presented to the observer and her job would be to report what ratio the louder tone bears to the softer one. That is, she might say the louder tone would get a rating of 90 on a scale of 1 - 100, while the softer one only received a rating of 10. This allows you, the human factors specialist, to know that there is a 9 to 1 ratio between the tones, as far as loudness is concerned, no matter what the intensity distance between the tones is.

(4) Magnitude estimation (or production) - typically provides the observer with a ready-made scale to use (i.e., the scale of 1 - 100 referred to above). In magnitude estimation procedures, the subjects are asked to assign a numerical property to the first stimulus and then judge each succeeding stimulus in relation to the first. Subjects assign numerical magnitudes to each stimulus presented.

In magnitude estimation procedures, would it be possible for the first stimulus to be assigned a numerical values of 10 by subject 1, and a value of 250 by subject 2, as well as a value of .5 by subject 3?

- (1) Yes. Turn to Page 71.
 - (2) No. Turn to Page 77.
-

From Page 2

(4) Your answer is incorrect. One of the other choices is correct though. Return to Page 2.

From Page 27

(2) Only one of these answers truly addresses the human factors specialist. The other falls under the cognizance of a training specialist. Return to Page 27.

From Page 61

(3) Remember, simulators are usually quite expensive. Before you can make this statement, many other factors need to be considered. Return to Page 61.

From Page 52

(2) Right on, ole buddy. If we know the number and type of errors made, we can redesign so as to reduce these errors. This, of course, increases the reliability of the human and the system's performance. Of course, this also points out the need for maintainability issues to be considered in the very earliest stages of systems acquisition.

To select the system aspects to be redesigned, you can compare two types of complexity; task and hardware. HEL TM 22-74 (Page 11) states that task complexity is found by dividing the number of human performance errors by the number of opportunities for error. Hardware complexity is found by dividing the number of human errors by the number of parts in the equipment group.

Now, if the equipment is high on task complexity, you know redesign is a good idea. The degree of hardware complexity will guide you in deciding how to redesign.

So, we've come to the close of another lesson. Before we go, however, we must say one thing on LSAR. (You remember ... from your task analysis lessons ... there's an example in your supplemental section for Lesson 24.) In the LSAR process, logisticians do a sort of task analysis of maintenance. The Army's LSAR scheme has recently been rewritten and is now being staffed as a DOD (Tri service) standard. We use this information to demonstrate the current emphasis on maintainability and human performance.

Hopefully, it is now apparent to you that increased maintainability hinges on a strong relationship between the design and skill level of the technician. Less than a complete knowledge of either aspect can do little but deflate the degree and ease of maintainability. In this lesson you have learned some of the important aspects of designing for maintainability. As it should now be apparent, designing for maintainability can have a substantial impact on system performance. Regardless of how reliable the system is, it will eventually fail; it requires maintenance. The speed and ease of repair will, in part, determine how effective the system will be during its life time. That's all for now. See you next time for your lesson on safety analysis.

From Page 15

(4) Only one answer is correct. Go back to Page 15 and select another answer.

From Page 93

(2) This is a reasonable choice, but it isn't the best choice. After reconsidering the ways to correct hazard A, a deferment may be recommended, but not at this time. Return to Page 93.

From Page 63

(4) You'd better review the definitions of fidelity once again. Return to Page 63.

From Page 52

(1) Increasing training 'time' for either an operator or maintainer is not necessarily the best choice of answers. In Lessons 28 and 29 you will learn about training. We guess this was a plausible answer since you haven't had those lessons yet, so you do get kudos for thinking. However, you'd better try another one to continue with the lesson. Return to Page 52.

From Page 58

(3) This is not the correct answer. A low rate of presentation would not increase detection. Lesson 16 will help you determine the correct answer. Go back to Page 58.

From Page 22

(2) Exactly right. In phase one an inventory of tasks is developed. From this inventory a listing of tasks which require training is produced.

In phase two, a job inventory is used to design the terminal objectives and testing for the subject course. In addition, a determination of target student population is made. Phases three and four deal with the development and implementation of the course. What does the final phase of ISD deal with?

- (1) Training evaluation. Turn to Page 69.
 - (2) Designation of agencies that will control the course. Turn to Page 82.
 - (3) Annual revision of the course. Turn to Page 33.
 - (4) All of these. Turn to Page 3.
-

From Page 68

(3) While modular versus nonmodular packaging trade-offs are necessary when evaluating maintainability, they are by no means the only analysis that must be looked at. Return to Page 68.

From Page 9

(3) Unfortunately, a lot of people feel this way and OJT programs suffer because of it. Return to Page 9.

From Page 37

(1) Corrective 'action' is not part of hazard analysis. As a human factors specialist, your job is to make recommendations for safety. Return to Page 37.

From Page 98

(2) You've selected a partially correct answer. The tasks themselves might very well be the same, but the people and the organization may very well be different. Return to Page 98.

From Page 30

(3) 'Dum, dum de dum.' Nice try. We appreciate your interest in the institution of marriage and in our attempts at humor. However, now it is time to attempt a correct response. Return to Page 30.

From Page 5

(1) Observer bias is taken into account in signal detection, not in the classical methods. Return to Page 5.

From Page 6

(2) This isn't really necessary. We know you have learned the previous lessons well and that you know where to find any needed data in the military specifications. Return to Page 6.

From Page 87

(3) Since simulators are so expensive, savings may not appear to be possible with the use of simulators, but when you are training people on highly sophisticated equipment, cost is a factor. It is not the only one, however. Return to Page 87.

From Page 31

(1) This is not correct. In this situation the signal (straight line on monitor) was present and the response was a 'yes.' This answer reflects the cell marked 'hit.' The technician correctly identified the situation. Return to Page 31.

From Page 79

(3) This is only one source of potential accident information; there are others. Return to Page 79.

From Page 19

(3) In some instances this might be true, but not with decision-making tasks. This is a tough one, isn't it? Return to Page 19 and try again.

From Page 71

(2) You would be correct if each subject perceived the stimulus to be one half the first presentation, but our situation did not present it that way. Return to Page 71.

From Page 24

(3) Exactly right. The Army feels that this systems analysis approach to teaching operation and maintenance skills will work because of its broad perspective.

SPAS use the technical manual as the primary tool. However, SPAS are written more clearly, accurately, and logically than most tech manuals. In addition to tech manuals, SPAS include multimedia materials. Similar to OJT, SPAS have as their main advantage the fact that training in the field reduces the loss of recall and retention that can occur when training takes place at a formal school. The training material used is designed to interface with the unit's daily mission and overall training program. With this material the soldier can continue to learn, using the material over and over again.

