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Equipment-Device Task Commonality Analysis and Transfer of Training

by

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HumRRO Division No. 6 (Aviation)

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FOREWORD

The overall objectives of Work Unit ECHO are to survey and evaluate current synthetic flight training in Army aviation; to determine experimentally the value of selected flight training devices; and to establish guidance for the development and effective utilization of flight training devices in present and future aviation training curricula. Activities directed toward these objectives were begun by the Human Resources Research Organization in FY 1964 at Fort Rucker, Alabama.

In Sub-Unit ECHO I, a survey of synthetic flight training equipment and practices was conducted at the U.S. Army Aviation School and at aviation field units within the continental United States. In ECHO II, the training value of a device embodying the captive helicopter concept was evaluated. In ECHO III, an evaluation was conducted of training devices, designed originally for fixed wing training, used in a rotary wing instrument training program. Costs associated with both flight and synthetic flight training in that program also were studied. The ECHO III research has been reported in Isley, Robert N., Caro, Paul W., Jr., and Jolley, Oran B., *Evaluation of Synthetic Instrument Flight Training in the Officer/Warrant Officer Rotary Wing Aviator Course*, HumRRO Technical Report 68-14, November 1968; and Jolley, Oran B., and Caro, Paul W., Jr., *A Determination of Selected Costs of Flight and Synthetic Flight Training*, HumRRO Technical Report 70-6, April 1970. The present Technical Report describes research conducted under ECHO IV. The ECHO III and ECHO IV research dealt with the same training program and equipment. The research was performed and most of the report preparation completed while HumRRO was part of The George Washington University.

The ECHO research was performed by HumRRO Division No. 6 (Aviation) at Fort Rucker. The Director is Dr. Wallace W. Prophet; Dr. Paul W. Caro is the Work Unit Leader. Military support for the study was provided by the U.S. Army Aviation Human Research Unit, Fort Rucker. LTC Edward B. Covington, III, was the Unit Chief at the time the research was conducted. LTC Ralph V. Gonzales was the Unit Chief during preparation of the draft report. LTC Dunell V. Schull is the present Unit Chief.

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Meredith P. Crawford
President
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SUMMARY AND CONCLUSIONS

MILITARY PROBLEM

A frequently occurring problem in Army Training is the adaptation of training equipment from one training requirement to another. Each time operational equipment undergoes modification or a model change, the suitability of available training devices comes into question. Frequently, when new equipment is procured, funds are not available for development of appropriate training devices to go with it, and improvisations are adopted.

When the Army undertook instrument flight missions in rotary wing aircraft, no training devices were available to support the necessary instrument training programs. Devices that were being used for fixed wing instrument training were modified to a quasi-rotary wing configuration and were used in rotary wing instrument training programs. The effectiveness of the training given in these modified devices was subjected to experimental investigation, and they were found to be of no demonstrable value in meeting rotary wing instrument training objectives.

ECHO IV, a follow-up study, was undertaken to provide guidance as to means for more effective utilization of the modified devices in meeting the Army's requirements for rotary wing instrument training. Because of the general nature of the problem of effective use of available training devices, however, the follow-up study was oriented toward the broader objective of developing generalizable, systematic, analytic procedures that would enable training personnel to assess the utility of a variety of existing devices for new training purposes.

RESEARCH PROBLEM

The use of existing devices for purposes for which they were not designed requires analyzing both an operational man-machine system and training devices designed for a different system in order to ascertain where common task elements lie. Using the information thus developed, principles of transfer of training may be applied to design a training program to maximize positive transfer of training and minimize negative. The development of procedures to accomplish such analyses was the research problem of the present study.

APPROACH

The approach taken in this study was to devise systematic procedures to:

(1) Identify task elements associated with criterion performance in the operational equipment.

(2) Identify task elements associated with performance in the training device.

(3) Systematically and objectively compare task elements associated with performance in the equipment and in the device.

(4) Estimate the extent to which task commonality is required for transferable training to be feasible.

(5) Specify the nature of the synthetic training program most likely to result in maximum positive and minimum negative transfer of training from device to operational equipment.

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RESULTS

Using the modified device employed in Army rotary wing instrument training as a vehicle for the research, procedures were developed for an equipment-device Task Commonality Analysis (TCA). Information derived through the TCA then was used to predict the occurrence of both positive and negative transfer of training from the device to the operational equipment. On the basis of these predictions, characteristics of training programs for use with the device in rotary wing instrument training were stated.

CONCLUSION

It was concluded that the systematic comparison of task elements involved in performance in training devices and operational equipment could provide an objective basis for development of effective training programs. The TCA procedures developed in this study can be used wherever training programs are developed which include training devices not optimized for use in the programs. Such situations occur wherever existing devices are modified to meet new training requirements or when "off-the-shelf" devices are procured for use in specialized training programs.

In the case of the device employed as a vehicle for the research described in this report, it was concluded that relatively little task commonality exists between it and the operational equipment. Predominantly negative transfer of training was predicted from its use, a prediction that tended to be supported by the earlier transfer of training study.

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Equipment-Device Task Commonality Analysis and Transfer of Training

BACKGROUND OF THE RESEARCH

INTRODUCTION

Recent expansion of Army aviation and the emphasis on helicopter operations have put a heavier burden upon the Army's capability for training rotary wing aviators. To meet these increased aviator training requirements, training concepts and techniques have been adopted which reasonably can be expected to increase the efficiency of rotary wing training. The use of synthetic flight training devices, for example, has become widely accepted in Army aviator training programs. Their use is based on the assumption that training in the device (a) will transfer to the aircraft, and (b) is more efficient and/or less expensive than equivalent training given in the aircraft.

The Army is currently developing a system of rotary wing trainers designed specifically to meet its requirements for rotary wing synthetic training devices.[1] Pending development of this Synthetic Flight Training System, however, the U.S. Army Aviation School is relying on available devices in its rotary wing program. One such device is a fixed wing instrument trainer, Device 1-CA-1, which has been modified to a quasi-rotary wing configuration. The modified 1-CA-1 is used to provide training in the skills required for instrument flight to officer-students and warrant officer candidate-students enrolled in the Tactical Instrument Phase of the Officer/Warrant Officer Rotary Wing Aviator Course (O/WORWAC).[2]

The 1-CA-1 was originally designed and manufactured in the late 1940s, and a number of studies have indicated that training in the device can lead to reductions in the amount of flight time required to complete training programs for fixed wing aviators, or to improved aviator proficiency, or to both.[3] Until recently, however, no studies were reported of the effectiveness of this device when modified for use as a synthetic trainer in rotary wing instrument programs.

