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A METHOD FOR MAN-MACHINE TASK ANALYSIS

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FOREWORD

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ABSTRACT

This report describes a systematic procedure for making a task analysis of the operator's job in any man-machine system. The quality and quantity standards defined for the man-machine system are analysed into constituent variables or functions. The operator is treated as part of the system's linkages from input-to output functions. Information displayed to the operator is analysed into essential discrimination requirements; control activations necessary to control the machine's outputs are analysed into component "effector" or response requirements. Other behaviors include "discrimination of response adequacy," "memory storage," "decisions," "coordinations," "anticipations," and "characteristic malpractices." Tasks are differentiated into discontinuous (procedural) and continuous (tracking). Formats for making the analysis are provided. The method, although of general applicability, is specifically designed for use by trained specialists in planning for training and training equipment. Associated procedures are described in WADC Technical Reports 53-135, A Method for Determining Human Engineering Design Requirements for Training Equipment; 53-136, Handbook on Training and Training Equipment Design; and 53-138, Human Engineering Design Schedule for Training Equipment.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

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A METHOD FOR MAN-MACHINE TASK ANALYSIS

The general purpose behind the development of these task analysis procedures was to fulfill the need for specifying training requirements in relatively detailed and unambiguous psychological terms. It was necessary that this procedure provide behavioral data about jobs even when the job was not yet performed by any persons, as for example when equipment was in blueprint and breadboard stages of development. On the other hand, it was also necessary that the procedure be adaptable to additional sources of information about job performance if such information could be obtained.

The application of the procedure is intended as follows. A task analysis of the man-machine job will be made from operational equipment. If this equipment is in actual use, the analysis will be comparatively easy, complete, and accurate because supplemental observations can be made of the operator performing the task. However, the task analysis procedures may be used to _anticipate_ job requirements by applying the technique when operational equipment is in such early developmental stages as blueprints and specifications, or pre-production prototype. In other words, this procedure can, with some limitations, be used to forecast a job before any operator has ever performed that job. The analysis can be just about as complete and accurate as design engineers are able to forecast the operating characteristics of the equipment which they are developing. From the task analysis of the operational equipment, decisions will be made as to which tasks will be trained, and to what degree, on a proposed training device. The task analysis will then be used to guide specifications in the design of the training device. This guidance will be directed towards presence or absence of various hardware items, and to the functional characteristics of those items which are provided in the training device.

These task analysis procedures may (and should) also be applied to the training device in order to determine what task requirements it imposes on the student-operator. This analysis may be performed on the training equipment during its blueprint, prototype, and production model stages. The purpose of this analysis would be to compare the behavioral demands of the operational equipment with the behavioral demands of the training device. The matching of these two sets of analyses would be made according to variables and criteria set down in the _Human Engineering Design Schedule for Training Equipment_. The _Design Schedule_ has been prepared as a companion for this method of task analysis. The extent to which the comparison of tasks (based respectively on operational equipment analysis and training device analysis) indicated behavioral overlap would be the extent to which transfer of training could be expected from the training device to the operational device. The interpretation of this overlap would be aided by the _Handbook on Training and Training Equipment Design_.

I. GENERAL STATEMENTS ABOUT TASK ANALYSIS

A. PURPOSES TO BE SERVED BY TASK ANALYSIS

The preceding general statement of purpose may be amplified into a number of considerations. These are stated as follows:

1. To determine the psychological factors essential to criterion performance of an operational task.

2. To describe these essential psychological factors in a way such as to permit statements to be made about the design requirements of a training device intended for the job or task.

3. To describe these psychological requirements in a way so that relevant research literature and findings may be made applicable to specifications of training devices and their optimum use.

4. To define the critical psychological activities occurring in the operational or training situation in such a way as to provide a sound basis for scoring and knowledge of results. This definition should specify what behavior components should be measured (or scored) and also in what kind of units. Scoring and knowledge of results, it is assumed, should serve for more than merely to rank students according to relative "proficiency" values. It is here regarded as of equal or greater importance that scoring and knowledge of results be such as to guide the trainee most effectively to better performance in the course of training.

A number of secondary purposes may be cited. A thorough task analysis may be used as an aid in modifying job operations so as to make their performance more simple and less liable to error. In some cases, such an analysis may show that a proposed organization of tasks is an unrealistic imposition upon human capacities, even at high levels of training. If such a recognition is achieved early in the development of operational equipment, design modifications may be suggested which impose less stringent demands upon the operator while achieving the same operational objectives. Furthermore, a task analysis obviously provides a basis for setting up a training syllabus. Although the principal intent of the procedures described herein is to provide one source of data leading to the design of training equipment, the same process should produce data for optimal use of the training device, and even for collateral classroom training materials.

Some statement should also be given as to the reasons for preparing so formal and explicit a technique for performing a task analysis as is described in this report. One of these reasons is to provide a consistent framework of definitions and processes for the guidance of the analyst. The method is intended to help the analyst remember what to look for and record in a thorough fashion. By using a self-consistent, methodical technique, the task analyst can not only be relatively assured of thoroughness, but also of progressive ease and skill as he gets practice in this method. An additional advantage derives from a technique which, in itself, aids in relating and organizing, in a psychologically meaningful way, the multitudinous behaviors of a complex job so that the behavioral processes and continuities as such may be revealed.

A special reason for the method proposed here, however, is that by it the fortuitous or incidental aspects of the human operator's response may readily be differentiated from the essential response demands imposed by the operational equipment. A strictly empirical procedure of watching what particular operators do, even though their skill be unusually high, may often fail to provide a distinction between response components which are sufficient and necessary for successful use of the equipment and those response aspects which are incidental, or even a hindrance, to effective performance. The present procedure directs attention to those discriminations, decisions, and muscle responses which are critical to each immediately antecedent event in the chain of events from the final criterion output of the man-machine combination back to the environmental stimulus which presents the "problem" or need for action by the man-machine team. Because these procedures help to trace man-machine "functions" from work done by the man-machine system (system outputs) to the problem fed into the system (system inputs), a more descriptive title of the method might have been "Functional Task Analysis."

B. WHO WILL USE THESE TASK ANALYSIS PROCEDURES

It is felt that the analysis of human behavior requires a specialist in much the same way that the analysis of machine behavior requires a specialist. In fact, the complexities of human behavior, its great capacity for varied response and its information-handling capacity, may make it even more deserving of a technical specialist.

It is therefore recommended that the following procedures by used by specialists in human behavior. These specialists will presumably be engineering psychologists with special experience in the field of human learning and transfer of training.

It is not proposed that, because task analysis procedures have been formalized in the following pages, task analysis has been reduced to no more than a rote or mechanical process. The procedure must rather be considered a guide to observation and analysis, not a substitute for it. It should permit an orderly approach to the determination of highly complex behaviors, many of which may interact with each other in job performance. We can hope that as additional information about various tasks becomes available through the use of these and related procedures, task analysis can become more and more routinized so that eventually people with less specialized training can perform task analyses appropriate to their purpose.

C. GENERAL APPROACH TAKEN IN TASK ANALYSIS

Task analysis (as proposed in this exhibit) is both a rational and empirical method. It can be used in the absence of empirical data about job performance on the basis of the following rationale: The behavioral requirements of a man-machine task are given by the equipment itself in the form of (a) the displays from which the operator must make essential discriminations, (b) various response alternatives from which decisions by the operator select a course of action, and (c) the controls which must be activated in certain ways in order that the machine will produce the criterion output intended for it within the quality tolerances specified for it. More simply stated, the way the machine is built and has to be used determines what the operator has to do. The study of the display-control characteristics of the machine into which the operator is fitted as a critical linkage or channel provides data from which behavioral requirements may be directly inferred. These inferences may remain defined by the job and task operations with a minimum of abstracting into general human traits or attributes.

One assumption accepted by task analysis is that the operational equipment will be taken as a given. That is, if the operational equipment is poorly designed from a human engineering standpoint, the task analysis will still be based upon that equipment, poor though it may be. Task analysis may reveal that operational equipment <u>is</u> poorly designed for the operator, and may show <u>why</u> it is poorly designed. But the analysis, per se, will be a statement of the task requirements of the equipment as it stands. Should it be modified, a modified task analysis would be in order.

The criterion output of a machine usually consists of several variables. That is, the quality of the man-machine output usually depends on a number of relatively independent factors. The operator is usually a critical link in each of these factors or variables, either by directly controlling it or by monitoring the machine's control of it. Task analysis is thus combined with operations research as a procedure and seems potentially to be capable of quite as rigorous solutions.

Task analysis consists of the enumeration of the discriminations, decisions, and action responses which are necessary and sufficient to operate the mechanism presumably within the tolerances allowed the man-machine combination. These behaviors are grouped in two ways: by their systems purpose and by their relation to each other in time.

Each separate variable in the machine's controlled output may be considered a purpose or function of the system. Each function has an input to the man-machine system; the output aspect of the function is a work variable of the machine. The man, as a link in this function, has inputs via displays and outputs via controls. These inputs and outputs respecting the man figure in the functional description of behaviors.

Various functions (and tasks describing the man's participation in these functions) overlap in time. It therefore becomes necessary to determine these behavioral overlaps in order to get a correct view of the psychological complex or "loads" which the operator has to carry during his job performance at various times.

Task analysis should therefore provide both a longitudinal and cross-sectional analysis of job behaviors with respect to time.