In addition to OJT-type training and classroom training, there is a third method which is increasing in popularity. This is computer-aided instruction (CAI). The method provides individualized instruction using a computer to provide immediate feedback. There are several kinds of CAI, but all use basically the same principles. Which of the following do you think best describes the advantages of CAI?

- (1) It provides individualized instruction and immediate feedback, and it gives instructors time to spend with individuals. Turn to Page 27.
- (2) It is a low-cost, individualized method of instruction which provides immediate feedback to the student. Turn to Page 15.
- (3) It is a low-cost, individualized method of instruction which provides immediate feedback to the student in less time than traditional methods. Turn to Page 57.

From Page 61

(1) Do you think that a simulator is more realistic than OJT? If you do, you're mistaken. Return to Page 61.

From Page 15

(1) Correct. There are certain trade-offs that must be considered when dealing with system design characteristics and maintainer skill level.

In this lesson we have addressed the issues involved in equipment design. You should recall from your lessons on systems acquisition and systems analysis that the current focus in these areas is on performance requirements and specifications. So, too, with maintainability.

The importance of assessing the impact of human performance on system reliability is quite clear when you consider two things.

(1) 50-70 percent of all failures in weapons and space systems are human-initiated.

(2) A reliability program which only addresses hardware solves less than 50 percent of the total reliability problem.

To determine the reliability of human performance, you need a determination of the time required to perform a task and the errors omitted in performing it.

TM 29-76 suggests that '...the full contribution of human performance to operational availability will not have been assessed unless the actual number of human errors (by category) measured during the ... test is compared with the opportunities for error, and that ratio used either in the calculation of ... system performance reliability component of the operational availability equation.'

If we use human reliability information, we can then improve our total system reliability. What is one way in which we could use this information?

- (1) To increase training time of the system operator. Turn to Page 46.
 - (2) To selectively redesign so as to decrease human performance error. Turn to Page 44.
 - (3) To compare task and hardware complexity. Turn to Page 3.
 - (4) To design only replaceable parts so as to totally prevent error. Turn to Page 20.
-

HUMAN FACTORS ENGINEERING

LESSON 28: TRAINING THE RIGHT PEOPLE

Welcome back once again to you Human Factors Engineering Course. As you recall, Lt. I. M. Eager is also in the middle of a course in Human Factors Engineering. His instructor, Professor Ed U. Kator is about halfway through his lecture series. Thus far, Kator has discussed the system acquisition cycle and how human factors fits into it. He has examined the methods of systems analysis and task analysis and has reviewed the concepts of maintainability and safety. Today Professor Kator tells his students that they are close to being ready to start practicing what they have learned. He asks them to think of a hypothetical system they would like to design (Eager, of course, thinks about his super helicopter). He tells the students that although many design concepts have been considered, there is still an important piece missing. What do you think that one piece is?

- (1) Personnel selection and training. Turn to Page 32.
- (2) Cost considerations. Turn to Page 36.
- (3) Reliability. Turn to Page 22.

From Page 68

- (2) It is true that trade-off analysis is important for making decisions concerning the value of repairing versus discarding equipment. However, other trade-offs must be evaluated as well. Return to Page 68.

From Page 62

- (3) One of these methods was extensively used as a way to upgrade maintenance skill levels. Return to Page 62.

(1) Well done. This was a tough one. Validity actually answers the question 'How well does a predictor predict that which it was designed to predict?' As we continue, you'll see how that relates to training programs.

When you examine how well a training program works, you see that there are really several different types of validity. In general, there are two: internal and external. Internal validity asks the question 'Did the training make a difference in this particular setting?' For example, assume there is a course on aircraft maintenance. The course lasts three weeks and a final exam is given on the last day. If the course improves an individual's performance on this final exam, the course would be said to have internal validity. The key here is that the validity refers to a given set of individuals and circumstances.

External validity goes a step further and questions the generalizability of the results of the training to situations outside the training environment. Will a second set of students show the same increase in performance? Can this training be used by the Army as well as the Navy? If the answers to these questions are yes, the course is said to have external validity.

Irwin Goldstein, a noted industrial/organizational psychologist, has examined in great detail the concept of validity as it relates to training programs. He has established four types of validity:

- (1) Training Validity
- (2) Performance Validity
- (3) Intra-Organizational Validity
- (4) Inter-Organizational Validity

Training validity concerns itself with the performance of an individual in the training environment. There is no consideration of the transfer of learning to the job. So, for example, a program which teaches 'management theory' might have as its goal just that--teaching students the philosophy involved in management. If it is shown that the program is successful in doing that, one could say that the program has training validity. Too many training analysts, then, say that this training better prepares a person for the job. This is an incorrect assumption, unless we have shown that the program has performance validity.

(GO ON TO THE NEXT PAGE)

From Page 54

Performance validity describes how well performance has positively transferred from the training program to the on-the-job environment. Take, for example, a course which teaches aircraft maintenance. How well a student performs on a final exam could be a measure of training validity. How well the student performs at the maintenance activity is a measure of performance validity.

With this background information, what can be said about training and performance validity?

- (1) Both are examples of external validity. Turn to Page 77.
 - (2) If training validity is to be of any practical value, you also must have performance validity. Turn to Page 91.
 - (3) Both are examples of internal validity. Turn to Page 23.
 - (4) For performance validity to be of any practical value you must also have training validity. Turn to Page 35.
-

From Page 38

- (3) You're only half correct. There would be an increase in hits, but with no penalty for an incorrect response, why would you expect a decrease in false alarms? Return to Page 38.
-

From Page 83

(2) A job analysis is correct, but what about the other techniques listed?
Return to Page 83.

From Page 19

(4) Your premise is wrong. What about a 747 cockpit simulator which is
used to train pilots how to react and make decisions during emergencies?
Return to Page 19.

From Page 93

(1) You can't take immediate action if the cost is prohibitive. Return to Page 93 and try again.

From Page 51

(3) CAI does often reduce training time, but rarely will it decrease costs. Return to Page 51.

From Page 38

(4) Oops! This isn't correct. Only one answer is the right one. Return to Page 38.

From Page 31

(3) Very good. You are correct. The function of a dew line observer is to report enemy aircraft (signal). In this case the observed plane was a TWA flight. Therefore, the signal was 'off' and the response was a 'no.' A rejection of the signal was correctly given. Keep up the good work.