THE ECHO III STUDY

During FY 1967, an experimental evaluation was conducted as part of HumRRO Work Sub-Unit ECHO III, to determine the contribution to inflight performance of rotary wing synthetic training being given in modified 1-CA-1 devices at the U.S. Army Aviation School.[4] Students who received instruction according to the prescribed syllabus in these devices (in addition to a prescribed program of inflight training) were compared with students who received only half as much device instruction and to students who received no device training at all. It was reasoned that differences in flight performance

[1] Paul W. Caro, Jr. "Adaptive Training—An Application to Flight Simulation," *Human Factors*, vol. 11, no. 6, 1969, pp. 569-576; also issued as HumRRO Professional Paper 5-70, March 1970.

[2] For a brief description of O/WORWAC, see: Robert N. Isley, Paul W. Caro, Jr., and Oran B. Jolley. *Evaluation of Synthetic Instrument Flight Training in the Officer/Warrant Officer Rotary Wing Aviator Course*, HumRRO Technical Report 68-14, November 1968, pp. 5-6.

[3] Smode, A.F., Hall, E.R., and Meyer, D.E. *An Assessment of Research Relevant to Pilot Training*, AMRL-TR-66-196, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio, November 1966.

[4] HumRRO Technical Report 68-14, *op. cit.*

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among groups, if any, would indicate the training contribution of the device and its associated programs of instruction to trainee flight performance.

The results of the ECHO III study showed that, overall, there were no consistent indications that the device-trained groups differed from the groups without such training. The few significant differences among groups were irregular in direction and so few as to suggest that they were chance findings. It was concluded that the synthetic instruction given in the modified devices in the O/WORWAC at the time of the study did not contribute significantly to trainee flight performance.

The ECHO III research involved an evaluation of the modified 1-CA-1 device combined with the program of instruction then in use at the Aviation School. The study indicated only that the combination of the device and its associated training program contributed nothing of significance to the development of trained pilots. It did not indicate whether the primary deficiency lay with the device itself or with the associated synthetic training program, that is, whether the device was inherently unsuitable for the intended application or whether it merely was being used in an ineffective manner. Therefore, a follow-up study was undertaken to develop a program of synthetic flight instruction for use with the rotary wing modified 1-CA-1. The intent of ECHO IV, the follow-up study, was to develop a program which would exploit the training capabilities of the device and, at the same time, avoid attempting to use it to teach flight skills for which it might be inappropriate.

PROBLEM AND APPROACH

MILITARY PROBLEM

The problem of making appropriate use of training devices is not restricted to rotary wing training or even to flight training generally. In a larger context, the Army and other organizations often face the problem of adapting training equipment from one task to another. Each time operational equipment undergoes modification or a model change, the suitability of available training devices comes into question. Frequently, when new equipment is procured, funds are not available for appropriate training devices to go with it, and improvisations are adopted. The improvisation—as with the 1-CA-1 trainer—is almost certain to be less than optimally suited for the instructional requirement, since it is not specifically modeled on the operational tasks and equipment. It is consequently difficult for a training officer to know how to use the device, or indeed, whether it is efficient to use it at all.

ECHO IV, therefore, in addition to investigating the possible usefulness of the 1-CA-1s with a revised training program, was oriented toward a broader objective: to develop systematic, analytic procedures that would enable training personnel to assess the utility of an existing device for a new training purpose (or to evaluate an "off-the-shelf" device for use in fulfilling a specific training requirement). This orientation relegated the development of a training program which could make effective use of the Army's rotary wing modified 1-CA-1 to being an objective of secondary importance. Nevertheless, interest in improved use of the modified 1-CA-1 made that device a desirable vehicle for the development of the broader procedures.

RESEARCH PROBLEM

Ideally, equipment, job, required personnel characteristics, training devices, and programs of instruction should be designed in concert with one another—the systems approach taken in modern man-machine developments. Basic to developing the human factors and training aspects of a man-machine system is a careful and thorough identification, through analysis of operational requirements, of the tasks human beings will perform in that system. Training programs and training devices with associated programs of instruction can then be developed from task analytic data, employing the psychological principles of transfer of training. That is, programs of training to be conducted using synthetic devices can be devised to assure that knowledges and skills are acquired that are directly usable in operational equipment (i.e., assure positive transfer), and *also* to assure minimum acquisition of

skills and knowledges that would interfere with performance using operational equipment (i.e., minimize negative transfer).

Applying the techniques of task analysis and the principles of transfer of training to the development of training programs for existing devices is, essentially, a retrofit process. The use of existing devices for purposes for which they were not designed requires analyzing both an *operational* man-machine system and *existing* training devices designed for a different system, in order to ascertain which task elements are common, and then applying principles of transfer of training, on a post hoc basis, to develop a program to maximize positive transfer and minimize negative.

From the research perspective, it is necessary to develop a systematic procedure to accomplish this. Such a procedure might be called an *equipment-device Task Commonality Analysis (TCA).* Task elements found to be common to the operational equipment and the device can then be used as the raw material for study. At one extreme, the TCA might indicate there is essentially no potential for positive transfer of training, either because common elements are lacking, or because interference elements cannot be avoided. At the other extreme, the TCA might identify sufficient commonality to assure probable substantial positive transfer of training with few, if any, interfering elements being present.

RESEARCH APPROACH

The approach in this study, therefore, consisted of devising systematic procedures to:

(1) Identify task elements associated with criterion performance in the operational equipment.

(2) Identify task elements associated with performance in the training device.

(3) Systematically and objectively compare task elements associated with performance in the equipment and the device.

(4) Estimate the extent to which task commonality is required for transferable training to be probable.

Once procedures for an equipment-device TCA have been devised, it then becomes possible to determine the characteristics of a training program for use with the device that would be consistent with the psychological principles of transfer of training.

DEVELOPMENT OF TASK COMMONALITY ANALYSIS PROCEDURES

ANALYSIS OF STIMULI IN THE OPERATIONAL EQUIPMENT

Criterion performance in the Tactical Instrument Phase of the O/WORWAC,[5] the course which served as a vehicle for the present research, consists of accomplishing, during a simulated tactical instrument flight, certain aircraft and navigation tasks. These tasks involve making specific responses to stimuli present during the flight. The first part of the problem found in the present study was that of specifying the stimuli present in the criterion situation and the responses elicited by them.