But the human operator has error systems and tendencies not all of which can be forecast from our present knowledge of him as a mechanism. These error systems are combined functions of relatively stable, built-in characteristics and limitations plus individual experiences, degree and kind of training, and methods by which the operator attempts to do his job. Empirical data in the form of "critical incidents" in which the representative student or operator was observed to make serious errors in some combination of discriminations, decisions, or motor actions should be gathered if possible to supplement the behavioral analysis. The more reliable the observer the more useful these incidents may be. It should be remembered that the malfunctioning of a man-machine combination may be remedied by redesigning the machine, change in selection or training of the man, or redesign of the method whereby the man and machine interact.

In any event, when empirical operator error data are available, they should be included in the task analysis so that they may be included in plans for selection and training. The term "training" includes the design and use of the training device.

Some of the advantages of setting up and following a formal procedure in task analysis should be enumerated. They are as follows:

1. Reliability. A technique which is made explicit can be checked for methodological flaws. In addition, various individuals can apply the method to the same problem to determine comparability of data obtained by the method.

2. Consistent levels of description. The use of previously agreed upon definitions and concepts makes more possible the comparison of one task with another and of one job with another.

3. Guide to thorough analysis. A formally stated conceptual structure to be followed in any given analysis helps to remind the analyst of the variables whose values need to be described.

4. Control of specificity in behavioral description. A sound format for analysis should provide not only internally consistent levels of behavioral description, but allow behavioral analysis to be "open-ended" insofar as specificity is concerned. The procedures will guarantee that at any molar level, the analysis will be complete, no matter to what extent certain portions of the molar analysis have been continued into molecular analysis.

5. Ease of conceptualization of the job complex. Mere enumeration of behaviors without a method of coding these behaviors makes practically any job seem almost overwhelmingly complex. A functional analysis which stresses inter-dependent processes and continuities of action and action linkages reduces the risk of semantic confusion.

II. DEFINITIONS OF TERMS AND CONCEPTS

In order to avoid, or at least reduce, unnecessary vagueness in the discussions it becomes desirable to define the key terms which will be used. The more inclusive the class, the less precise will the definition tend to be. It is hoped that some of the following terms may become, in the context of this research area, somewhat more standardized and more rigorously and operationally defined than by the following statements.

It should at once be pointed out that the terms "job," "job segment," "function," and "task" are necessarily relative to the system under examination. Thus what is a task in one stage of analysis may conceivably be function in another stage of analysis. It should be remembered that the concepts of job, function, and task are those of descriptive convenience for the purpose of ordering the behaviors described under discriminations, decisions, and effector activities or actions. Thus we may think of the terms job, job segment, function, and task as requiring "analytic" definitions, whereas behaviors (in our framework) will be operationally defined both in describing the procedure of analysis as well as in using the procedure.

Job: The job is defined as the sum-total of requirements, responsibilities, and tasks assigned to a given position in a work-structure. It consists of the total requirements of a position (such as F-84 pilot) during on-duty hours or such time as demand for the person's performance is in effect.

Job segment: A part of a job leading to a terminal output with goal importance. In man-machine task analysis, the job segments with which we are principally concerned are those dealing with the equipment for whose use the operator is responsible. What is defined as a job segment is a matter of convenience, and thus should be treated as arbitrary rather than absolute. The distinction between one job segment and another in analysis of a job is also arbitrary. No time restrictions enter into the definition of a job segment.

Examples: Pilot- (1) Flies an airplane on a "mission" from origin to final destination (which may be point of origin.)
(2) Commanding a crew to coordinate and accomplish a mission
(3) Communicates information to outside agencies

Job function: A variable in the man-machine output in which the man is a link necessary to adequate quality control. (Examples of job functions in a computing machine-gun include azimuth and elevation tracking, "smoothness" of tracking rate, ranging, and triggering.) Note that these job functions are also system functions. We give them the name "job function" when we are speaking in the context of the operator's activities. In other words, a job function is a part of a system function which is localized in the man. Whether or not the bullets hit the target is a joint function of the values which the man-machine combination put into these variables. The error tolerance for success is the size of the target. Other variables, such as the built-in characteristics of the bullets and the gun, which act in an unsystematic way are outside the control of the operator, and thus are not included as job functions. The contribution of these variables not controllable by the operator may be measured and included in the tolerance ranges by which the ceiling proficiency of the operator is defined.

The concept of job function should be a convenient one for tieing in the actions of the operator with the action requirements of the machine. Job functions are obviously analysed on the basis of man-machine systems variables and not primarily on psychological variables. They are part of the "longitudinal" analysis of job requirements. A number of job functions may intersect in the performance of one task.

The functions of a man-machine system cannot be determined unless the system criterion output is operationally defined. The system's criterion output should be a simple statement which identifies what the system is intended to do. (An example of the criterion output of a bombing system is "30 mil bombing accuracy"; of a gunnery system: "20 mil accuracy at relative speeds of target and gun platform up to 1200 miles per hour.") The system's criterion output is further defined by identifying the variables or functions which contribute to that output. Characteristically, any system function can be isolated by the input-output linkages within the machine which control some variable in the criterion output of the machine.

Task: A group of discriminations, decisions, and effector activities related to each other by temporal proximity, immediate purpose and a common man-machine output. It may occur within 1/2 second or require several minutes for execution of one cycle.

Examples: Gunnery: Identifying, tracking, ranging, and triggering on a target during one attack in order to shoot it down.

Radar bombardier: Identifying target on a radar scope and making appropriate instrument settings for bombing.

Pilot: (1) Perceiving enemy on tail, executing roll and dive in order to escape fire.
(2) On signal, executing bank and turn of 180 degrees in order to change direction of airplane movement.
(3) On signal, starting airplane in preparation for take-off.

Note that a task has a goal. The more precisely the goal is defined, the better it can serve as a criterion for performance effectiveness.

A task may include several job functions, and probably will, although not necessarily in absolute simultaneity. The name given a task is rather arbitrary. Once the man-machine purpose of some identified task becomes stated, the behaviors which must necessarily be included in that task become operationally determined.

Future work in task analysis may provide principles whereby behaviors can be organized into groups on a psychological basis which can be generalized to many task situations. The concept of "task" may then become more rigorously defined by prescribed sets of operations. For example, span of apprehension or perhaps "span of motor anticipation" may at some future time prove a practicable psychological basis for providing some criterion of a task independent of the specific problem at hand. At present, however, it is offered as a shirt-sleeve concept to meet practical problems in linking task analysis to training requirements.

Sub-task: A form of task in which the occurrence or conclusion of one response is the cue for a second response which may be in turn the cue for the next response and so forth in a relatively invariant sequence of responses. The series may be automatic after being triggered off, or there may be conscious direction (verbal intermediation) between each response, or some of both may occur within one sub-task. The term is coined for convenience in the performance of a task analysis.

Example: Starting a car: (1) Put gear shift into "Neutral" position; (2) turn ignition key "On"; (3) Press starter button . . . .

Job Behavior or Behavior: Any human action in the context of job function, task, or sub-task. Generally a behavior is defined by a stimulus and a response and usually implies a goal or purpose but not necessarily so.

Discrimination: The process of responding differentially or selectively to one cue (or set of cues) in a context of other cues. This definition is intended to cover so-called discrete or relational cue-situations. The response may be in the form of "recognition" or "identification" of what is perceived or it may be simply responding to presence or absence of a cue. A discrimination may occur without the person being able to report the nature of the discrimination, that is, he may make a differential motor response to the cue without awareness of the action or its stimulus. Furthermore, the cues discriminated may function as symbols (spoken words, map contours, etc.) or be primarily responded to according to their sensory character (an enemy airplane approaching an aerial gunner's range.) Discriminations are made from signals or cues displayed to the operator.

Decision: The process (or product of that process) of selecting, symbolically or otherwise, one of various courses of action open to the individual. ("Sitting still" or "lying down" is included as a course of action here.) In general, a mediating or symbolic process is implied; that is, we will regard decision-making as a conscious phenomenon implying volition and choice. The basis of choice will be regarded as being regulated by: (a) Perception of cues as immediately given; (b) Transfer of direct experiences associated with the respective perceptions; (c) Transfer of symbolic experiences associated with the respective perceptions; (d) The motivational pattern dominant at the moment.

Effector activity: Any motor response instrumental in progress towards achieving the task goal. The context of the present problem deals almost exclusively with the use of equipment in achieving goals, therefore, in general, an effector activity will involve the manipulation of equipment controls. The term is extended to include speaking into a transmitter or otherwise transferring information relevant to operations of the man-machine system, when other men are regarded as part of the system.

Proximal stimulus: An arbitrary term coined for shorthand convenience to refer to such stimuli as provide sensing the presence, location, or identity of a given task. Feedback originating in an output of an operator which does not result in the machine's doing any work, the results of which are fed back to the operator, will be included as a proximal stimulus. Thus the knob shape of a control which permits the operator to identify it would be a proximal stimulus. The resistance to initial movement of a control should probably be considered a proximal stimulus.

Distal stimulus: An arbitrary term coined for convenience to refer to a stimulus which incites a task performance and is different from those stimuli associated with sensing the presence, location or identity of a control used in that task. Feedback which involves action by or through the machine will be considered a distal stimulus.

If there is doubt as to whether to use "distal" or "proximal" in describing a stimulus, it will be better to avoid either term and describe the stimulus with more concrete adjectives.

Program: It has been found convenient to coin some technical word which can be used to refer to sample stimulus configurations which may occur in operational conditions, or which may be devised for training purposes. The term "program" will be used in this technical sense, unless qualified and made appropriate to some other context.

Time-sharing: Activities which go on at or about the same time. Thus, task analysis may show various sequences of behaviors within tasks. Various system "programs" will show what tasks and behaviors may occur at about the same time and thus share in the operator's time for response. Time-sharing does not pertain only to motor-activities but includes perceptual and decision-making behaviors.