The last question was difficult, but by answering correctly, you have demonstrated your understanding of the basic design of a signal detection experiment. The answer involving the sonarman was a 'miss,' and the heart monitor answer was a 'hit.' The correct answer (dew line) was a 'correct rejection,' so that leaves only the cell labeled 'false alarm' to explain. This is the situation in which an observer indicates that a signal is present when in fact it is not. If you reverse the sonarman situation to one where there was no sub, but the response was that there was a signal, you would have an example of a false alarm.

In Lesson 16 (vigilance) you were exposed to a type of response bias related to the observer's expectation that a signal would occur. Remember, in that lesson you learned about the increase in detection of a signal as it relates to the rate of signal presentation.

What was this relationship between the rate of detection and the rate of signal presentation?

- (1) The most signals presented in a given time interval, the higher the rate of detection. Turn to Page 38.
 - (2) A moderate number of signals presented in a given time interval leads to the highest rate of detection. Turn to Page 99.
 - (3) The fewer the number of signals presented in a time interval, the greater the rate of detection. Turn to Page 46.
-

From Page 92

(3) If the conditions are similar in their severity, we want to know that. We don't want to readjust our findings. Return to Page 92.

From Page 95

(2) This probably won't work too well. However, if you were faced with a minimum number of men and could not change the system design, this might be a last resort. Return to Page 95.

From Page 98

(3) The task requirements may be the same, but the organizational goals may be quite different. Return to Page 98.

From Page 79

(2) This is only one source of potential accident information; there are others. Return to Page 79.

From Page 35

(1) Investigating the possibility of training is a good answer, but what if it turns up with a negative result; i.e., you cannot train someone to do the job? Return to Page 35.

From Page 67

(3) This isn't the primary purpose of this method. In fact, most of the classical methods are fairly easy to administer and score. Return to Page 67.

From Page 87

(4) Well done. You've used the little information you have on simulators as a basis for selecting this answer and you're right.

To explain in some detail the various reasons for simulator use, let's look at an example. Professor Ed U. Kator asked his class to choose one and Lt. Eager, of course, picked his helicopter. Let's follow their lead. If you were responsible for determining whether or not to use a simulator to train operators (pilots), your reasoning might be as follows on the following subjects.

Controlled Reproducibility — If I use a simulator I can control the environment. If I use an actual helicopter, I have little control. Some of the more important tasks I must train are landing the helicopter, taking off, and handling emergencies. With a simulator I can present these situations over and over again.

Safety -- Going back to the take-offs, landings, and emergency situations, I really expect the trainee to make mistakes at first. If I use an actual helicopter, he probably will not have a chance to make the same mistake twice.

Cost — The actual helicopter itself may cost only \$2 million dollars. The cost of a simulator may easily be triple that. But... what are the other costs involved in using the actual equipment? A mistake by the trainee might destroy the aircraft. Having the student practice under emergency situations might require destruction of the aircraft. Thus, for some sophisticated equipment, simulation is less expensive in the long run.

In addition to these factors, the trainer, with more control, can better utilize known learning principles. In this particular instance, then, you would select the simulator as your method.

In general, what would you say about your choices for training methodology?

- (1) Simulation provides a more realistic replication of an actual job than any other training method. Turn to Page 51.
 - (2) When developing a training program, simulation is usually the preferred choice. Turn to Page 40.
 - (3) When cost is the primary factor, simulation provides the best solution. Turn to Page 43.
 - (4) None of these. Turn to Page 19.
-

From Page 66

(3) Overall, from the maintenance point of view, maintainers at this level usually do not repair and replace faulty equipment, but perform inspections, preventive maintenance, and periodic checkout requiring no high degree of skill.

Usually, the least skilled men, from a maintainability point of view, are those associated most closely with equipment operation. Maintenance at this level is generally restricted to monitoring equipment performance. Personnel at this level usually do not repair the faulty components; rather, forward them to a more skilled level of maintainers. As is implied by the last statement, maintenance services are typically stratified into several categories: on-line (unit) maintenance, intermediate (organizational) maintenance, and depot maintenance. These three categories are also listed in order of increasing skill requirements for technicians. On-line depot level maintenance requires the lowest level of maintenance skill. Depot maintenance requires the most highly skilled and specialized technician.

Thus, while some progress has been made in incorporating human factors engineering into design for maintainability, much work still needs to be done at the point of interface between maintenance personnel and the equipment being maintained. The skills of a maintainer can be modified, enhanced, or supplemented by various methods--methods that when utilized properly reduce system life-cycle costs. These methods include such things as training, improved tools and test equipment, computer programs for maintenance, maintenance aids, and procedural support, such as technical manuals. Before equipment complexity became overwhelming, which method do you think was considered to be the most effective way of minimizing downtime (and consequently increasing maintainability)?

(1) Maintenance training was considered the most effective method of minimizing downtime. Turn to Page 14.

(2) As early as the 1940s, computer programs for maintenance were considered the most effective methods for maintainability. Turn to Page 4.

(3) Neither of these maintenance methods were considered very effective in skill maintenance. Turn to Page 53.

From Page 19

(1) That's right. The most important requirement should be the trainee's capability to perform the tasks that will be required of him. Physical fidelity is important and necessary with motor tasks, but in this instance it is secondary.

Another aspect of simulators of importance to you is the distinction between 'part-simulation' and 'whole simulation.' Part-simulators replicate a critical or difficult portion of a task without attempting to provide the complete environment that is present in whole-simulators. What do you think is the main advantage of part-simulators?

- (1) They do not require a high degree of functional fidelity. Turn to Page 70.
- (2) They rarely require physical fidelity. Turn to Page 97.
- (3) They are more cost-effective than whole simulators. Turn to Page 28.
- (4) All of the answers listed here. Turn to Page 45.

From Page 24

(2) Not really. This method was developed specifically for the Army. Return to Page 24 and try again.

From Page 91

(2) This is very true, but not the only answer. Return to Page 91.

From Page 18

(2) Oh, come now. You were just introduced to this concept as a definition of maintainability. We're sure you were just kidding. You've had your laugh; now it's time to pick the correct answer. Return to Page 18.

From Page 69

(2) You've made a common mistake. Reliability reflects the consistency and reproducibility of an observation. So a training program could be consistently unsuccessful--and therefore reliable, but not desirable. Return to Page 69.

From Page 5

(2) Remember that the lower difference level is that value of the stimulus which is just barely detectible. Would we want to use values even lower than that? Return to Page 5 and try again.

From Page 68

(4) You're absolutely correct. Trade-offs need to be applied to a variety of situations. Also, it is important to keep in mind that these trade-off analyses are done not only within a particular area but also across areas.