[5]The Tactical Instrument Phase of the O/WORWAC, introduced in late 1965, was designed to prepare rotary wing aviators to operate under instrument flight conditions in a tactical situation. Graduates were qualified for a Tactical Instrument Rating. The Standard Instrument Rating, which allows graduates to operate under FAA Instrument Flight Rules, at the time of the research was awarded following completion of another training course, the Helicopter Instrument Flight Course. Many flight skills were common to these two courses. Since this research was conducted, the Tactical Instrument Phase of the O/WORWAC has been replaced by a phase leading to the award of a Standard Instrument Rating. Further information about the training relevant to the present study may be found in HumRRO Technical Report 68-14, *op. cit.*

These inflight stimuli are of two types: (a) hardware, that is, the displays and controls found inside[6] the cockpit of the aircraft; and (b) non-hardware, that is, the factors which relate to the mission being flown. Examples of non-hardware stimuli include environmental influences, such as winds, and verbal instruction received via radio, such as flight clearances.

Appendix A contains a list of all displays and controls found in the TH-13T aircraft, and was compiled by examining the aircraft itself and its Operator's Manual.[7] Since the purpose of the list was to enable the researchers to identify all the hardware stimuli to which an aviator might be responding during criterion performance, the list is exhaustive. For example, in identifying the displays and controls, no assumptions were made concerning whether any item had significance for training. The complete listing of these hardware stimuli is given in Appendix A.

The question of whether a particular stimulus in the criterion equipment has relevance for training must be resolved if a determination is to be made concerning the adequacy of a synthetic training device. To resolve the question with respect to the TH-13T hardware stimuli, the list was given to six instructor pilots whose primary duty at the time was to conduct Tactical Instrument Training in the O/WORWAC. The instructors were told to, "Delete from this list all those displays and controls which are not employed in the conduct of O/WORWAC Tactical Instrument Training in the TH-13T."

It was the consensus of the instructors queried that trainees in the course under study were required to respond to all displays and controls in the TH-13T cockpit except those associated with the VOR and ILS instrument navigation equipment. These items are so indicated in Appendix A.

With respect to non-hardware stimuli, interviews of these same instructor pilots verified that, during criterion performance, aviators are required to respond to all radio and interphone communications directed to them or their aircraft, electromagnetic signals received from ground-based radio navigation facilities, and factors associated with the weather through which the aircraft is flying.

ANALYSIS OF STIMULI IN THE TRAINING DEVICE

Paralleling the determination of the stimuli to which an aviator responds in the operational equipment, was the determination of the stimuli to which he must respond in the training device. These stimuli also are of two types—hardware and non-hardware.

Appendix B contains a list of all the displays and controls found in those 1-CA-1 devices at the U.S. Army Aviation School which have been modified to a quasi-rotary wing configuration. As is the case for the TH-13T, the list of modified 1-CA-1 displays and controls is exhaustive. The modifications were made locally by personnel assigned to the Aviation School, and there is some variation from device to device. Therefore, in compiling the list, each[8] device was examined, and the items contained in Appendix B are not all found in any one device.

In addition to a lack of standardization among these devices with respect to the presence of specific displays and controls, a number of the items, generally present in the

[6] For the purposes of the present study, only stimuli present within the cockpit during flight were considered. Since the 1-CA-1 devices were designed to simulate flight under instrument flight conditions, i.e., weather, and since no out-of-the-cockpit visual displays are incorporated in it, no consideration was given to stimuli unique to flight under visual flight conditions.

[7] TM 55-1520-226-10, October 1969.

[8] There were 51 such devices at the time of the research reported here.

devices, do not function or function in such manner that they are not considered usable by the device instructors. For example, most of the engine-instrument displays that are present do not function at all; the standby compasses incorporate errors as high as 60°; the engine tachometer registers zero RPM when the master switch is off and a fixed operational value when the master switch is on. Further, some of the displays and controls in the device have no counterpart in the TH-13T, such as the pitot heater switch and the trainer lock-release lever.

Accordingly, a revised list of displays and controls was prepared and is presented in Appendix C. It contains all of the hardware stimuli that were considered appropriate for consideration in this study, that is, all those displays and controls which (a) are operable, and (b) are found in a majority of the rotary wing modified 1-CA-1 devices. It is the list in Appendix C which was used for further study.

With respect to non-hardware stimuli, it was determined that verbal instructions, simulating radio and interphone communications, can be given to trainees in the device through a headset—the simulation originating from the instructor of the device's instructor station. In addition, electromagnetic signals from a single—but programmable—ground radio navigation station, wind velocity and direction, and turbulence levels may be simulated.

EQUIPMENT-DEVICE TASK ELEMENT COMPARISON

The lists of controls and displays (hardware stimuli) found in the operational environment and in the training device were compared. For each stimulus in the TH-13T, a comparable stimulus was sought in the device. In some cases, almost identical counterparts were found—for example, both contain an Airspeed Indicator and a Cyclic Control. In other cases, some variation occurred between the aircraft and the trainer, but a common function could be identified; for example, the Microphone Switch in the device is comparable in function to both the Radio Microphone Switch and the ICS Microphone Switch in the TH-13T, and the aircraft's Elapsed Time Clock performs (but is not limited to) the function of the trainer's Eight-Day Clock. Table 1 contains a list of all of the TH-13T displays and controls for which counterpart items could be identified in the modified 1-CA-1.

In order to evaluate the degree of similarity between the two sets of stimuli, 11 TH-13T instructor pilots from the Tactical Instrument Phase of the O/WORWAC were asked, while "flying" typical modified 1-CA-1s, to evaluate each of the device's 10 displays that are identified in Table 1. The instructors indicated independently their opinions as to whether the (a) appearance, and (b) function of each of the displays were realistic or unrealistic in comparison with the corresponding instrument in typical Army helicopters.[9] In Table 2 the instructor evaluations—or "realism ratings"—are summarized as percentages rated "realistic"[10] for each of the displays. The instructors reported that, without exception, the evaluated displays were realistic in both appearance and function. Thus, it was concluded that stimulus commonality does exist between these displays in the trainer and in the operational equipment.[11]

[9]The comparisons were made between the 1-CA-1 and a hypothetical "typical Army helicopter" rather than the TH-13T specifically. The reason for this comparison was the assumption that training useful for typical helicopters probably would be useful in the TH-13T. The TH-13T of course, *is* a typical Army helicopter in many respects, although it is not employed tactically.

[10]The "realism ratings" were two-point scales, so far as individual raters were concerned: realistic or unrealistic. The purpose of a two-point scale was to increase the probable reliability of each rating.