Procedural task or procedure: A procedure is a kind of task in which discrete, principally all-or-none, responses are made to given cues, or to specific values of cues in a continuous series of stimuli. Procedures are verbally mediated (that is, voluntarily instigated and directed) early in the process of learning them. During such stages they are rather highly generalizable from one situation to another which may vary in several ways. If procedures involve relatively invariant sequences of response with a minimum of decisions required within the sequence, a high degree of practice may make a procedure relatively automatic (unmediated) at which time less positive transfer to different situations can be expected, especially if the operator is under heavy performance load.

Procedures as here defined are also synonymous with the term "discontinuous task" as sometimes used in the psychological literature. (See Handbook on Training and Training Equipment Design sections for more detailed information about "procedures".)

Continuous feedback skill: A performance involving continuously changing response to a continuously changing stimulus. ("Continuous" refers to the maximum continuity capable of the human operator as a system.) The response is a continuous adjustment to a changing error signal which is fed back to the operator. The ordinary tracking task is an example.

Continuous feedback skills may differ in the amount of operator anticipation which is possible on the basis of the programs presented in operations or known to occur. A sine wave is completely predictable whereas the track of an evading enemy aircraft is less so. Continuous feedback skills also may be divided into "pursuit tracking" and "compensatory tracking." In "pursuit tracking" the operator must eliminate error between a moving target and a moving cursor under his control. Gunnery tracking is an example of pursuit tracking. In "compensatory tracking" the operator must move his controls so as to keep a moving target on some zero reference point in his display. Examples are: (a) bombardiering in which the target must be kept on the cross-hairs of the scope, and (b) keeping the artificial horizon and the "little plane" lined up on the artificial horizon indicator. As Senders and Cruzen[1] point out, the differences between these two kinds of task are only of degree. In many practical situations the same display may require both kinds of performance. In general, visual pursuit tracking is more accurate than compensatory tracking,[2] and may have somewhat different learning characteristics. In the former, the operator can better predict future motion.[3]

The principal basis for distinguishing between "procedures" and "continuous feedback skills," is the practical one that they seem to show somewhat different transfer of training characteristics, as well as posing different training problems.

Accordingly, the method of task analysis for procedural performances is different from that for continuous feedback skills and separate formats have been prepared. The detailed reasons for the distinctions will appear in their respective rationales.

The general approach taken in the proposed method of task analysis is that a behavior can operationally be defined by the stimuli, the response alternatives (if any), and the effector activities which are involved in that behavior. If the operator uses machines or equipment, the task-relevant discriminations will be based on displays of information or cues and the task-relevant responses will be controls activations. If it is possible to determine the critical figure-field differentiation which the operator must make in a given behavior, the discrimination which he must learn and make in performing the task is thereby defined.

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1 Senders, J. W. and Cruzen, M. Tracking performance on combined compensatory and pursuit tasks. WADC Tech. Report 52-39, Wright Air Devel. Center, Air Res. and Develop. Comm., Wright-Patterson, AFB, Ohio, Feb. 1952.

2 Poulton, E. C. Perceptual anticipation in tracking. Med. Res. Council, A.P.U. 118/50, Applied Psychol. Unit, Cambridge, England, Aug. 1950.

3 See Handbook on Training and Training Equipment Design, Section V.C.2.e.

III. TASK ANALYSIS METHODS

The following description of task analysis procedures is intended to serve as a guide rather than as a routine or apothecary's prescription. Particularly with respect to tracking kinds of task, it is doubtful if such a prescription, even if it could be written, would not be so cumbersome as to be inefficient, or risk losing sight of the behavioral processes among a large group of categories. It should be emphasized that a form or a procedure should not be allowed to tyrannize over every problem encountered. If so there is the risk that the job of filling out the format becomes more complicated than the information which is recorded. A form is inflexible because it is a mere object; users of forms may be inflexible or flexible, and should be adjured to be the latter if there are grounds for it over and above the reasons for following a formal procedure as given on page 2. Certainly the width of a ruled column should not determine the relative importance or amount of what is written in that column.

Two supplementary procedures for task analysis are offered. The second format which provides for analysis of continuous tasks is the more general procedure and could be applied to analysis of procedural tasks with the omission of various categories. Because procedural analysis is a somewhat simpler exercise than analysis of continuous tasks, it will be presented first. Even jobs which require tracking skills usually will also include some procedural tasks.

A relatively simple and informal statement of the procedure of making a task analysis may be a desirable prelude to the details of the formal procedure.

1. The first step is to specify the man-machine system criterion output. A single, elementary statement should suffice. This output should be stated according to a criterion of overall quality, such as permissible error in a given gun-laying system.

2. The next step consists of determining the system functions. These are the variables in the machine's output which are necessary and sufficient to control the quality of the overall output.

3. Trace each system function to the machine input or control established for the operator to activate. The description of this control and the manipulations necessary for given machine output variation provide the statements which include the effector activities required of the operator in the job segment.

4. For each respective function determine what information is displayed by the machine to the operator whereby he is directed to appropriate control activation (or monitoring) for that function. These data provide statements about the discriminations which the operator will have to make.

5. Determine what indications of response adequacy in the control of each function will be fed back to the operator. These data will also be

included in the discriminations the operator will have to make.

6. Determine what information will be available and necessary to the operator from the man-machine "environment." The environment consists of any processes affecting the system but not included in the definition of the system. Also include stored information which may be essential to the operator for making discriminations or choosing from various response alternatives. These data should provide the programs, situations, or problems which the operator will encounter as part of the system.

7. Determine what functions of the system must be modulated by the operator at or about the same time, or in close sequence, or in cycles. The behavior groups associated with these combinations of functions may be called tasks, and labelled according to some subpurpose which they fulfill within the system.

8. In reviewing the analysis be sure that each stimulus is linked to a response and that each response is linked to a stimulus. A statement of the critierion of response adequacy (related to the system criterion) for each behavior will tend to insure that it is task relevant.

A. TASK ANALYSIS OF PROCEDURES

This analysis is conducted in two phases. The breakdown is almost entirely for convenience and is made in order to avoid needless repetition in setting down behaviors. One phase consists of a method for analyzing system and job functions; the other consists of analysis of tasks and sub-tasks within a given job function.

1. Job function analysis

a. Starting and stopping procedures

One rather simple division of tasks dealing with machines, although easy to make, does not fit easily into other principles of division. This division consists of starting or make-ready procedures, "operating" procedures, and stopping or shut-down procedures. Make-ready and shut-down procedures are usually specified in more or less general terms by the equipment manufacturer. Technical orders, operating instructions, or demonstrations by competent operators should provide the necessary job data, although supplementation may sometimes be necessary.

Regard "starting procedures" and "stopping procedures" arbitrarily as job functions and analyse the appropriate behaviors under these titles. Include pre- and post-operational checks under these titles.

b. Operating procedures

Let us presume that the system criterion output has been defined formally. Under this definition list the variables which figure in the quality (and quantity) system criterion output. These are the system functions. One method for finding out these variables or system functions is to determine what controls are built into the machine for dealing with them. The controls may not be exhaustive or system functions. Some functions may have to be done by direct manual manipulation such as aiming a rifle.

When the variables are isolated, tolerance values of acceptability should be obtained. It is not the function of the analyst to set up system standards although he may assist in doing so. In cases where the system has not yet been put into actual operation, the standards selected may have to be somewhat tentative. If the system turns out a product, it may be desirable to have samples of the product which are just above and below acceptability so that suitable measurements can be made. If, however, the system controls a process, some feedback indication of output adequacy will be provided by an automatic or other inspection method concerning quality standards.

The reason that the analysis should begin with finding the system criterion output is that a yardstick is provided for determining task-relevant from task-irrelevant behaviors. By working an analysis "backward" from system criterion outputs to job behaviors and system inputs, the analyst is able to ask: "What are the causes necessary and sufficient to produce this effect?"

In most practical situations, however the actual steps required in carrying out a given procedure on a machine will already be spelled out from starting functions, to the terminal functions. We are presuming that the engineer and job designer have already decided upon the proper sequence of operations in the procedure. The task analyst may find, however, that gaps have been left, especially in the description of the display features which require essential discriminations. He will therefore need to ask questions or observe the performance of the procedure.

2. Task identification in procedures

The naming of tasks in an anlysis of procedures may be based simply on the sequence of purposes leading from starting the equipment to shutting it off. Such phrases as "Getting the materials pre-positioned," "Getting the propellers feathered," indicate such stages of purpose in a procedural sequence. Later refinements in task analysis methods may suggest that any point in a series of activities which calls for a decision as to which of several alternative sub-tasks (as defined above) should be performed is a good reference point for identifying a task.

Since task names and groupings of behaviors into tasks will be matters of convenience, task identification will be fairly arbitrary. This means that analysts of equal competence might come up with somewhat different sets of task names for the same job segment. They should not come up with different sets of behaviors when these behaviors are laid end to end from the start to the conclusion of the procedure.

Furthermore it is not necessary that the behaviors to be included in any one task must be excluded from appearing in any other task. Tasks are not necessarily mutually exclusive, since coverage of job behaviors is more important than categorical nicety.

The format for setting down the behaviors in a task analysis consists of two portions. The first, called Gross Task Analysis permits naming the major tasks required in the procedure and emphasizes the display or situational features of job behaviors. The Analysis of Sub-tasks portion of the format emphasizes the control action or response aspects of the job. The reason for this division is the convenience of referring to response patterns by code designation after they have once been described and analysed. Frequently the same response patterns are applicable to varieties of situations either singly or as combinations of response patterns.

It will probably be easier to make a Gross Task Analysis first and then complete the behavior descriptions by filling in the Analysis of Sub-tasks. Both parts of the analysis may be done concurrently, however. The reader should inspect the sample analysis included in this report (see Appendix I) for a clearer understanding of the method.