An extremely important trade-off analysis that must be undertaken involves the general trade-offs related to the appropriate uses of men and machines to achieve the system objectives. These decisions are based on a number of variables, such as cost, reliability, speed, manpower availability, and flexibility. For instance, when dealing with the cost factors that affect a decision, it might be found that machine functions usually require a higher initial investment but are performed more rapidly during use. In general then, to be cost effective automated equipment must have a high use factor. Similarly, decisions at every point of the analysis take into account the flexibility of man and the speed of response by automated equipment, as well as the reliability and availability factors affecting both sides.

When dealing with such factors that affect a decision on manpower requirements, operator skill level is a very important source of input to the decision. This process is covered thoroughly in Lessons 28 and 29 on training. Still, we would like to go into some detail on how the maintainability of a system is affected by the skill levels of the maintainers.

Until relatively recently, maintainability designers were primarily concerned with the efficient accomplishment of the electronic task on function, and very little attention was given to the maintainer's capabilities and limitations. Only recently has the training of maintenance personnel been considered to have a large influence on design considerations. Equipment that requires maintenance skill levels higher than those provided by training, or beyond what can possibly be expected, cannot be maintained successfully. Thus, if the needed skills greatly exceed what is available, the equipment becomes a liability rather than an

(GO ON TO THE NEXT PAGE)

From Page 65

asset. With all of this in mind, where would you expect to use the least skilled maintenance personnel?

- (1) The best skilled maintenance personnel are usually paired with maintenance experts in a rework type facility. Turn to Page 83.
 - (2) In places that are most completely removed from equipment operation. Turn to Page 97.
 - (3) Usually the least skilled maintenance personnel are those associated most closely (in terms of physical proximity) to equipment operation. Turn to Page 62.
 - (4) These people are typically assigned to nonpower or automated equipment so as to reduce the potential for errors. Turn to Page 33.
-

From Page 21

When using this method to determine a DL, the observer is presented with a comparison stimulus and a standard stimulus on each trial. His task is to indicate whether the comparison stimulus is equal to, greater than, or less than the standard. In this case, two thresholds are established: the upper one, which indicates a change from an equal response to a positive one, and the lower threshold, which indicates a change from an equal response to a negative one. The DL is established as the average of these two thresholds.

You probably have had experience with a variation of the classical method of limits. If you've ever had your hearing tested, you probably used an audiometer. This instrument presents a tone which grows louder and louder (ascending series) until you push a button or indicate in some manner that you can hear the tone. Then it grows fainter (descending series), until you can no longer hear it. On the next trial, a different frequency may be presented in a similar manner. Anyway, you get the idea.

The second classical method is called the method of adjustment. In this method an observer adjusts a stimulus until he perceives it to be equal to a standard stimulus that has been presented by the experimenter. For example, the experimenter may present a bright light of a certain luminaire level and ask the observer to adjust another light source until he feels it is equal in brightness to the first light.

The main purpose of this method is not to determine a threshold, although it can be used to determine AL or DL. Given the explanation above, which of the following do you think is the primary purpose of using the method of adjustment?

- (1) To establish a point of subjective equality (PSE). Turn to Page 30.
 - (2) To establish a point of objective equality (POE). Turn to Page 23.
 - (3) The method of adjustment is used only when it is impossible to use one of the other methods. Turn to Page 60.
 - (4) None of these is a correct answer. Turn to Page 71.
-

From Page 81

(4) You're quite right. All of these features should be carefully evaluated from a systems standpoint, and those features which are most important in a particular system depends on the unique functions of that system. Thus, the importance of a feature will vary from system to system.

As we discussed earlier, systems analysis involves the allocation or organization of functions to provide a structure for making decisions concerning man-machine trade-offs. The increasing complexities and subsequent high costs of equipment design and maintenance have increased the importance of making correct design decisions; one can no longer depend on intuition or guesswork. Trade-off analysis is a decision-making technique that can help reduce the possibility of making a poor decision. Thus, trade-off analyses are required to provide evidence that all related factors have been systematically evaluated prior to making a decision.

Taking into account the information that has been presented over the last several lessons, as well as what has been discussed thus far in this lesson, in which of the following areas should trade-off methodologies be applied in designing for maintainability?

- (1) Trade-off between reliability and maintainability. Turn to Page 3.
 - (2) Trade-off between repair and replacement of equipment. Turn to Page 53.
 - (3) Trade-off between modular versus nonmodular packaging. Turn to Page 47.
 - (4) All of these areas must be evaluated in terms of the trade-offs involved. Turn to Page 65.
-

From Page 47

(1) That's it. Evaluation and revision are the key elements of this final phase. This lesson will deal with the overall evaluation process and its importance to you as a human factors specialist.

So, you see that an important part of training is making sure it works. Obviously, a training program is of limited use if it fails to achieve its goals. What do you think is the technical term used to measure this success?

- (1) Validity. Turn to Page 54.
 - (2) Reliability. Turn to Page 64.
 - (3) Probability. Turn to Page 78.
 - (4) All of these answers. Turn to Page 15.
-

From Page 79

(1) This is only one source of potential accident information; there are others. Return to Page 79.

From Page 27

(1) The human factors specialist is concerned with training, but not at this level. This is the job of a training specialist. Return to Page 27.

From Page 18

(2) While the military has as one of its purposes defense through offense, it has also been very strict in its safety regulations. Return to Page 16.

From Page 32

(1) In rare instances, if enough training takes place, you can all but write off the need for selection (assuming you can afford all the training), but that wasn't the case in the space program. Return to Page 32.

From Page 63

(1) C'mon! What good is a simulator (part or whole) that does not have a high degree of functional fidelity? Return to Page 63.

From Page 42

(1) Correct. Using this method, the subjects themselves may assign the numerical value to the first stimulus.

To continue with this line of reasoning, if the initial stimulus values were assigned like those in the last question, which one of the following sequences would be correct if the second stimulus value was one half that of the first? Remember, initially, subject 1 said 10, subject 2 said 250, and subject 3 said .5.

- (1) 10, 250, .5. Turn to Page 85.
 - (2) 5, 125, .25. Turn to Page 50.
 - (3) 20, 500, 1. Turn to Page 82.
 - (4) You cannot determine the values from the information presented. Turn to Page 26.
-

From Page 2

(3) Both of these answers are not correct. Return to Page 2.

From Page 67

(4) One of these is a correct answer. Return to Page 67.

(4) Exactly right. All of these are ways to determine skills required for a specific job and they are all ways of studying the human performance requirements.