[11]It should be noted that the comparisons made by these instructors were made under dynamic conditions appropriate to the task under study, i.e., while the devices were being "flown." It was presumed that the realism judgments were made in relation to corresponding displays in a typical Army helicopter under dynamic, i.e., flight, conditions.

Table 1

TH-13T DISPLAYS AND CONTROLS AND THEIR COUNTERPARTS IN THE ROTARY WING MODIFIED 1-CA-1[a]

Rotary Wing Modified 1-CA-1 Device	TH-13T Aircraft
Displays	
Airspeed Indicator	Airspeed Indicator
Attitude Indicator	Attitude Indicator
Altimeter	Altimeter
Turn and Slip Indicator	Turn and Slip Indicator
Radio Magnetic Indicator Heading Card	Bearing Heading Indicator (BHI) Heading Card
Vertical Velocity Indicator	Vertical Velocity Indicator
Manifold Pressure Gage	Manifold Pressure Gage
Radio Magnetic Indicator ADF Pointer	Bearing Heading Indicator ADF Pointer
8-Day Clock	Elapsed Time Clock
Radio Call Label	Radio Call Placard
Controls	
Cyclic	Cyclic
Pedals	Tail Rotor Control Pedals
Collective	Collective
Attitude Indicator Pitch Adjustment Control	Attitude Indicator Pitch Adjustment Control
Altimeter Setting Control	Altimeter Setting Control
Ignition Switch	Ignition Switch
Master Off-On Switch	Battery On-Off Switch
Volume Control	Signal Distribution Volume Control
Microphone Button	Radio and ICS Microphone Switches
8-Day Clock Set and Control Knob	Elapsed Time Clock Set and Control Knob
Instrument Lights Off-On Switch	Instrument Light Circuit Breaker
Cockpit Lights Rheostat	Cockpit Lights Rheostat

[a]Only displays and controls that are used in tactical instrument training are included.

The commonality of the controls identified in Table 1 was determined in a similar manner. The same 11 TH-13T instructor pilots, while seated in typically modified 1-CA-1s, were asked to provide realism ratings of the 1-CA-1 controls along five dimensions: (a) appearance, (b) location, (c) direction(s) of movement, (d) control feel, that is, amount of pressure required to activate the control and the tactual feedback to the pilot, and (e) the effect of control activation upon the appropriate displays. The realism ratings for the 12 controls involved are indicated in Table 3. With respect to the dimensions evaluated, it can be seen that the Cyclic, Pedals, Collective, Master Off-On Switch, and Instrument Lights Off-On Switch tended to be rated as unrealistic in comparison to corresponding controls in typical Army helicopters, while the other seven controls tended to be rated as realistic.[12]

The realism of non-hardware stimuli associated with the device was judged by the research staff after consultation with TH-13T instructor pilots. It was decided that

[12]The previous note concerning the dynamic conditions under which the ratings of display realism were made, applies to the rating of controls as well.

Table 2

RATINGS OF REALISM OF DISPLAYS IMPORTANT IN AIRCRAFT CONTROL COMMON TO THE TH-13T AND THE 1-CA-1[a]

Display	Percent Realistic	
	Appearance	Function
Airspeed Indicator	91	73
Attitude Indicator	73	91
Altimeter	91	91
Turn and Slip Indicator	73	91
Radio Magnetic Indicator Heading Card	100	100
Vertical Velocity Indicator	73	91
Manifold Pressure Gage	64	73
Radio Magnetic Indicator ADF Pointer	100	100
8-Day Clock	100	82
Radio Call Label	80	100

[a]The data indicate the percentage of the 11 responding TH-13T pilots who rated each instrument realistic or unrealistic in terms of its appearance and function.

Table 3

RATINGS OF REALISM OF CONTROLS IMPORTANT IN AIRCRAFT CONTROL COMMON TO BOTH THE TH-13T AND THE 1-CA-1[a]

Controls	Appearance	Location	Direction(s) of Movement	Control Forces	Effect Upon Displays
Cyclic	36	9	9	64	78
Pedals	45	55	9	45	55
Collective Pitch	27	9	100	36	27
Attitude Indicator Horizontal Adjustment Control	73	82	91	71	90
Altimeter Adjustment Control	100	100	100	100	100
Ignition Switch	80	55	80	86	70
Master Off-On Switch	27	9	56	57	25
Volume Control	64	55	80	70	67
Microphone Button	73	78	100	86	100
8-Day Clock Set and Control Knob	91	55	100	100	100
Instrument Lights Off-On Switch	0	9	40	50	44
Cockpit Lights Rheostat	55	45	100	100	91

[a]The data indicate the percentage of 11 responding TH-13T instructor pilots who rated each control realistic or unrealistic in terms of the appearance, location, etc.

simulated radio and interphone communication were essentially identical in content and of generally superior quality to such communication in the TH-13T during an operational mission. Electromagnetic signals from simulated ground stations affect navigation instrument displays in the trainer in a manner essentially identical to the manner in which corresponding displays are affected in the aircraft. Aural identifiers associated with ground radio navigation facilities, however, are not present in the trainer.

The influences of winds upon the aircraft are represented realistically in the device, since both wind direction and velocity are simulated. Turbulence may be simulated, but the levels involved are not as great as are sometimes experienced in the aircraft. Effects of other weather factors, such as rain and ice, cannot be simulated in the device, but magnetic variation may be simulated realistically.

ANALYSIS OF CRITERION PERFORMANCE

The portion of the TCA described above suggests some limits that might be placed upon the use of a training device in a specific training situation, but the extent to which commonality is *required* for training to take place also must receive attention. Subjectively, it might be suspected, for example, that a low realism rating for the device's Instrument Lights Off-On Switch might not be a severe limitation to use of the device for instrument training. It might even be suspected that effective training could be provided in the device with no such control present at all. The question which arises, then, is: What stimuli are required in order to use a device for training oriented toward a specific operational requirement? In other words, what are the stimulus components of criterion performance?

In order to answer this question, an analysis was made of representative flight maneuvers[13] involved in criterion performance. Again using the O/WORWAC as the vehicle for the research, these maneuvers consisted of a TH-13T instrument take-off and climb to altitude; an ADF orientation, tracking, approach and missed approach; holding over a beacon; and an autorotation. In addition, accelerations, decelerations, turns, and recovery from unusual attitudes were included in the analysis. Performance of these maneuvers under limited visibility conditions constitutes most of the Army's tactical instrument mission. Consequently, the aircraft displays and controls involved in them are those which are the most significant from the standpoint of the training course under study.