On the following pages is an item by item description of the purpose of each category in the formats, and suggestions on obtaining the data for that category. Some of the preceding statements will be repeated in order to clarify the context.

3. The categories in Gross Task Analysis

a. TASK

In this column is entered the name of the Task. If the performance of an actual task is observed for analysis, the first "mission" or cycle may provide to the observer the basis for setting down these task names. The names may be arbitrary. The tasks so named, however, should be exhaustive of those outputs, aspects, or areas of the job intended for consideration. Mutual exclusiveness of tasks is by no means necessary, since coverage of job behaviors is what is more essential. The name of the Task will usually be stated as some purpose within the job. This job purpose will call for a group of procedural tasks instrumental in achieving the purpose. These are listed in the columns and rows to the right of the TASK column. Gross tasks, by the way, may be serial or concurrent in performance.

b. DISPLAY/DESCRIPTION

In this column should be entered those task-relevant cues which initiate each task or present the requirement of a control action in order to help achieve the Gross Task. It should be noted that a display may consist of the given appearance or position of a control object, or some symbolic display as a dial or map or printed directions, or a direct display such as a landscape viewed from the air. The "display" or cue may also be in the form of information recalled by the operator, or that should be recalled by the operator.

Note: If the critical feature of the display is in a standard position relative to the operator performing the function or previous task in the series, no comment on this is made. If, however, the operator must search in the display context for the critical cues, the word "search" should be written in the box with the Display Description.

c. DISPLAY/CRITICAL VALUES

In the cells below this item there is entered the specific and essential feature, or value, or stimulus difference which provides the basis for a discrimination. This is the discrimination which leads to correct control action or a decision which leads to such action (or the inhibiting of action). It might be called the critical value of the error signal. In a procedural task as here defined, however, the discrimination will be in terms of presence or absence of a critical cue or a critical value of a cue (which operationally amount to the same thing). If the discrimination involves estimates of size or qualitative differences, the word ESTIMATED should be written in the cell* in the CRITICAL VALUE column. Tolerance limits for these estimates will be provided in the Analysis of Sub-Tasks in the columns INDICATION OF RESPONSE ADEQUACY or OBJECTIVE CRITERION OF RESPONSE ADEQUACY or both.

d. DECISIONS

In this column will be indicated the principal alternative choices which the display situation may present. These choices or alternative modes of response may be considered as tasks or sub-tasks. In many cases only one response or task is appropriate to the situation; one can say that the "competing" choices have, from a psychological standpoint, extremely small competition value. In such cases, of course, there is no point in writing down more than one task item in a given cell under DECISIONS.

The "decision" may be thought of as a mediating action in the chain of psychological events between the display or stimulus situation external to the operator and the control action of the operator's effector response. The occurrence of the decision must then be regarded as the proximate "stimulus" for the control action--that is, the execution of the task or sub-task is cued to the "decision." These mediating actions have an important bearing on training and expectations of performance and must therefore be recognized in the task as best they can.

e. TASK OPERATION OR SUB-TASKS

The code designation of the response, response pattern, or response group necessary to complete the task requirement will be put in this column. This code designation will be obtained from the accompanying page-format of ANALYSIS OF SUB-TASKS. The control actions will be analyzed on the page containing the ANALYSIS OF SUB-TASKS. That this is done on a separate page is merely for convenience since many different tasks may call for the same sub-tasks or different combinations of sub-tasks which have already been analyzed. Examination of the specimen Task Analysis is suggested for demonstration of this point.

f. CHARACTERISTIC ERRORS OR MALFUNCTIONS

In this column there may be noted, when evidence is available, ways in which the human operator may tend to fail in performing the task (error) or ways in which the equipment may fail in performing the task (malfunction). Such information would be obtained from data on the use of this or similar equipment. These data would be provided by operational log books, malfunction records, critical incidents, records of difficulties in training, and so forth. In this column would also be included precautions to be taken with respect either to making a decision or in the performance of the task.

4. Analysis of sub-tasks

The form entitled ANALYSIS OF SUB-TASKS is separated from the Gross Task Analysis form only for purposes of convenience in recording behavioral data. It is a supplementary and not an alternate form. Its principal purpose is to provide for setting down the response details of tasks, sub-tasks, or both.

It should be recalled that a sub-task is defined as a task or portion of a task which consists of a response sequence performed in a relatively invariant order and within which the preceding response provides cues for the following response. The following discussion describes what should be set down under each of the categories on the Analysis of Sub-Tasks form.

a. TASK OR SUB-TASK

In this column will be written the descriptive title of the Task or Sub-task which is to have its response or control action analyzed. In this column will also be written an identifying number which can be used on the Gross Task Analysis sheet for shorthand reference to the sub-task.

b. DISPLAY

This column will frequently not be used because the control level or object will usually be the proximate stimulus for the control action. (The distal stimulus will consist of those stimuli or display features which give rise to the decision to activate a given control or set of controls. The distal stimulus initiating the sub-task or task will usually be described on the Gross Task Analysis form.) Occasionally, however, some distal display feature may intervene in the performance of a sub-task and require modification of that sub-task. The column for DISPLAY provides for this contingency.

c. CONTROL DESCRIPTIONS

In this column will be described the control or controls instrumental in the execution of the sub-task or task. Where a photograph, or better, the actual specifications of the equipment are available, this material should be used for reference purposes. The description should be as simple as possible while making exact reference to dimensions available.

d. CONTROL ACTION

In this category is specified what human action is required on the control in order to get the appropriate machine activity for the task at hand. The description should be sufficiently explicit that a person with no previous experience with the equipment, or even similar equipment, could perform the control action on the sole basis of that description.

e. INDICATION OF RESPONSE ADEQUACY

Here is described what stimulus (if any) will show the operator that the control action he has made is, within its limits, effective. It is usually the indication of response adequacy which can and should act as the cue for the next step in the control action series.

f. OBJECTIVE CRITERION OF RESPONSE ADEQUACY

This column is used when some criterion independent of the immediate sub-task or man-machine system is available. The number of parts rejected by an inspector would be an objective criterion of the adequacy with which a worker controlled a machine operation, a criterion independent of the indications of response adequacy which his own machine might present to him. It is not expected that this column will be used extensively, and it may later be eliminated.

g. CHARACTERISTIC ERRORS OR MALFUNCTIONS

If an operator always follows the prescribed procedures correctly, assuming the procedures are appropriate, there should not be human errors. This expectation is unrealistic, however, and it therefore seems desirable to use any information which will guide training so as to minimize sources of human error which are especially prone to occur.

Some kinds of machine or equipment are more likely to be unstable or fail on certain operations than on others. Where a particular control action has this liability it should be specified. The information may be used to determine additional sub-tasks which will prevent or alleviate the problem.

5. Checking a Task Analysis of Procedures

A crucial test of the adequacy of a task analysis would consist of giving the description to a person who had never before been associated with the task and let him perform the task from this description. The only provisions would be that he be informed about the names and locations of the controls and displays and that his performance speed not be critical.

The following two pages illustrate the basic forms used for a task analysis of procedures. Appendix I provides an example of a task analysis of mimeography. Several restrictions were placed on this example so as to avoid too lengthy an example. Therefore the example as given in this appendix does not include all aspects or programs of the job of mimeography which would be covered if the purpose of this task analysis were more broadly defined than it is for the present illustrative purposes.

TASK ANALYSIS OF PROCEDURES

GROSS TASK ANALYSIS

TASK	DISPLAY		DECISIONS	SUB-TASKS LISTED	CHARACTERISTIC ERRORS OR MALFUNCTIONS
	DESCRIPTION	CRITICAL VALUES			

TASK ANALYSIS OF PROCEDURES

ANALYSIS OF SUB-TASKS

SUB-TASK OR TASK	DISPLAY	CONTROL DESCRIPTIONS	CONTROL ACTION	INDICATION OF RESPONSE ADEQUACY	OBJECTIVE CRITERION OF RESPONSE ADEQUACY	CHARACTER-ISTIC ERRORS OR MALFUNC-TIONS

B. TASK ANALYSIS OF CONTINUOUS FEEDBACK SKILLS

A continuous feedback skill involves continuous adjustments (within the capacity of the operator) to continuously changing stimulus conditions, part of which are a consequence of the operator's adjustments.

1. Functional analysis

The first step in feedback task analysis is to define the major functions of the job under investigation. These major functions may be limited to those which involve man-machine outputs in order to maintain relevance to matters of trainer design. The first order of major functions may be very few in number. Thus it appears that the major functions in driving a car (at least with respect to feedback performances) consist of accelerating, stopping, reversing, changing direction right or left. (Note sample analysis in Appendix II attached to this report.) From these functions may be analyzed, by a combination of empirical observation and rational method, the tasks required to perform these functions.

It is not essential that there be uniformity (reliability) in the names of functions or number of functions which have been isolated for a given job. What is important is that there be coverage and agreement in the description of the task requirements. Furthermore, there may be little if any operational difference between calling a task "avoiding obstacles" or "getting through apertures," although one concept may be more flexible than the other for the particular task or function under consideration. But, to repeat, the essential reliability for the analysis consists of the data entered on the Task Analysis of Continuous Feedback Skills forms.