Now, let's review the overall approach to personnel and training requirements in terms of the following example:

(1) An operational requirement exists (e.g. protect the coast of the U. S. from SNX-4 missile attack);

(2) A system made up of several elements or subsystems is conceived to meet the objectives of the operational requirement;

(3) The system is operationally defined in terms of the functions it performs. These, in turn, are accomplished by carrying out a series of tasks which are performed at various positions in the system by either man or machine;

(4) Certain skills are required of personnel to perform their assigned tasks;

(5) Numbers and time frame requirements for personnel are determined.

With this overall viewpoint of selection and training process in mind, let's return to the concept exploration stage of systems acquisition. At this stage a series of alternate approaches to meeting the mission requirements exists. How does the human factors specialist assist in determining the best approach? - Through a series of analyses. Specifically, through organizational, job, and person analyses.

First, let's examine organizational analysis. The goals of the military organization a human factors specialist is involved with are usually fairly obvious; namely, to be prepared to defend the nation from 'foes both foreign and domestic.' However, the resources which a service has available to meet these goals require some analysis. This should include an analysis of available equipment (Do you already have a system which meets the requirements?), the organization's financial resources, and, perhaps most importantly, manpower availability.

The second in this series of analyses is the job analysis. What do you think is the main purpose of a job analysis?

(1) To describe the important aspects of a job which are critical for job success. Turn to Page 94.

(2) To determine the cost of performing a given job. Turn to Page 85.

(3) To determine whether or not a given job can be performed. Turn to Page 13.

From Page 72

(3) Absolutely correct. You are doing very well.

You would recommend a reanalysis for hazard A. There may be a variety of ways to abate the hazard. Each of these methods would have a different level of expense associated with it. Each also would probably have a different level of effectiveness associated with it as well. By reanalyzing, you could arrive at a solution that was both cost-effective and hazard-reducing. This analysis is where the experience of the safety officer comes into play.

DI-H-7058, which is the DID for human engineering test report, has a block (block 10) on how to prepare instructions. Paragraph 7 is devoted to the description of observed safety hazards. This section contains instructions on the data necessary for the evaluation phase of hazard analysis. DI-H-7058 is in your supplement on Page 129.

Essentially, this section of the DID requires:

(1) A narrative description of each safety hazard and any appropriate photographs. In addition, each hazard is analyzed as to the frequency with which it was encountered by the test participants.

(2) The severity of each hazard is determined and the consequences of each hazard are delineated.

(3) The actions recommended are stated in terms of design, task alternatives, and/or personnel. It may reduce the hazard and be more cost effective to allocate functions differently than current situations. Or, the hazard may only be eliminated or reduced by equipment redesign. Remember, the name of the game is safety, but the rules require system effectiveness within the established cost parameters.

In this lesson it may appear that the safety officer, as an individual, is making all the decisions. This is not the case in most situations. The safety officer is part of a team. You, as a human factors specialist, would probably be a part of this team.

Now, there are dozens of ways to perform a hazard analysis and even more methods for determining cost effectiveness. We don't expect you to be proficient in hazard analysis from this lesson. However, it is helpful to you as a human factors specialist to be aware of all facets of the system in which you are involved.

(GO ON TO THE NEXT PAGE)

From Page 73

For example, an R and D team was called in to evaluate a new structural arrangement to be placed on the flight deck of an aircraft carrier. The purpose of the structure was to house men who were involved in nuclear missile attack capabilities in the event that the system had to be operated. Once the men had entered the structure, it would be sealed and could only be opened by a maneuver from the bridge. The men inside the structure could not open the seal.

Only the human factors specialists on the R and D team saw a major flaw in that system. All the other members of the team were concerned with the hardware operations or the manpower planning scheme. What major flaw do you think the human factors engineers found?

- (1) There was a fire hazard on the structure which all others missed. Turn to Page 90.
- (2) If the bridge were knocked out, the men could not escape the structure. Turn to Page 96.
- (3) There was no toilet. Turn to Page 23.
- (4) The personnel were not thoroughly trained. Turn to Page 100.

From Page 87

(2) Controlled reproducibility is, indeed, a key reason for the selection of a simulator, but there are other considerations also. Return to Page 87 and try again.

From Page 77

(3) While it's true that a perfect design might allow anyone to maintain the equipment, there are definite trade-offs between equipment sophistication and simplicity of design. Anyway, regardless of the ramifications, each of diagnosis is not necessarily related to designing for accessibility. Return to Page 77.

From Page 9

(4) Look again. You're making some incorrect assumptions. For example, do you really think that OJT programs require less effort than others? Return to Page 9.

From Page 25

(3) This example wasn't a classical method. Return to Page 25.

(1) Good show, you're absolutely right. Reliability refers to the ability of the system to remain free from failure.

Before we move on to other aspects important when designing for maintainability, let's stop and spend a little time discussing some important ways in which we can quantitatively measure maintainability and reliability. Notice that in defining these two terms, a specific time element is incorporated as a part of each definition, thus emphasizing the need for an assurance that 'maintenance time' will not exceed a specified value. Therefore, both of these concepts, when quantitatively measured, become the system's predictors of 'operational availability.' An oft-used operational availability measure is mean time to repair (MTTR). The MTTR is the average time it takes a technician of a specified skill level to locate a problem, repair or replace the unit, and verify that the correction has been made.

In addition to this measure of maintenance a quantitative measure of reliability is also used frequently -- mean time between failures (MTBF). This operational availability measure focuses on the total system's operating time divided by the number of system failures during that time period. These quantitative measures are an important source of input during the design cycle. However, neither of these operational availability measures incorporates the human performance involved in maintainability. By looking at MTTR or MTBF, valuable information can be gained. Unfortunately, the full contribution of human performance to operational availability will not have been assessed unless, for example, the actual number of human errors measured at any period of time is included in a measure of operational availability.

In the past, measures of human performance reliability have been a 'sore thumb' to maintainability designers. This is because the 'human' part of the system has not traditionally been incorporated into the design during early stages of the materiel life-cycle. Then, when man was introduced as part of the system, he no longer was an asset to the system (often times he no longer 'fit,' if you'll remember our earlier lessons on anthropometry). However, with the aid of human factors specialists, we have begun to pull out of the 'dark ages of designing for maintainability,' as will become apparent to you by the time you finish this lesson.

Now that you are familiar with the concepts of maintainability, reliability, and maintenance, it's time to move on to other important aspects of maintainability. We will begin with a discussion of some design factors that have been found to enhance systems maintainability. Throughout this discussion you should keep in mind that these features are generally applicable, but that they should not be applied blindly. Strict adherence to the features and suggestions discussed in this section is to be avoided; their generality across all situations is unlikely.