The analysis of the instrument take-off and climb is included in this report as Appendix D in order to illustrate the level of detail involved in these analyses. It will be noted that emphasis is placed upon identification of the stimuli and responses involved in the execution of the maneuvers analyzed. Thus, the analysis identified the TH-13T displays and controls which are required to be employed in the accomplishment of criterion performance. In addition, it identified the responses a pilot makes to these stimuli while accomplishing criterion performance. Non-hardware stimuli were not addressed directly in these analyses; however, their effects constitute secondary tasks which must be performed by the trainee, such as responding to instruction received via radio and overcoming the effects of environmental factors while controlling the aircraft.

The task analysis indicated that, during the maneuvers analyzed, each of the TH-13T displays identified in Table 1 provided necessary stimuli to the pilot except the Radio

[13] An analysis of all aspects of the tactical instrument mission of Army aviation, as performed in the TH-13T aircraft, was beyond the capability of the research staff with the resources available. While such an analysis would be desirable for purposes of developing an optimum, mission-oriented instrument training program for the Army aviator, the analysis of representative portions of the operational mission was judged adequate to provide data for the present research.

Call Placard. The analysis assumes that the information contained on the Placard is known to the pilot, and he therefore does not need to refer to it during the maneuvers analyzed.

The analysis also indicated a display required to perform these maneuvers in the aircraft which is not contained in Table 1, the Engine and Rotor Tachometer.

The analysis also indicated that each of the TH-13T controls listed in Table 1, except the Attitude Indicator Pitch Adjustment Control, the Ignition Switch, the Battery On-Off Switch, the Instrument Light Circuit Breaker, and the Cockpit Lights Rheostat, were necessary to performance of the maneuvers analyzed. The analysis assumed, however, that the Attitude Indicator Pitch Adjustment Control has been set properly; otherwise performance of these maneuvers would be unduly difficult. The analysis also indicates an important omission from Table 1, the Throttle Control, about which more will be noted later.

DETERMINATION OF TRAINING PROGRAM CHARACTERISTICS

TRANSFER OF TRAINING CONSIDERATIONS

The purpose of developing the analytic procedures described above was to make it possible to predict transfer of training accomplished in the device to the operational equipment. Principles of transfer of training, therefore, must enter into consideration. The principles which may be used as guidelines for forecasting improved criterion performance as a result of device training may be summarized as follows:

(1) Positive transfer will occur when both stimuli and responses are similar in the training situation (e.g., the 1-CA-1) and the criterion situation (e.g., tactical instrument flight in the TH-13T).

(2) Negative transfer will occur when the stimuli are similar in the training and the criterion situations, but the responses to the similar stimuli are different.

The intent of device training is, of course, to maximize those situations where positive transfer may be predicted and to avoid completely, if possible, those situations in which negative transfer may be predicted.

RESPONSE COMMONALITY AND PREDICTION OF TRANSFER OF TRAINING

The TCA described above identified the stimuli and responses involved in criterion performance and the extent to which those stimuli are common to both the operational equipment and the training device. The next consideration to be addressed is response commonality, that is, the extent to which responses made in the criterion environment may be made in the training device. With information concerning both stimulus and response commonality in hand, prediction of positive or negative transfer of training will be possible.

Aircraft Control

The more obvious responses under consideration are those related to aircraft control, and they were identified in the analyses described above of criterion performance. Aircraft control may be defined as the actions of the pilot as he closes the loop between displayed information and control inputs in order to maintain a steady state condition or to proceed from one steady state condition to another. Thus, in controlling the aircraft

(or simulated aircraft), the pilot responds through the aircraft controls to information (stimuli) he receives. Where relatively inexperienced instrument students are concerned, this information comes principally from instruments on the panel and feedback from the controls themselves. Proprioceptive and auditory cues associated with aircraft motion and sound have relatively little effect upon transfer of training during early stages of training.[14]

The displays used in aircraft control that are common to both the TH-13T and the modified 1-CA-1 (see Table 1) are (a) the Airspeed Indicator, (b) the Attitude Indicator, (c) the Altimeter, (d) the Turn and Slip Indicator, (e) the Bearing Heading Indicator (BHI) Heading Card, (f) the Vertical Velocity Indicator, and (g) the Manifold Pressure Gage. Except for the Manifold Pressure Gage, which is the primary indicator of the amount of power applied by the pilot, these instruments are useful for those aspects of aircraft control that do not involve aircraft subsystem control (e.g., engine and fuel subsystem control).

Reference to Table 2 indicates that these seven instrument displays were generally judged to be realistic in both appearance and function. Thus, it was concluded that similarity exists between these seven stimuli in the training device and in the criterion environment.

The analysis of maneuvers performed in the TH-13T indicated a display important to aircraft control which is not present in the 1-CA-1. It is the Engine and Rotor Tachometer.[15] The absence of this important display constitutes a significant dissimilarity of stimuli between the training and the criterion situation.

The responses important to aircraft control require the appropriate manipulation by the pilot of certain levers, pedals, switches, knobs, and so forth, in the aircraft or simulated aircraft. The controls identified in the criterion performance analysis as being important to aircraft control that are common to both the TH-13T and the 1-CA-1 were determined to be (a) the Cyclic, (b) the Pedals, (c) the Collective, (d) the Altimeter Setting Control, (d) the Signal Distribution Volume Control, (f) the Radio Microphone Switch, and (g) the Elapsed Time Clock Set and Control Knob.

Reference to Table 3 indicates that four of these controls were judged to be relatively realistic in the modified 1-CA-1. The Cyclic, Pedals, and Collective—controls which play an important role in aircraft control—were judged to be relatively unrealistic in either direction of movement or effect upon displays. The consensus of the pilots who made the realism ratings was that the Cyclic and the Pedals required unrealistic directions of movement (in order to obtain a given effect), and the Collective had an unrealistic effect upon the appropriate displays when comparison was made with typical Army helicopters. Thus, it must be concluded that dissimilarity exists between responses required to operate the three most important controls used in the training and in the criterion situations.

The TCA indicated an important omission from the list of common controls: the Throttle. Since adjustment of the Throttle is required in the TH-13T whenever a change is made from one steady state condition to another, the lack of a Throttle in the modified 1-CA-1 constitutes an important dissimilarity in response capability between the training and the criterion situation.

Two facts significantly limit the potential of the device from the standpoint of transfer of training: (a) training involving power adjustment through the Throttle in response to information displayed on the Engine Tachometer cannot be provided in the

[14] Smode, A.F., *et al.*, *op. cit.*

[15] An instrument labeled Engine Tachometer is present in the 1-CA-1. It does not function, however. For purposes of this research, instruments and controls in the 1-CA-1 which do not function are considered to be missing.