2. Task analysis

The following discussion involves the categories on the form for making Task Analysis of Continuous Feedback Skills. Note that a separate sheet or more will be required for the analysis of each task. It should also be pointed out that if a task includes a "procedure," the procedural behaviors may be specified on the form for analysis of procedural tasks and referred to by code number. The reader should consult the sample analysis in Appendix II for clarification of the following terms.

a. TASK

In this space put the name of the task. Where possible, state it in terms of some goal outcome which is generic to the performances included by the task analysis.

b. DISPLAY/Problem

A representative sample of the task problem should be described here. The problem as stated will generally consist of a concrete example of the statement describing the TASK. Assumptions and qualifications should be stated as a part of the problem.

c. DISPLAY/Critical stimulus variables

List here the essential variables or stimulus components generic to the display problem and the task. These variables will provide the basis for determining the discriminations which the operator must make in the situation. In many cases this category will be the most difficult to fill in, and will provoke the greatest unreliability of analysis in the entire task analysis procedure. This difficulty is in part due to the relative lack of information in the field of psychology about the inciting cues to action--those cues necessary and sufficient for given forms of action. Reference to the Human Engineering Design Schedule for Training Equipment, under Displays, Control-display interactions, and Programs, and to the references in the Handbook on Training and Training Equipment Design coded to these Design Schedule items may be of assistance in providing additional categories for consideration. The reader and task analyst are also referred to Gibson's The Perception of the Visual World[1] and Hick and Bates' The Human Operator of Control Mechanisms[2] for concepts appropriate to this analysis. In this space should also be set down whatever "preparatory situation" may lead up to the display problem if it has a presumed bearing on the display problem (e.g. "dark adaptation preceding glare of oncoming headlights"). Time values as they affect rate at which the stimuli must be perceived and integrated should be given separate consideration.

d. DISPLAY/Noise

In this space should be set down the kinds of interference which may disturb the operator's reception of the information conveyed by the display. The sources of this interference are those outside the operator himself. Those sources of interference within the operator will be mentioned under CHARACTERISTIC ERRORS.

e. DECISIONS

This space is reserved for setting down gross response alternatives which may be available to the operator. Those alternatives will consist of tasks or sub-tasks. The addition of a category for decisions violates the internal consistency of the analysis method because a decision, according to our earlier definitions, involves the choice of the performance of some task or not per-

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1 Gibson, J. J. The Perception of the Visual World. N. Y.: Houghton-Mifflin, 1950.

2 Hick, W. E. and Bates, J. A. V. The Human Operator of Control Mechanisms. England: Ministry of Supply, May, 1950.

forming it. In the interests of flexibility, however, consistency has been violated.

f. CONTROLS/Description

The appearance, location, and other cues relevant to the identification of the control or controls involved in the task are written here. If there is some reference which may be consulted in specifying the descriptive characteristics (such as an illustration, engineering specifications, blueprints, etc.) obviously no more than the conventional name of the control need be mentioned. It may again be emphasized that the analysis forms are for the purpose of data collection and recording, and a simpler way of getting or having the requisite data available should be used if it is available.

g. CONTROLS/Activation

In this space should be described what the operator has to do to the controls to achieve the goal of the task--that is, to get alignment of the task-goal and the man-machine output. Direction of movement, rate of movement, magnitude of movement, sequence of movements, combination of movements, should be recorded. Preparation for movement should also be included (e.g., the driver must shift his foot from the accelerator pedal to the surface of the brake pedal before he can begin to exert braking action.) The force required should also be set down unless there is reason to presume that this consideration is irrelevant to success or failure at the task, or in transfer of training. See the Design Schedule, under Controls, for variables to be considered.

h. CONTROLS/Action

State here the machine functions modulated by the control--that is, the ratio of movement of the control to the magnitude of a machine output. Example: A coordinate curve showing the relationship between the distance a given brake pedal is pushed and the stopping rate of the car.

i. FEEDBACK/Cues

This topic refers to "proximal feedback cues"--those cues directly fed back to the operator from the initial grasping of the control and also "distal feedback cues"--these cues fed back to the operator from changes in the machine outputs with respect to goal requirements or alignments.

j. FEEDBACK/Time delay

In this space there is specified the time relations between activation of the control and the onset or availability of the respective feedback cues. In some cases a curve or families of curves will be required to present these data. It is often highly important that these time values be accurately specified since they may be of great importance in determining the amount of transfer of training from one equipment to another.

k. FEEDBACK/Criterion of response adequacy

This area should have put in it information about the cues available to the operator which show that his response is or is not achieving the criterion demanded. It should also (separately) include signs which, although not available to the operator, may show to an outside observer (such as an instructor or operations analyst) whether the response of the man-machine system is adequate. Tolerance limits should be specified.

l. FEEDBACK/Critical values

These refer to cues which may indicate to the operator that the machine system is approaching a "discontinuity" in action. Thus, the screech of tires and tipping of a car rounding a curve at high speed is a cue that the car may skid or overturn. Either of these would be discontinuous with the action of four wheels following a steered track around the curve.

m. FEEDBACK/Corrective action

This refers to corrective action against the consequences of reaching or exceeding critical values of machine response. When a car rounding a curve shows the critical value of starting to skid, the corrective action may be to turn the steering wheel into the direction of the skid. (It has also been suggested that the operator should slightly accelerate in order to reduce, at least temporarily, the tendency of the car to skid sideways.)

n. CHARACTERISTIC ERRORS AND MALFUNCTIONS

The data put in this space will not be strictly relevant to task analysis which is complete when it specifies what the operator does when he fulfills the task or job requirements. However, there are practical advantages in getting data on the kinds of human error which characteristically occur in the performance of a given task, or tasks similar to it. Such data may be of importance in formulation of training, and even in the construction of a training device and its scoring systems.

If a machine has more or less characteristic malfunctions which it may develop under given conditions of operation, information about them will assist the training curriculum by suggesting what kinds of "emergency conditions" should be sampled for presenting to the student.

A parenthetical note should be added about the data to be obtained by task analysis. There should be a sufficiently detailed and complete description of the stimulus conditions which influence performance of the task to establish what and how many concurrent streams of signals are being fed into the operator (including both DISPLAY and FEEDBACK CUES categories) and the frequency or rate at which perceptual responses, decisions, and motor adjustments must be made under conditions up to and including the maximum of difficulty for that job. If the complexity of the job makes this integration difficult, one more step may be required before the analysis is complete. If a name is needed for this step it might be called "program analysis."

C. PROGRAM ANALYSIS

The purpose of program analysis is twofold. One is to determine what activities, tasks, and behaviors are time-shared. The other is to determine what situations sample the universe of environments to which the man-machine system will have to adapt, either by virtue of inputs fed into it or what its outputs will have to work upon.

If empirical data are available about sample programs to which the system is subjected, they should be used. If not, then conceptualization by the analyst will be required with the assistance of experts who have designed the system.

Examples of program data in the case of the flexible gunner will be various attack patterns of various expected enemy aircraft flying at different speeds and at different approaches. Different groupings of enemy and friendly aircraft may be additional variables in the programs.

Program data with respect to the radar bombardier may include different kinds of target areas, change in weather from radar to visual conditions, wind, aircraft velocity and other problems. Various forms of equipment malfunction or other forms of interference within the system which still tolerate operations may be included. Noisy channels of communication should not be disregarded.

The Design Schedule should be consulted for details about program variables.

From these programs there may be observed (or deduced) the behaviors which overlap in time or are in close temporal contiguity. A sheet of paper may be marked off with a time-scale along one margin. On this time scale indicate what tasks are concurrent as a standard matter of course. These standard concurrences should be marked as such. The pilot's flying a beam on an approach to a landing field would be an example.

At another level of the paper may be indicated tasks or behaviors which are not necessarily correlated in time with other tasks. The use of the radio by the pilot may be an example.

By stacking the non-standard (with respect to time) tasks above the densest layers of time-shared activities, the maximum behavioral load which will be required of the operator is suggested.

IV. CONCLUDING COMMENTS ABOUT TASK ANALYSIS METHODS

The foregoing pages have outlined the concepts of a more or less systematic method for arriving at the behaviors sufficient and necessary in the operation of equipment or instruments. It does not contain all the information which could make the difference between an excellent task analysis and one which was only passably good. Specialized information would have to be had about the subject matter for which the analysis was being made. For example, if the task analysis is for the purpose of the design of a training device and recommendations for a training program, the analyst should be familiar with the psychology of human learning. A background in engineering psychology will also aid in the identification of relevant behaviors. Special acquaintance with the particular kind of job under study will also be of major assistance, if this background does not lead to failure to make explicit a number of assumptions about the learning and performing of the job.

But finally there will also be the demand for a kind of imagination which can conceptualize processes and the continuity of processes from one stage to another. In this respect task analysis will rest upon the analyst's private insights about human behavior. It is hoped that when these insights are made explicit they will be recognized as tentative hypotheses made in the absence of more precise and public experimental data.

As task analyses and experimental research continue over representative kinds of procedural and continuous activities there should be a growing backlog which will reduce (but probably not eliminate) the need for the analyst to depend on insights and hypotheses. Only as this information is made public, however, can it pyramid its usefulness. Furthermore, its usefulness may be in direct proportion to the extent that it is framed in internally consistent taxonomic and methodological structures which can show up inconsistency and inadequacy. It is hoped that the foregoing procedures will have been a step in this direction as well as towards the solution of the immediate purpose in aiding the design of training devices and training programs.

APPENDIX I

AN EXAMPLE OF A TASK ANALYSIS OF PROCEDURES

For illustrative purposes a task analysis of the job of mimeographing was done. The format presently in use was developed by Robert B. Miller. The actual task analysis illustrated was performed by Charles H. Scheidler. It should be pointed out that this task analysis does not cover all facets of the job of mimeographing. For purposes of exposition a limited program of operations was considered.

JOB FUNCTION ANALYSIS

and

TASK ANALYSIS

of

Mimeograph Machine

Model A.B. Dick Mimeograph 445

Note: The Job Function Analysis appears on the first two of the following pages. The Gross Task Analysis is next, followed by the Analysis of the numbered subtasks.