(GO ON TO THE NEXT PAGE)

From Page 76

One important design feature is that of accessibility. In terms of maintainability, what do you think accessibility refers to?

- (1) Simplification of design so as to allow the maintainer to easily assess the problem. Turn to Page 84.
 - (2) The relative ease with which a component of an assembly can be approached to be repaired, replaced, or serviced. Turn to Page 88.
 - (3) Designing equipment to enable even the lowest level maintainer to repair any problems. Turn to Page 75.
-

From Page 55

- (1) You'd better review the definitions again. External validity concerns itself with generalizing outside the training environment. This is, indeed, the concern of performance validity, but not training validity. Return to Page 55.
-

From Page 42

- (2) This isn't correct. Subjects do assign any number they want to the first stimulus. Return to Page 42.
-

From Page 17

(3) We believe in gremlins too. Especially when we can't find our car keys where we're sure we left them. However, some people suspect that gremlins really aren't real. So maybe you'd better try another answer. Return to Page 17.

From Page 69

(3) Probability? Probability of what? If the answer read probability of success you'd have a case for your answer. Return to Page 69.

From Page 19

(2) This is a tough one. Since we've pinpointed the task to be learned as 'decision making,' physical fidelity is not the prime concern. Return to Page 19.

From Page 16

(1) Very good, the military has been forerunner in safety design.

The various military services have developed very sophisticated safety programs. They are aware of the value of men and equipment. The military organizations do have an advantage over private sector industries in that they have a great deal more control over their personnel than the private sector does.

So, now you know that one general way of identifying potential accidents is through historical records. Can you think of specific types of information to be found in company records that might also indicate the source of potential accidents? Give it a shot, which of the following would show a possible hazard?

- (1) Reports of unusual delays in the normal routine. Turn to Page 69.
- (2) Reports of damaged goods. Turn to Page 60.
- (3) Reports of employee complaints. Turn to Page 50.
- (4) All of these can be used as sources of potential accident information. Turn to Page 37.

From Page 11

(3) Right. Each hazard discovered should first be grouped according to its severity ranking. Return to Page 11.

From Page 18

(3) You're joking, right? If you'll stop and think for a minute, we hope you'll remember this sentence being presented to you as a definition of maintenance. Maybe it would be wise if you went back and reread part of this lesson again. Return to Page 18.

From Page 24

(1) Most people are more enthusiastic, and therefore, more motivated by 'hands on' experience rather than classroom training. SPAS give an alternative to that type of formal training. Return to Page 24.

From Page 88

(4) You're absolutely right. These locational recommendations are all good guidelines to follow when designing for maintainability.

Okay, so far we have discussed two important maintainability design features; namely; accessibility and ease of replacement. In addition, several other factors should be discussed that are important when designing for maintainability. We have alluded to unit packaging placement in the preceding discussion, and it needs to be pointed out that 'unit packaging' is one such suggested design feature. Packaging equipment into separate, replaceable units can enhance maintainability by facilitating troubleshooting, reducing handling problems, and making it easier to replace malfunctioning parts. Thus, modular or unit packaging is recommended whenever feasible. Along these same lines, replaceable modules should be independent and interchangeable, if at all possible. For instance, you might have had the unfortunate experience of needing to replace the spark plugs on your car, only to find that the air conditioning system had to be either partially or totally disassembled beforehand. Obviously, such poor design features have a negative impact on maintainability.

When designing for maintainability, it is also a good idea to include self-checking features or test points that can be tested by auxiliary test equipment. To be most useful, test points (or spots at which a technician can trouble-shoot various portions of a system) must be in the proper functional location. Therefore, the test points should be tied into circuits where the technician needs to sample signals, as well as in places where the technician can reach them easily.

Now, we have just discussed a number of design features important for effective maintainability. Which one of these features would you consider to be most important for designing for maintainability?

- (1) Ease of access to test points and internal parts of the equipment. Turn to Page 22.
- (2) Modular or unit packaging. Turn to Page 27.
- (3) Replaceable modules or units that are independent and interchangeable. Turn to Page 7.
- (4) All of these features should be carefully evaluated from the overall system point of view. Turn to Page 68.

From Page 13

(1) We've done this too. We keep saying it is the rug's fault and not our clumsiness. Do you? Anyway, this isn't the only source of hazard recognition. Return to Page 13.

From Page 47

(2) The designation of agencies responsible for controlling the course will have been made much earlier than this. Return to Page 47.

From Page 71

(3) You've missed the point completely. Remember, assigned values are based on relationships of perceived stimulation. Return to Page 71.

From Page 35

(3) Exactly right. Which of the two you choose depends on several factors. Now is the time for a trade-off analysis.

You have determined the skills required to operate and maintain your system, you have analyzed your available skills and you discover a gap which needs to be bridged. If that gap is not too wide, personnel selection and training come into play. Before we go any further though, answer the following question. How did you determine the skills required for the system?

- (1) By talking with operators of similar equipment. Turn to Page 36.
 - (2) Job analysis. Turn to Page 56.
 - (3) By taking with the equipment designers. Turn to Page 16.
 - (4) All of these. Turn to Page 72.
-

From Page 58

(1) While it would probably be a good OJT technique to pair skilled and unskilled personnel, this answer really doesn't apply to the question. Return to Page 58.

From Page 66

(1) While it would probably be a good OJT technique to pair skilled and unskilled personnel, this answer doesn't apply to the question. Return to Page 66.

From Page 77

(1) This is not a correct answer. An ability to assess the problem is important in maintainability, but this is not a part of designing for accessibility. Return to Page 77.

From Page 31

(4) Look a little more closely. Only one of these is correct. Return to Page 31.

From Page 88

(1) This is not the best possible answer. Still, you are correct in assuming that this answer is important in maintainability design. Return to Page 88.

From Page 72

(2) The cost of performing a job is an important factor, but it is not the responsibility of job analysis to determine the cost. Return to Page 72.

From Page 71

(1) You've missed the point completely. Remember, assigned values are based on relationships of perceived values. Return to Page 71.

From Page 98

(1) Exactly right. It is very dangerous to attempt to generalize the training results in one organization to trainees in another without a needs assessment.

This generalization from one organization to another is what Goldstein calls inter-organizational validity. The point made here, as was made above, is: Do not borrow the results from one level of validation and apply it to another. Do not assume you have an intra-organizationally valid training program when all you've conducted is performance validation.