1-CA-1, and (b) Throttle (i.e., RPM) control is an important aspect of the aircraft control task in the TH-13T. Furthermore, the fact that the displays in the 1-CA-1 and the TH-13T are similar, but the responses required to operate the Cyclic, Pedals, and Collective are dissimilar, leads to a prediction of negative transfer of training from the 1-CA-1 to the TH-13T where aircraft control skills are concerned. Only in the relatively insignificant cases of training pilots to adjust the altimeter, set the clock, adjust radio volume, and speak through the microphone, are the stimuli and responses involved appropriate to a prediction of positive transfer of training from the training device to the criterion equipment.

Communication

Under instrument conditions, communication takes place between the pilot and the copilot, and between the pilot or copilot and certain ground stations. Communication stimuli are received through earphones[16] in both the TH-13T and the 1-CA-1. Simulation of the copilot and of ground communication stations can be provided in the 1-CA-1 by the device operator. The stimuli presented to the pilot to simulate these two sources of communication were judged by the research staff to be realistic in the 1-CA-1 (except that the signal received by the pilot in the device typically is superior in quality to that received in the TH-13T).

From the response standpoint, the pilot of the 1-CA-1 has only two operable communications controls which have counterparts in the TH-13T, the Microphone Button and the Volume Control. It was the consensus of the TH-13T instructor pilots who evaluated the 1-CA-1 display and controls, as indicated in Tables 2 and 3, that these two controls were realistic when compared to the corresponding controls in typical Army helicopters. Thus, within the limitation imposed by the availability of only two communication controls, the stimuli and responses necessary to tactical instrument communication are similar in the 1-CA-1 and the TH-13T. Positive transfer can be predicted.

The communication function of tuning radios, as required in the TH-13T, is not possible in the 1-CA-1. It should be noted, however, that this function is performed by the copilot in the TH-13T, upon verbal instruction from the pilot. This situation may be simulated in the 1-CA-1 by instructing the device operator to perform the radio tuning function when requested to do so by the trainee.

ADDITIONAL TRAINING PROGRAM CONSIDERATIONS

The modified 1-CA-1 was investigated to determine whether it had any capabilities that might contribute positively to its training usefulness but that had not been noted in the systematic analyses described above. In addition, the O/WORWAC Tactical Instrument Training syllabus was reviewed to identify any areas of training that might be conducted, in part, in the modified 1-CA-1 but that had not otherwise been noted in the present study. Two such areas were noted for further investigation.

Environmental Simulation

The 1-CA-1 provides the capability of simulating three aspects of the environment in which the simulated aircraft operates: wind direction and intensity, turbulence, and electromagnetic signals. The similarity of the stimuli presented by this simulation to the

[16] Earphones are not identified as common equipment in Table 1. Earphones are contained in the pilot's personal flight helmet which he uses in the TH-13T, rather than being an integral part of the aircraft. Headsets are integral to the training device.

pilot in the modified 1-CA-1 and the TH-13T was observed by the research staff, and, after consultation with the TH-13T instructor pilots, was judged to be realistic. The effect upon aircraft navigation of simulation of wind direction and intensity subjectively corresponds closely to the corresponding effect in the TH-13T. The simulation of turbulence in the device corresponds subjectively to that experienced in the TH-13T, except that the degree of turbulence in the device is not as great as that which may be experienced in the aircraft. Simulations in the device of all electronic signals which originate outside the aircraft (e.g., ground-based radio navigation stations) were judged to be realistic representations of the corresponding signals in the aircraft with one exception—aural station identifiers typically are missing. This defect in the simulation is considered of little consequence in the present instance, since the information the aural station identifiers provide is redundant.

Thus, the extra-aircraft environmental stimuli presented in the modified 1-CA-1 and the TH-13T are similar. The responses made to these stimuli all involve, to one degree or another, manipulation of the controls of the aircraft; therefore, the above comments dealing with aircraft control apply. It should be noted, however, that certain procedural aspects of the responses required to environmental effects are similar in the training and criterion situations in spite of the dissimilarity of aircraft control responses. For example, corrections for wind are similar, procedurally, in the two situations, although the specific psychomotor responses required of the pilot are dissimilar.

Training in the modified 1-CA-1 in the procedural aspects of responding to environmental stimuli may be predicted to result in positive transfer to the criterion situation, although certain aircraft control responses being practiced during such training will lead to negative transfer. The net result of such training is questionable, since most of the responses which must be made to environmental stimuli involve aircraft control to a greater degree than procedures.

Aircraft Malfunction

Too few of the displays and the controls in the modified 1-CA-1 are sufficiently similar to those of the TH-13T to justify consideration of using the training device to train pilots to cope with TH-13T systems (e.g., engine) malfunctions. Malfunctions of certain instruments, however, can be simulated in the device in order to teach the pilot to fly under "partial panel" conditions. In the case of attitude control, for example, the Attitude Indicator may be failed in the modified 1-CA-1 by turning the Artificial Horizon On-Off Selector to the Off position. The simulation of failure of other instruments may be accomplished simply by taping a mask over the instruments and requiring the pilot to fly by reference to the remaining unmasked instruments.

The simulation of instrument malfunctions in the modified 1-CA-1 is realistic when compared to the malfunction of corresponding instruments in typical Army helicopters in that such simulation requires the pilot in the device to resort to the remaining instruments for the appropriate stimuli for aircraft control. Although the stimuli are realistic, the responses required of the pilot are those of aircraft control, and the previous comments concerning transfer of aircraft control training apply. So far as training in the modified 1-CA-1 to cope with instrument malfunction in the TH-13T is concerned, negative transfer is predicted.

An important part of "partial panel" training is teaching the pilot to respond correctly to the standby compass. The standby compass, however, is not considered operable in the modified 1-CA-1. Therefore, those aspects of "partial panel" flight training which depend on this instrument (i.e., training for compass lead, lag, acceleration, and deceleration effects) cannot be provided in the device.

DEVELOPMENT OF A TRAINING PROGRAM

The analyses described also provide the basis for the development of a training program. In such activity, the two rules to be followed are: (a) maximize positive transfer of training, and (b) minimize negative transfer of training.

In the case of the specific training program which was the subject of analysis in this study, it is apparent that significant improvements in criterion performance will not result from a new program of instruction for the old device. It would appear that nothing can be done to avoid some amount of negative transfer of aircraft control training from the modified 1-CA-1 to the criterion situation because any use of the device likely to lead to positive transfer of other skills inevitably will require the trainee to practice inappropriate aircraft control responses.