Contents

JOB FUNCTION ANALYSIS

A.B. Dick 445 Mimeograph Operator

A. Output Control:

The skilled operator working on a machine in good condition should control the following variables as indicated:

1. Rate: The man-machine system should be capable of turning out 1000 reproduced pages per hour including ten stencil changes within the hour.

2. Quality criteria:

   a. Blackness of print: samples will be provided of minimum acceptable standards of:

      (1) Print being dark enough

      (2) Print being too smudgy

   A sample will also be prepared of "ideal" copy.

   b. Placement of print on page: within 1/4" of margins as given on original stencil, (or as directed for one vertical and one horizontal margin).

   c. Cleanliness of copy:

      (1) Samples provided of maximum offset printing allowable on back pages.

      (2) No perceptible finger-marks on page, front or back.

      (3) Samples provided of maximum ink-smearing permissible.

   d. Waste: maximum of four pages per inking; four pages per stencil change. This may increase if reproduction on both sides of page is required.

B. Input Control:

The system will have to accomodate to the following kinds of input variations:

1. Change in thickness of paper: from 16 lbs. to 29 lbs.

2. Size of paper: the system will be required to handle only 8 1/2" x 11" size of paper.

3. Quality of ink: ordinary variation in one brand as supplied by dealer.

4. Quality of stencil: samples provided of stencils cut at just acceptable values for reproduction with respect to being:

   a. Cut too thin

   b. Cut too thick

   c. Cut too dense (many cuts close together)

   d. Old, brittle stencils

Program Analysis

Samples of the major program variables are cited above under "Input Control." Additional items of relevance to formulating programs of operations will be found in the following task analysis in the column marked "Characteristic Malfunctions or Malpractice."

TASK ANALYSIS OF PROCEDURES

GROSS TASK ANALYSIS

TASK	DISPLAY		DECISIONS	SUB-TASKS LISTED	CHARACTERISTIC ERRORS OR MALFUNCTIONS
	DESCRIPTION	CRITICAL VALUES			
A. Set up before first run	Position of brake	Not in 9 o'clock position	Release break - move to 9 o'clock position	1	*
	Recall of last inking	Copy light since last inking (est.)	Measure ink - add if necessary	18, 19, 20, 21, 22	
	Positioning of paper guides	Paper not set up for first stencil run	Adjust for length, width and amount of paper	8, 23, 24, 25, 12	
	Positioning of strippers	Set up for different sized paper	Adjust for standard paper	40	
	Positioning of receiving tray	Paper different from preceding day	Adjust for length and width of paper	26, 27	
	Weight of paper	Normal positions of controls for 20 lb. paper			
		a. Feed grip control lever = 2nd notch from top	Increase for less 20 lb. Decrease for more 20 lb.	28 29	
		b. Paper buckle = middle number	Increase for less 20 lb. Decrease for more 20 lb.	32 33	

TASK ANALYSIS OF PROCEDURES

GROSS TASK ANALYSIS

TASK	DISPLAY		DECISIONS	SUB-TASKS LISTED	CHARACTERISTIC ERRORS OR MALFUNCTIONS
	DESCRIPTION	CRITICAL VALUES			
	Proposed speed	Feed pressure control at second notch for speeds up to 100 copies a minute	Increase to left for higher speeds	30	
			Decrease to right for lower speeds	31	
	Desired speed	At middle notch for medium speed	Increase Decrease	35 36	
B. Set up before each different stencil run	Cover on cylinder or not	Cover on	Remove cover	10	
	Stencil on or not	Stencil off	Attach stencil	2	
	Number on counter	Not correct	Set correct number	3	
	Machine on or off	Off	Start	4	
	Length paper	Different from previous setting	Change breaker bar and back stops	5, 8, 24, 12, 27, 4	
	Amount of paper	Less than 1 inch	Add paper	5, 8, 11, 12, 4	

TASK ANALYSIS OF PROCEDURES

GROSS TASK ANALYSIS

TASK	DISPLAY		DECISIONS	SUB-TASKS LISTED	CHARACTERISTIC ERRORS OR MALFUNCTIONS
	DESCRIPTION	CRITICAL VALUES			
C. Any-time during run	Print with respect to:				1. Failure to divide attention so as to notice following malfunctions in printed copy within 2 - 5 sheets
	a. Top of page	Too close (est.)	Lower print	5, 13, 4	
	b. Side of page	Too close (est.)	Move from side	5, 14, 4	
	c. Horizontal of page	Diagonal (est.)	Straighten	5, 15, 4	
	a., b., or c.,	Print off page	Use ink up procedure	5, 16, 4	
	Blackness of print				
	a. Ink not previously distributed	Print too light (est.)	Distribute ink	5, 17, 4	
	b. Ink previously distributed	Print too light (est.)	Add ink	5, 18, 19, 20, 21, 22, 4	
	Speed of machine		Increase speed or decrease speed	35 36	

TASK ANALYSIS OF PROCEDURES

GROSS TASK ANALYSIS

TASK	DISPLAY		DECISIONS	SUB-TASKS LISTED	CHARACTERISTIC ERRORS OR MALFUNCTIONS
	DESCRIPTION	CRITICAL VALUES			
	Dirt on paper				
	a. Sides	Noticeable smudge on sides	Clean retainer pads	5, 34, 4	
	b. Center	Line or smudge through center	Clean feed roll	5, 37, 4	
D. End of each diff. copy	Counter bell rings		End of procedure	5, 6, 7, 8, 9, 10	1. Failure of operator to clean machine
E. Close Down	Machine off	Stencil cover not on	Put stencil cover on	38	
	Controls	Still in locked position	Unlock for day	8, 39	

TASK ANALYSIS OF PROCEDURES

ANALYSIS OF SUB-TASKS

SUB-TASK OR TASK	DISPLAY	CONTROL DESCRIPTIONS	CONTROL ACTION	INDICATION OF RESPONSE ADEQUACY	OBJECTIVE CRITERION OF RESPONSE ADEQUACY	CHARACTERISTIC ERRORS OR MALFUNCTIONS
1. Release brake		Brake	Turn clockwise (up)	Brake stop in 9 o'clock position		
2. Attaching the stencil		Wheel	Turn	Stencil head clamp available		
		Stencil head clamp	Lift left end	Stencil head clamp loosens		
		Release latch	Lift	Stencil head clamp loosens further		
		Stencil head clamp lever (Edge away from stencil)	Push down	Stencil head clamp comes open		
		Stencil	Put under head clamp as far as it will go (face down)	Feels it is against "end" of clamp		
		Stencil head clamp lever	Push down	Stencil secure and straight		Put on crooked
		Stencil back	Pull backward	Torn off		
		Stencil	Smooth around cylinder (with hand)	No wrinkles on stencil		Tears while smoothing

TASK ANALYSIS OF PROCEDURES

ANALYSIS OF SUB-TASKS

SUB-TASK OR TASK	DISPLAY	CONTROL DESCRIPTIONS	CONTROL ACTION	INDICATION OF RESPONSE ADEQUACY	OBJECTIVE CRITERION OF RESPONSE ADEQUACY	CHARACTERISTIC ERRORS OR MALFUNCTIONS
		Wheel	Turn counterclock (L. hand)	End clamp up		
		End clamp lever	Lift	End clamp opens		
		Stencil	Push under clamp			
		End clamp	Push down	Holds stencil firmly		
		End clamp lever	Push down	Clamp flush - stencil secured		
		Wheel	Turn clockwise	Stop here's matched on cylinder and frame		
3. Setting the counter		Recorder control knob	Lift up	Stops		
		Counter	Set to appropriate number copies (clockwise) little hand in 100's big hand in units	Correct number		Misinterpretation of dial reading
		Recorder control knob	Push down	Clicks and cocks		

TASK ANALYSIS OF PROCEDURES

ANALYSIS OF SUB-TASKS

SUB-TASK OR TASK	DISPLAY	CONTROL DESCRIPTIONS	CONTROL ACTION	INDICATION OF RESPONSE ADEQUACY	OBJECTIVE CRITERION OF RESPONSE ADEQUACY	CHARACTERISTIC ERRORS OR MALFUNCTIONS
4. Starting the machine		Motor switch	Turn to right	Motor hums and vibrates		
		Feed control lever	Lift	Paper goes through		
5. Stop		Feed control lever	Press down	Paper stops going through		
		Motor switch	Turn to left	Machine stops		
6. Stop heres match		Wheel	Turn	Stop heres match		
7. Remove copy		Copy	Pick-up transport (both hands)	Copy removed to table		
8. Lower feed table		Feed table release knob	Push to left	Feed table goes down		
9. Single copy or file folder		File folder or single copy	Push folder in above paper positioning plate	Stops against sides of machine		

ANALYSIS OF SUB-TASKS

SUB-TASK OR TASK	DISPLAY	CONTROL DESCRIPTIONS	CONTROL ACTION	INDICATION OF RESPONSE ADEQUACY	OBJECTIVE CRITERION OF RESPONSE ADEQUACY	CHARACTERISTIC ERRORS OR MALFUNCTIONS
		Wheel	Turn	Folder out other side		
		Wheel	Turn "stop here" to 9 o'clock position	"Stop here" match		
10. Removing stencil or cover		End clamp lever	Lift	Clamp open		
		Stencil	Take from under clamp and hold up with left hand	Stencil out		
		Wheel	Turn clockwise			
		Head clamp lever	Lift (R. hand)			
		Stencil	Pull from beneath clamp and place in file folder			
11. Adding paper	Any order	Wheel	Turn	Stop heres match		
			(Left)			
		Retainer pads	Push into their housings (two)	Clicks into place		