Let's pause for a moment and look at a question which should be foremost in our minds. That question is: How does this affect me as a human factors specialist? The answer to this can be found in Army Regulation No. 602-1, 'Human Factors Engineering Program.' Summarizations of some HFE responsibilities in this document are the following:

(1) Coordination with other agencies in determining the needs for, and then developing and evaluating job procedures, performance aids, training devices and aids, equipment, and technical publications.

(2) Assessing the training burden which competing material design concepts may impose on the military.

(3) Developing the information needed for new or revised training plans, courses, or programs of instruction as required by new or modified material, doctrine, or organization.

The information presented thus far will assist you in accomplishing these missions. The preceding lesson showed you how to assess training needs. This lesson will guide (or assist) you when training evaluation is required. Be aware, however, that training evaluation is highly technical and requires a professional to conduct it. The remainder of this lesson will cover training devices and your role in their development.

In recent years the Department of Defense has placed increased emphasis on using sophisticated simulation training devices rather than actual equipment for the training of complex tasks. Ideally, the development of these training devices is guided by training requirements, which are in turn determined by task analysis. Let's take a look at simulation--its theory and its application.

(GO ON TO THE NEXT PAGE)

From Page 86

As you may recall from the last lesson, simulation training is merely one of several different methods. Why is it so important? Its importance lies in the fact that for complex tasks it is often the 'best' method. Think about what you know of simulators and answer the following question. What do you think are the major reasons for selecting simulation as a training method?

- (1) Safety considerations. Turn to Page 36.
 - (2) Controlled reproducibility. Turn to Page 74.
 - (3) Cost. Turn to Page 49.
 - (4) All of the answers listed here. Turn to Page 61.
-

From Page 16

(3) In between what? The question requires an answer in one direction or the other, not both. In this course you can't have your cake and eat it too. Return to Page 16.

From Page 32

(3) You obviously read the news when they advertised for astronauts, but you didn't when they told of the years of training required. Return to Page 32 and try again.

From Page 77

(2) Good show, you're absolutely right. It is fundamentally important that a maintainer be able to gain access to the equipment he/she is to maintain. Thus, one principle of designing for maintainability is to design for accessibility.

Poor accessibility to routine service points and parts of equipment reduces the efficiency of the maintenance operation, while increasing the time required for maintenance. If service points are difficult to reach or use, routine maintenance tasks might not be performed as required, or they might not be performed at all. Thus, accessibility is an important feature that should be taken into consideration when designing for maintainability.

Another important factor to be considered in designing for maintainability is ease of replacement. Once a malfunction has been diagnosed, the next logical step is to correct that problem. The most obvious way to minimize the system's 'downtime' (the total time a system is down (inoperative) for active maintenance) is to design the system so as to provide for easy replacement of malfunctioning parts. There are a number of design recommendations that should be used as 'rules of thumb' when planning for the replacement of units. Which of the following recommendations would you consider to be important for ease of replacability?

- (1) Locate each unit in the equipment in such a way that no other unit or piece of equipment has to be removed to get to the unit. Turn to Page 85.
 - (2) If it is necessary to put one unit behind another, the unit requiring less frequent attention should be placed behind the one requiring more frequent attention. Turn to Page 13.
 - (3) Do not put a unit in a recess, or behind or under other structural units, floor boards, operators' seats, hoses, pipes, or other equipment parts that are difficult to remove. Turn to Page 98.
 - (4) All of these answers are important 'ease of replacement' recommendations. Turn to Page 81.
-

From Page 2

(2) This answer may sound correct, but rather, it is a correct definition of maintenance, not maintainability. Return to Page 2.

From Page 91

(3) This is very true, but not the only answer. Return to Page 91.

From Page 74

(1) This is the wrong answer. Nothing was said about a fire hazard.
Return to Page 74.

From Page 35

(2) Reallocating functions may be the answer, but it might not be the best.
Return to Page 35.

From Page 25

(4) This example wasn't a signal detection experiment. Try again. Return
to Page 25.

From Page 55

(2) Exactly right. We doubt that you'll find an organization that is interested primarily in training validity (with the exception of a school). Most organizations want an indication that job performance will improve.

As you recall, before developing any training program, a series of analyses must take place. This is often referred to as a needs assessment. You examine what tasks are required, the importance and frequency of each task in the ultimate setting (whether that be a final exam or on the job), and how difficult it is to learn how to do a given task. In addition, you need to assess the characteristics of the trainee population. The task inventory that is used for other purposes, such as design and workload analysis, is the same one that you would use for training analysis.

Before you can hope to establish acceptable training validity, both the task requirements and the trainee population characteristics need to be assessed. Using only these two analyses would prove insufficient to establish performance validity. Why do you think we say this?

(1) Because history has shown that training programs which ignore organizational analysis fail in achieving high performance validity. Turn to Page 40.

(2) Since performance validity is concerned with the transfer of learning to another environment, you must know something about that environment. Turn to Page 63.

(3) Because there are system-wide components in an organization which affect performance and are not included in task or trainee characteristic assessment. Turn to Page 89.

(4) All of the answers listed here. Turn to Page 98.

From Page 11

(3) Right on. Each hazard discovered should first be grouped according to its severity ranking.

The first thing you would do in a hazard analysis is to fill out a data form such as Figure 27.3 for each hazard identified. Next, you would rank each hazard or group the hazards according to their severity. Now you can continue the evaluation by analyzing similarly ranked hazards. If, for example, there were no observed hazards, and hazards A, B, and C had all received a rating of catastrophic, what would your next step consist of?

- (1) Ranking these hazards (A, B, and C) according to their probability of occurrence. Turn to Page 93.
 - (2) Determining the cost of corrective action for each hazard (A, B, and C). Turn to Page 40.
 - (3) Reevaluating these hazards (A, B, and C) until there were no tie ratings. Turn to Page 59.
-

From Page 17

- (2) This is not correct. We suggest that you review the material in Lesson 3. Return to Page 17.
-

From Page 30

- (1) A difference threshold is one of the types of values that we will be discussing, but the present example doesn't depict this type. Return to Page 30.
-

AD-A132 561

HUMAN FACTORS ENGINEERING A SELF-PACED TEXT LESSONS
26-30(U) HUMAN ENGINEERING LAB ABERDEEN PROVING GROUND
MD R BROGAN ET AL. AUG 81

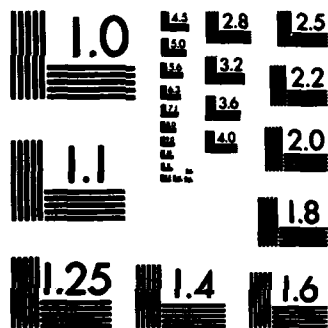
2/2

UNCLASSIFIED

F/G 5/5

NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

From Page 92

(1) Very good, you are exactly correct. Keep up the good work.