As a consequence of this situation, the design of a new program of instruction, an original objective of the research program of which this report is a part, was determined to be of insufficient value to the Aviation School to warrant an extensive development program. Nevertheless, any degree of improvement in the O/WORWAC training program would be of some value. Therefore, changes in emphasis in the training being conducted in the modified 1-CA-1 devices would probably be of benefit by providing slight improvements in aviator proficiency in the aircraft. These changes in emphasis are indicated below:

(1) The best way to avoid negative transfer of skills is to eliminate the source of the negative transfer. This could be done in the O/WORWAC by teaching trainees attitude flying in the TH-13T before any training is given in the 1-CA-1. All aircraft control training could be provided in the aircraft. After the trainee has learned to control the aircraft, the incompatible responses he must make in the 1-CA-1 while learning procedures will be less likely to interfere with subsequent criterion performance.

(2) It is useless to require the trainee to develop high skill levels in the control of the 1-CA-1; being able to "fly" the 1-CA-1 to tight tolerances has no intrinsic value in terms of performance in an aircraft. Being able to control altitude to ±100 feet in the 1-CA-1, for example, will not enable him to control altitude any better in the TH-13T. In fact, the reverse may be true.

(3) It would be desirable to minimize instruction in maneuvers in the 1-CA-1 which involve frequent throttle adjustment. The absence of a throttle and an engine tachometer in the 1-CA-1 is possibly a major source of negative transfer of training. Attempting to teach acceleration and deceleration, for example, can only make bad matters worse.

(4) It would appear that use of the 1-CA-1 in the tactical instrument training program can be justified only for procedures training. Therefore, instruction in which the device is used would most profitably concentrate on procedures. Emphasis on anything other than procedures should be avoided, even to the extent of allowing very "sloppy" flying.

CONCLUSION

The primary objective of the research described here, to develop systematic, analytic procedures that will enable training personnel to assess the utility of an existing device for a new training purpose, was met. These procedures permit the estimation of the transfer of training value of a device when employed in a new or a to-be-developed training program and provide substantive guidance to the training officer responsible for efficient use of the device.

The procedures were applied to an existing training system where the transfer of training value of a flight training device had been determined empirically during earlier research. A general lack of task commonality was found between the device and the operational aircraft, and predictions were made that the device would have little transfer of training value. These predictions were generally compatible with the findings during the earlier research that, overall, there were no consistent indications that the device-trained groups differed, in terms of performance in the aircraft, from groups without such training.

Applications of these analytic procedures are not limited to evaluations of existing devices in new training programs. Other applications include:

(1) Comparison of several devices, either in the inventory or available commercially, to determine which one would be best suited for a known training device requirement. Situations where such an application would be appropriate include those in which a less-than-fully satisfactory device might provide an interim solution to a training problem while an appropriately designed device is being developed.

(2) Investigation of a prototype device to verify the suitability of its design prior to awarding follow-on procurement contracts. Situations where such an application would be appropriate include those in which circumstances preclude immediate empirical validation of the prototype's design features.

(3) Analysis of existing training programs in which training devices are employed to determine whether optimum use is being made of those devices.

The procedures described in this report are general in application. Throughout their development, it was intended that they apply to all military as well as nonmilitary situations in which training devices are employed in the development of operationally required skills.

The secondary objective of this research, to develop a training program which could make effective use of the Army's rotary wing modified 1-CA-1, was not met. The application of the analytic procedures to the training situation in which that device was employed led to the conclusion that significant improvements in criterion performance would not result from a new program of instruction for the old device due to negative transfer factors previously discussed.

APPENDICES

Appendix A

DISPLAYS AND CONTROLS FOUND IN THE TH-13T AIRCRAFT

I. Displays
- A. Flight instruments
  - (1) Airspeed Indicator
  - (2) Standby Compass
  - (3) Standby Compass Deviation Card
  - (4) Attitude Indicator
  - (5) Attitude Indicator Power Off Warning Flag
  - (6) Altimeter
  - (7) Vertical Velocity Indicator
  - (8) Bearing Heading Indicator Heading Card
  - (9) Bearing Heading Indicator Deviation Card
  - (10) Turn and Slip Indicator
- B. System Status Instruments
  - (1) Chip Detector Light
  - (2) Fuel Boost Fail Light
  - (3) Heater Fail Light
  - (4) Inverter Fail Light
  - (5) Cylinder Head Temperature Indicator
  - (6) Fuel Gage
  - (7) Loadmeter
  - (8) Engine Gage
    - (a) Engine Oil Temperature
    - (b) Transmission Oil Temperature
    - (c) Oil Pressure
    - (d) Fuel Pressure
  - (9) Tachometer
    - (a) Rotor
    - (b) Engine
  - (10) Manifold Pressure Gage
    - (a) Manifold Pressure
    - (b) Compressor Pressure
  - (11) Carburetor Air Temperature Gage
    - (a) Carburetor Air Temperature
    - (b) Filter Air Temperature
- C. Radio Navigation Instruments and Displays
  - (1) Marker Beacon Light[1]
  - (2) Course (Omni) Indicator[1]
    - (a) Course Pointer and Reciprocal Pointer[1]
    - (b) Off Vertical Flag[1]
    - (c) Off Horizontal Flag[1]
    - (d) To-From Meter[1]
    - (e) Vertical Pointer[1]
    - (f) Horizontal Pointer[1]

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(3) Bearing Heading Indicator
(a) ADF Pointer
(b) Omni Pointer[1]

D. Miscellaneous Instruments and Displays
(1) Elapsed Time Clock
(2) TH-13T Frequency Card
(3) Transmitter Selector Decal
(4) Radio Call Placard

II. Controls

A. Flight Control Systems
(1) Cyclic
(2) Cyclic Friction Adjuster
(3) Collective Pitch
(4) Collective Pitch Friction Adjuster
(5) Tail Rotor Control Pedals
(6) Tail Rotor Pedal Adjustment Controls
(7) Altimeter Setting Control
(8) Attitude Indicator Adjustment Controls
(a) Pitch Adjustment Control
(b) Roll Adjustment Control
(9) Phase A Attitude Indicator Circuit Breaker
(10) Phase B Attitude Indicator Circuit Breaker
(11) Compass Slaving Switch
(12) Turn and Slip Indicator Circuit Breaker
(13) Instrument Circuit Breaker
(14) Vertical Velocity Indicator Adjustment Screw