TASK ANALYSIS OF PROCEDURES

ANALYSIS OF SUB-TASKS

SUB-TASK OR TASK	DISPLAY	CONTROL DESCRIPTIONS	CONTROL ACTION	INDICATION OF RESPONSE ADEQUACY	OBJECTIVE CRITERION OF RESPONSE ADEQUACY	CHARACTERISTIC ERRORS OR MALFUNCTIONS
		1/2 pack paper	Fan paper and push up to paper positioning plate and register edges by slapping	Paper registered on each side and against plate		
		Paper	Push down paper (toward table top) between retainer pads			
	Simultaneously	Retainer pad release pad	Push down (both sides)	Paper retains "bend"		
12. Raise feed table		Feed table elevating knob	Turn counterclockwise	Top of pack above positioning plate below feed roll		
		Feed table release knob	Push to right	Table stays up		
13. Correction for print too close to top	Observance at least of every fifth reproduced page will reveal the error	Wheel	Turn counterclockwise until ink cap shows	Ink cap shows		
		Raise-lower copy lever	Lift	Up from cylinder		

TASK ANALYSIS OF PROCEDURES

ANALYSIS OF SUB-TASKS

SUB-TASK OR TASK	DISPLAY	CONTROL DESCRIPTIONS	CONTROL ACTION	INDICATION OF RESPONSE ADEQUACY	OBJECTIVE CRITERION OF RESPONSE ADEQUACY	CHARACTER-ISTIC ERRORS OR MALFUNC-TIONS
		Cylinder	Move wheel so pointer is farther from zero in the direction desired. Scale and stencil graduated in type-writter line spaces for accu-rate setting	Desired word where wanted		Failure to inspect finished product
		Raise-lower copy lever	Push down	Flush with cylind-er	Do not let setting change	
14. Cor-rec-tion for print tøo close to side	Obser-vance of finished product will reveal	Lateral cylinder control	Clockwise to move print to right-counterclockwise to left	Print correct on duplicated page		Failure to inspect finished product

TASK ANALYSIS OF PROCEDURES

ANALYSIS OF SUB-TASKS

SUB-TASK OR TASK	DISPLAY	CONTROL DESCRIPTIONS	CONTROL ACTION	INDICATION OF RESPONSE ADEQUACY	OBJECTIVE CRITERION OF RESPONSE ADEQUACY	CHARACTERISTIC ERRORS OR MALFUNCTIONS
15. Correct for print diagonal across page	Observance of finished product (every fifth one will reveal)	Copy leveler	Turn toward 'raise' to raise right side of print to horizontal - toward 'lower' to lower same to horizontal	Print correct on duplicated page		Failure to inspect finished product
		Finished copies on stacking table	Pick up and transport			
16. Ink up	Observation of finished product (every fifth page) will reveal when needed	Tinsel bracket	Slide out then lift and transport			
		Impression roller lock lever	Lift	Feel of lever striking against roller inside		
		Impression roller	Pull straight out and clean (with cleaning tissue)	No slippery spots on roller		
		Cylinder and stencil and cleaner	Clean	No ink visible		

TASK ANALYSIS OF PROCEDURES

ANALYSIS OF SUB-TASKS

SUB-TASK OR TASK	DISPLAY	CONTROL DESCRIPTIONS	CONTROL ACTION	INDICATION OF RESPONSE ADEQUACY	OBJECTIVE CRITERION OF RESPONSE ADEQUACY	CHARACTER-ISTIC ERRORS OR MALFUNC-TIONS
		Impression roller	Place right roller bearing in its socket in machine and slide other end of roller into other side	Roller does not fall out		
		Impression roller lock lever	Push down	Click and holds roller		
		Tinsel bracket	Place bolt on bottom through hole and slide forward	Tinsel bracket is rigid		
17. Distributing ink	Observation of finished product will reveal when needed	Wheel	Turn	Match stop here		
		Ink reservoir control knob	Turn clockwise	Until it is stopped		
		Wheel	Turn counterclockwise (slowly) stop at stop here position	One complete revolution of cylinder		
18. Remove cap		Wheel	Turn wheel so ink cap shows	Ink cap on top of cylinder		

TASK ANALYSIS OF PROCEDURES

ANALYSIS OF SUB-TASKS

SUB-TASK OR TASK	DISPLAY	CONTROL DESCRIPTIONS	CONTROL ACTION	INDICATION OF RESPONSE ADEQUACY	OBJECTIVE CRITERION OF RESPONSE ADEQUACY	CHARACTERISTIC ERRORS OR MALFUNCTIONS
		Ink hole cap	Counterclockwise to remove	Cap comes off		Dirtying cylinder with ink cap
19. Measure ink		Ink measuring rod	Insert in ink hole as far as it will go--remove and look at it	Level of ink on gauged measuring rod		Misplacing ink rod
20. Amount of ink on stick		Less than 1/2 inch	Add ink (see 21)	Print becomes clear		
		More than 1/2 inch	Don't add ink			
21. Add ink		Can of ink	Pour ink through ink hole (1/2 can originally)			Adding too much ink
22. Replace cap		Ink hole cap	Clockwise on ink hole to close			

TASK ANALYSIS OF PROCEDURES

ANALYSIS OF SUB-TASKS

SUB-TASK OR TASK	DISPLAY	CONTROL DESCRIPTIONS	CONTROL ACTION	INDICATION OF RESPONSE ADEQUACY	OBJECTIVE CRITERION OR RESPONSE ADEQUACY	CHARACTER-ISTIC ERRORS OR MALFUNC-TIONS
23. Set retainer rails		Left retainer locking thumb nut	Turn counterclockwise	Loosens		
		Left retainer rail knob	Turn	Scale indicator on zero		
		Left retainer locking thumb nut	Turn clockwise	Tightens		Retainer knob may move with retainer lock nut
		Right retainer locking thumb nut	Turn counterclockwise	Loosens		
		Right retainer rail knob	Turn counterclockwise	Rail strikes a stop		
24. Set breaker bar		Breaker bar	Insert through openings in retainer rails or brackets so bar is one inch from end of paper when paper against positioning plate (lower bracket hole for short paper) and adjusted by lower bracket knob	Remains in place and paper overlaps it one inch		

TASK ANALYSIS OF PROCEDURES

ANALYSIS OF SUB-TASKS

SUB-TASK OR TASK	DISPLAY	CONTROL DESCRIPTIONS	CONTROL ACTION	INDICATION OF RESPONSE ADEQUACY	OBJECTIVE CRITERION OF RESPONSE ADEQUACY	CHARACTERISTIC ERRORS OR MALFUNCTIONS
		Retainer release latches	Press down	Retainer clamp plate opens		
		Retainer assemblies	Move both	1/2 inch in front of breaker		
		Retainer clamp plate	Lift up and push	Clicks and tightens retainers		
		Retainer pads	Push right into housing have left one out by pushing lever	Right clicks and remains in housing-left remains out		
25. Set retainer rails (cont.)		Stack of paper (about 2 in.)	Place on table against left retainer and positioning pad and forward to paper positioning plate	Against retainer and plate and registered		
		Quick set lever	Turn counterclockwise	Hits stop		
		Right retaining rail knob	Turn (clockwise)	Retainer pad housing about 1/16 inch from paper		

TASK ANALYSIS OF PROCEDURES

ANALYSIS OF SUB-TASKS

SUB-TASK OR TASK	DISPLAY	CONTROL DESCRIPTIONS	CONTROL ACTION	INDICATION OF RESPONSE ADEQUACY	OBJECTIVE CRITERION OF RESPONSE ADEQUACY	CHARACTERISTIC ERRORS OR MALFUNCTIONS
		Right retainer locking thumb nut	Turn clockwise	Tightens		Moving adjustment back and forth
		Retainer pad release latches	Push	Pads tightly against paper		Setting paper too loose between retaining pads
		Paper	Have paper edge opposite positioning plate sitting on top of breaker bar	Wiggle and pull paper tight--not easily picked out		Retainer pad too light paper bunches
26. Setting guides for width		Knurled locking knob	Clockwise	Loosens		
		Left side guide knob	Turn counterclockwise	Guide moves away from center		
		Sheet of paper	Push in feeding slot above positioning plate	Paper does not fall out		
		Wheel	Turn counterclockwise a little	Paper still gripped but out other end		

TASK ANALYSIS OF PROCEDURES

ANALYSIS OF SUB-TASKS

SUB-TASK OR TASK	DISPLAY	CONTROL DESCRIPTIONS	CONTROL ACTION	INDICATION OF RESPONSE ADEQUACY	OBJECTIVE CRITERION OF RESPONSE ADEQUACY	CHARACTERISTIC ERRORS OR MALFUNCTIONS
		Right guide lock	Turn counterclockwise	Loosens		
		Right side guide knob	Turn	Guide about 1/8 inch from paper		
		Right guide lock	Turn clockwise	Tightens		
		Wheel	Turn counterclockwise	Stop here at 12 o'clock position		
		Left side guide knob	Turn	Until guide pushes paper over to other guide--but does not bend paper		
		Knurled lock knob	Turn counterclockwise	Tightens		
27. Adjust back stops for length		Back stops release knob	Turn counterclockwise	Loosens		
		Back stops	Push forward	Push paper up to tinsel bracket		
			Push backward	Pushes back edge of paper while front edge touches tinsel bracket		
		Front stops release knobs	Turn clockwise	Tighten		