After you have grouped the hazards according to severity and probability of occurrence, the next step is to evaluate according to costs. To keep to our hazard example, suppose after you ranked hazards A, B, and C for their probability of occurrence, you found that hazards A and B were imminently probable. Then you were informed that the costs required to fix hazard A were far more than the budget allowed. You would rate hazard A's costs as prohibitive. Hazard B, however, would only cost a minimal amount. What action would you recommend for hazard A?

- (1) Take immediate action. Turn to Page 57.
 - (2) Defer action. Turn to Page 45.
 - (3) Analyze further. Turn to Page 73.
-

From Page 11

(1) This isn't the first grouping. There is a more important category than cost. Return to Page 11.

From Page 38

(1) It would be unlikely that the number of misses would increase even through the false alarms probably would. Return to Page 38.

From Page 72

(1) Exactly right. Describing those aspects of a job which are critical for job success is the main purpose of a job analysis.

A job analysis produces a job description. For example, for the operator of our coastal defense system, the job description might include the following: operates air search radar for detection of enemy aircraft and missiles, directs the use of antiair weapons, tracks air targets, identifies targets as hostile or friendly, etc.

The third analysis of this series has been called person analysis by some researchers. However, we think you will recognize this third training analysis as task analysis, which was discussed in Lessons 23 and 24. In doing this analysis the job requirements must be translated into human attributes required to perform given tasks. One facet of this analysis is an examination of the performance capabilities of your available population. You must know whether or not the required behavioral characteristics are already within the individual's capabilities.

Let's talk about actual procedures that you as a human factors specialist would follow. Remember, you're trying to identify the people who will operate this system and determine how best to select and train them.

As a human factors specialist you will draw information from many sources—from the systems design team, from mock-ups, from prototype tests, and from field experience. In addition, there is a series of documents you will need to examine to initiate your staffing study. Figure 28.1 summarizes the following discussion.

There are four basic documents with which you will be concerned: engineering drawings, operational and maintenance scenarios, reliability analyses, and operation manuals. These documents are referred to as basic source documents.

Engineering drawings provide the human factors specialist with information about location and dimensions of work stations, the nature of the work environment, and other valuable information which allows him to make inferences about the duties and sequence of tasks an operator maintainer will follow when involved with a system. If these drawings indicate probable trouble spots, the human factors specialist must propose solutions (using the same alternatives as shown in DI-H-7058) at this stage to prevent later problems.

(GO ON TO THE NEXT PAGE)

From Page 94

The second source document a human factors specialist needs to examine is the operational and maintenance scenario. This document will detail how the system will be used and maintained when it is put into operation. The variations in system load will be addressed. What will the impact of war be on the system and its operators and maintainers? Will there be certain peak periods? If so, how can we provide for this?

If you were a military manpower analyst, how would you provide for peak periods?

- (1) By manning systems with people capable of using them in a wartime scenario. Turn to Page 9.
 - (2) By providing the minimum number of personnel required for peacetime operations and increasing the training of these people. Turn to Page 59.
 - (3) Since peak periods occur so infrequently, it is not cost effective to man a system this way. Turn to Page 38.
-

From Page 41

- (3) A difference level is established by using the classic psychophysical methods, not the direct scaling methods. Return to Page 41.
-

From Page 74

(2) Right. By asking the old stand-by questions 'What are the limitations and capabilities of the human?' and 'What are the human performance requirements?' Human factors specialists discovered that the operations of this system might be required to escape. However, the humans inside the structure didn't have the capabilities to do so. The situation was soon remedied.

Well, we once again come to the end of a lesson. You've learned about hazard analysis and, probably, have acquired a 'hazard awareness' in the process. We hope so, anyway. At least I. M. Eager did. After taking this lesson, he immediately went over his design for the super helo and reanalyzed it for safety. He discovered that while his helo had land, air, and sea capabilities, it didn't have an air-lock. Therefore, his sea capabilities would have required fish for crew members, because humans would have been up to their neck, so to speak, in water.

See you next lesson where you will learn everything you ever wanted to know about training but were afraid to ask.

From Page 58

(2) The workers most removed from day-to-day maintenance operations possess a considerable amount of expertise because they handle the most technically sophisticated maintenance. Return to Page 58.

From Page 63

(2) You're way off. Physical fidelity is quite often important whether you are dealing with part or whole simulation. Return to Page 63.

From Page 66

(2) The workers most removed from day-to-day maintenance operations possess a considerable amount of expertise because they handle the most technically sophisticated maintenance. Return to Page 66.

From Page 91

(4) Very good. The main point here is that you must examine all variables if you desire success.

Assuming we account for the organizational variables, our next concern is intra-organizational validity. This type of validity assumes that we have established training and performance validity, and are now concerned with predicting the performance of a new group of trainees. This is a primary goal of many corporate training programs. This is ordinarily the level of generalization desired. There are several factors which must be considered. First, you must be certain that the various components of your needs assessment have not changed. You must also be certain that your training program has not changed. Finally, the value of your generalization from performance validity to intra-organizational validity rests on how well your original evaluation was conducted. It should be clear that the higher the quality of the training and performance validity, the easier it is to generalize.

Imagine the following situation. A corporation has developed a training program for its accountants. Training, performance, and intra-organizational validity have been established. You are in business for yourself (not the same business as the corporation) and you feel you need a training program for your accountants. Do you think it wise to generalize the validity of the corporation's training program?

- (1) No, since the needs assessment and evaluation have not been performed for your organization. Turn to Page 86.
 - (2) No, since the tasks which need to be taught are different. Turn to Page 48.
 - (3) Yes, since the tasks requirements are essentially the same. Turn to Page 59.
 - (4) Yes, although you must take into account any difference between the two organizations. Turn to Page 7.
-

From Page 88

(3) While you are partially correct in assuming that this answer is important in designing for maintainability, it is not the best answer provided here. Go back to Page 88.

From Page 11

(2) This isn't the first grouping which needs to be made. There is another category which is of higher priority than the probability one. Return to Page 11.

From Page 58

(2) This is not the right answer. If you are guessing, it might be a good idea to go back to Lesson 16. Return to Page 58.

From Page 74

(4) Nothing in this situation indicated that training or expertise was deficient. There is a structural problem here, not a personnel one. Return to Page 74.

From Page 41

(2) This is the rationale behind the estimation methods. The production methods require more active participation on the observer's part. Return to Page 41.

END

FILMED

9-83

DTIC