TASK ANALYSIS OF PROCEDURES

ANALYSIS OF SUB-TASKS

SUB-TASK OR TASK	DISPLAY	CONTROL DESCRIPTIONS	CONTROL ACTION	INDICATION OF RESPONSE ADEQUACY	OBJECTIVE CRITERION OF RESPONSE ADEQUACY	CHARACTERISTIC ERRORS OR MALFUNCTIONS
28. Increase feed power		Feed grip control lever	Down to increase	Clicks into notch		
29. Decrease feed power		Feed grip control lever	Up to decrease	Clicks into notch		
30. Increase feed roll pressure		Feed pressure control	Clockwise to increase	Next ring appears on feed pressure control shaft		
31. Decrease feed roll pressure		Feed pressure control	Counterclockwise to decrease	Next ring appears on feed pressure control shaft		
32. Increase buckle		Buckle control knob	Clockwise to increase			

TASK ANALYSIS OF PROCEDURES

ANALYSIS OF SUB-TASKS

SUB-TASK OR TASK	DISPLAY	CONTROL DESCRIPTIONS	CONTROL ACTION	INDICATION OF RESPONSE ADEQUACY	OBJECTIVE CRITERION OF RESPONSE ADEQUACY	CHARACTERISTIC ERRORS OR MALFUNCTIONS
33. Decrease buckle		Buckle control knob	Counterclockwise to decrease			
34. Cleaning pads		Retainer release latch	Press and lift assembly	Assembly comes off rail		
		Retainer pads	Push forward from assembly	Pad out		
		Pads and damp cloth	Clean pads			
		Retainer pads	Push back in assembly			
		Retainer assemblies	Place back on rail	Same position as removed from		
		Retainer clamps	Lift and push into assemblies	Clicks and secures assemblies		
35. Increase speed		Speed control	Push to left	Clicks into notches		
36. Decrease speed		Speed control	Push to right	Clicks into notches		

TASK ANALYSIS OF PROCEDURES

ANALYSIS OF SUB-TASKS

SUB-TASK OR TASK	DISPLAY	CONTROL DESCRIPTIONS	CONTROL ACTION	INDICATION OF RESPONSE ADEQUACY	OBJECTIVE CRITERION OF RESPONSE ADEQUACY	CHARACTERISTIC ERRORS OR MALFUNCTIONS
37. Clean feed roll		Right end feed roll shaft	Press	Shaft comes out left side of feed roll assembly		
		Left end feed roll shaft	Pull out	Feed roll comes out		
		Feed roll	Clean	Clean		
		Feed roll	Insert with gear to right	Feed roll hub lined up with holes in side support brackets		
38. Attaching the cover		Wheel	Turn	Stencil head clamp available		
		Stencil head clamp	Lift left end	Stencil head clamp loosens		
		Release latch	Lift	Stencil head clamp loosens further		
		Stencil head clamp lever (edge away from cover)	Push down	Stencil head clamp comes open		
		Cover	Put under head clamp as far as it will go (face down)	Feels it is against "end" of clamp		

TASK ANALYSIS OF PROCEDURES

ANALYSIS OF SUB-TASKS

SUB-TASK OR TASK	DISPLAY	CONTROL DESCRIPTIONS	CONTROL ACTION	INDICATION OF RESPONSE ADEQUACY	OBJECTIVE CRITERION OF RESPONSE ADEQUACY	CHARACTERISTIC ERRORS OR MALFUNCTIONS
		Stencil head clamp lever	Push down	Cover secure and straight		
		Wheel	Turn counterclockwise (L. hand)	End clamp up		
		Feed roll shift	Push to insert from left side	Clicks into place		
39. Unlocking controls		Quick set lever	turn clockwise	Rails and retainers move away		
		Retainer pads	Push into their housing	They click into place and stay there		
		Speed control	Move all the way to right	Clicks into last notch		
		Break counter	Turn clockwise until it stops	Stops in 6 o'clock position		
		Cover	Drop over cylinder and machine	Machine protected from dirt		

TASK ANALYSIS OF PROCEDURES

ANALYSIS OF SUB-TASKS

SUB-TASK OR TASK	DISPLAY	CONTROL DESCRIPTIONS	CONTROL ACTION	INDICATION OF RESPONSE ADEQUACY	OBJECTIVE CRITERION OF RESPONSE ADEQUACY	CHARACTERISTIC ERRORS OR MALFUNCTIONS
40. Stripper Assembly		Stripper knobs	Turn counterclockwise	Loosen		
		Stripper control	Push left and right until they are just beyond ink roller on both sides	Clear ink roller 1/32 of an inch on each side		
		Stripper knobs	Turn clockwise	Tightens		

APPENDIX II

AN EXAMPLE OF A TASK ANALYSIS OF CONTINUOUS FEEDBACK SKILLS

For illustrative purposes a partial task analysis of the job of driving a car was done. The format presently in use was developed by Robert B. Miller. It should be pointed out that the job of driving a car has been narrowly defined for purposes of exposition. Furthermore, of the various tasks enumerated, only one has been selected for analysis into its component behaviors.

FUNCTION AND TASK ANALYSIS

Pontiac 1950 Hydramatic

Definition of principal purpose of the job: To get from a starting point to a destination with minimum hazard. Secondary purposes: To do so with minimum cost of time, material and gasoline.

I. FUNCTIONS ANALYSIS

A. Accelerating, stopping and reversing
(Getting the car into motion, keeping it in motion, stopping the car, reversing its motion, stopping reverse motion.)

B. Changing direction, right and left.

II. GROSS TASK DETERMINATION OF FUNCTION A: Accelerating, stopping and reversing

A. Starting the engine

B. Initiating motion

C. Continuing or accelerating motion

D. Decelerating motion

E. Braking and stopping

F. Reversing motion

G. Performing A through F on:

1. Level road

2. Downhill

3. Uphill

III. GROSS TASK DETERMINATION OF FUNCTION B: Changing Direction Right or Left

A. Changing direction to the right

B. Changing direction to the left

C. Tracking (keeping track on a path) in forward motion

1. Keeping a straight track

2. Getting through constant apertures (e.g. tunnel entrance)

   a. Sideways

   b. Vertically (not important)

3. Getting through variable apertures (overtaking car in approach to one-way bridge)

   a. Two rates involved as in sample above, or in beating or waiting for a car going cross-wise at intersection

   b. Three rates involved: as in passing a moving car with another car approaching in passing lane from opposite direction

D. Tracking in backward motion (rate usually unimportant)

1. Following straight track

2. Following curved track

3. Following minimum curved track into lateral aperture (parking a car)

IV. PROCEDURES

A. Switching on lights

1. Parking lights

2. Headlights--beam up

3. Headlights--beam down

4. Dash panel lights

B. Heating and ventilation

1. Windshield defroster and air intake

2. Heater switch

3. Air vents

4. Blower

C. Windshield wiper

D. Driver's seat adjustment

E. Fueling and maintenance

V. PROGRAMS AND SITUATIONAL PROBLEMS

A. Heavy traffic: Problems abstracted

1. Responding to those cues relative to maintaining optimum track and not being distracted by adventitious or irrelevant stimuli.

2. Scanning and "apperceiving" objects and situations which have probability value of interfering with the track: cars to the side and behind; front wheel motion of parked cars; pedestrians; signals changing; turning street-cars; drivers ahead turning or stopping without warning, or veering into O's path before turning out of it. . .

B. Driving with poor traction

Traction is a matter of degree, that is, it is relative to the changing rate or direction or both of motion relative to the frictional contact of tire surfaces and surface of roadway. Critical values of slewing vs. overturn will change, however. Sudden shifts from good to poor traction present major source of traction hazards (e.g. patch of ice on dry roadway).

C. Restricted vision of path

1. Night-driving: Operator's headlights and visual ambiguity--scanning techniques

2. Night-driving: glare of oncoming headlights--fixation and scanning techniques

3. Rain on windshield

D. Emergency procedures

1. Impending accident: posture to take etc.

2. Choices in impending accident: ditch vs. collision, etc.

TASK ANALYSIS
Feedback Skill

Job Driving 1950 Pontiac Hydramatic

Page ______ of ______
done by RBM
date 3 March 1952

TASK Tracking toward a variable aperture: three rates problem (Passing a car with an oncoming car in the passing lane.)

DISPLAY

Problem Path ahead with oncoming car; competing car ahead and to the right. Assume competing car will not accelerate

Critical stimulus variables
(1) The absolute rate of competing car (X):
(2) The absolute rate of oncoming car (Y); cars of variable size and speed
(3) The absolute momentary distance between X and Y
(4) The acceleration potential of O's car at that speed (knowledge requirement)

Time values Critical since a time of no return will be reached when it is too late to get into aperture or to brake, t is function of 1, 2, 3 & 4 above

Noise (1) Stress may occur (2) Worry that X will increase speed while passing

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DECISIONS Pass now or pass later

CONTROLS

Description Accelerator Steering wheel

Activation For rapid access of power, press all way to floor board past a resistance detent.

Action Drops transmission from 4th to 3rd gear below 50-55 mph. More power from faster engine-to-wheel ratio.

FEEDBACK

Cues Same as display but as X, Y and O approach, the success of the solution or lack of it becomes more apparent

Time delay Function of acceler, rate of car

Criterion of response adequacy Getting back into right lane with "safety margin" (50' plus) depending on speed. (Better criterion would be in terms of time between turning in to right lane and collision: 5 seconds)

Critical values Collision course perceived imminent

Corrective action Brake and return to right lane; ditch on left side

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Continued on following page

CHARACTERISTIC ERRORS AND MALFUNCTIONS	(1) Getting too close behind X before accelerating and passing X (2) Failing to take into account slight grade (3) Failing to take into account cars behind O which may prevent return behind X in emergency (4) Not returning to right path as soon as safe to do so.