B. Aircraft System Control
(1) Throttle
(2) Throttle Friction Adjuster
(3) Fuel Pump Circuit Breaker
(4) Fuel Mixture Control
(5) Fuel Shut-Off Control Knob
(6) Engine Start Button
(7) Engine and Transmission Oil Temperature Selector Switch
(8) Manifold Purge Valve Button
(9) Carburetor Heat Control
(10) Hydraulic System On-Off Switch
(11) Hydraulic Circuit Breaker
(12) Ignition Switch
(13) Battery On-Off Switch
(14) Generator On-Off Switch
(15) Engine Starter Circuit Breaker
(16) Inverter Circuit Breaker
(17) Inverter Spare Switch
(18) Phase A Inverter Fail Relay Circuit Breaker

C. Radio Navigation/Communication Controls
(1) UHF Command Radio Set Control Panel
(a) On-Off Switch
(b) Channel Selector
(c) Volume Control
(d) Tone Button
(e) Remote-Local Switch

(2) UHF Circuit Breaker
(3) Signal Distribution Panel
  (a) Receiver Switches, 1, 2, 3, and 4
  (b) Receiver Interphone Switch
  (c) Receiver Navigation Switch
  (d) Volume Control
  (e) Transmit-Interphone Selector Switch
(4) ICS Circuit Breaker
(5) VOR-ILS Control Panel[1]
  (a) Volume-Off Switch[1]
  (b) Squelch Control[1]
  (c) Whole Megacycle Channel Selector Switch[1]
  (d) Fractional Megacycle Channel Selector Switch[1]
(6) VOR Circuit Breaker[1]
(7) Marker Beacon Volume-Off Control[1]
(8) Marker Beacon Sensing Switch[1]
(9) Omni Course Selector Knob[1]
(10) Marker Beacon/Glide Slope Circuit Breaker[1]
(11) ADF Receiver Control Panel
  (a) MC Band Switch
  (b) Volume Off Control
  (c) Function Switch
  (d) Loop Switch
  (e) Tuning Control
  (f) BFO Switch
(12) ADF Circuit Breaker
(13) Bearing Heading Indicator Controls
  (a) Heading Synchronization Knob
  (b) Set Heading Knob
  (c) VOR-ADF Knob[1]
(14) DG-401 Compass Circuit Breaker
(15) Phase A DG-401 Compass Circuit Breaker
(16) Phase C DG-401 Compass Circuit Breaker
(17) Radio Light Rheostat
(18) Radio Microphone Switch
(19) ICS Microphone Switch
(20) ICS Foot Switch

D. Auxiliary Equipment Controls
(1) Door-Mounted Cabin Ventilator
(2) Cabin Heater Controls
  (a) Heater Start Switch
  (b) Heater Control Switch
  (c) Heater Power Switch
  (d) Heater Blower Switch
  (e) Cabin Heater Thermostat Control
  (f) Fire Shut-Off Control
(3) Cockpit Light Rheostat
(4) Instrument Lights Rheostat
(5) Position Lights On-Off Switch
(6) Anti-Collision Lights On-Off Switch
(7) Landing Light On-Off Switch
(8) Cockpit Lights Circuit Breaker

(9) Caution Lights Circuit Breaker
(10) Landing Lights Circuit Breaker
(11) Instrument Light Circuit Breaker
(12) Bubble Defrost Knob
(13) Elapsed Time Clock Set and Control Knob
(14) Shoulder Harness Lock Knob
(15) 26-Volt AC Transformer Circuit Breaker
(16) Radio Lights Rheostat

[1] Indicates displays and controls associated with VOR-ILS systems. The VOR-ILS and associated displays and controls are not used in the Tactical Instrument training portion of the O/WORWAC. All other displays and controls in the TH-13T are used by the student pilot or the instructor pilot or are of potential use to them during the course.

Appendix B

DISPLAYS AND CONTROLS FOUND IN 1-CA-1 DEVICE MODIFIED AT USAAVNS TO A ROTARY WING CONFIGURATION

I. Displays
   A. Attitude Instruments
      (1) Standby Compass[1, 2]
      (2) Airspeed Indicator
      (3) Attitude Indicator
      (4) Altimeter
      (5) Turn and Slip Indicator
      (6) Radio Magnetic Indicator
      (7) Vertical Velocity Indicator
   B. System Status Instruments
      (1) Engine Tachometer[3]
      (2) Manifold Pressure Gage
      (3) Vacuum Gage[1, 4]
      (4) Fuel Quantity Gage[1, 5, 6]
      (5) Fuel Pressure Gage[1, 5]
      (6) Oil Temperature Gage[1, 5]
      (7) Air Temperature Gage[1, 5]
      (8) Carburetor Temperature Gage[5]
      (9) Oil Pressure Gage[1, 5]
   C. Radio Navigation Instruments and Displays
      (1) Radio Compass Indicator[4, 5, 6]
      (2) Army Cross Pointer Center Line Deviation Indicator
      (3) Army Cross Pointer To-From Indicator
      (4) Radio Magnetic Indicator ADF Pointer
      (5) Radio Magnetic Indicator Omni Pointer
      (6) Course Selector Display
      (7) Marker Beacon Indicator Light
   D. Miscellaneous Instruments and Displays
      (1) 8-Day Clock
      (2) Radio Call Label
II. Controls
   A. Flight Control System
      (1) Cyclic
      (2) Pedals
      (3) Collective Pitch Stick
      (4) Attitude Indicator Horizontal Adjustment Control
      (5) Altimeter Adjustment Control
      (6) Radio Compass Indicator Magnetic Variation Adjustment[1, 4]
      (7) Turn and Bank Gyro-Off Switch[4]

B. Aircraft Systems Control
   (1) Ignition Switch
   (2) Fuel Tank Selector[4,5]
   (3) Master Off-On Switch
   (4) Carburetor Open-Close Cooling Shutter Lever[4,5]
   (5) Oil Open-Close Cooling Shutters Lever[4,5]
   (6) Cowl Open-Close Cooling Shutters Lever[4,5]
   (7) Pitot Heater Off-On Switch[4]

C. Radio Navigation/Communication Control
   (1) Army Cross Pointer Center Line Deviation Indicator Adjustment Screw[4]
   (2) Army Cross Pointer To-From Indicator Adjustment Screw[4]
   (3) Course Selector Knob
   (4) I.F.F. Control Switch[4,5]
   (5) Antenna Selector Switch[5]
   (6) Loop Drive Switch[5]
   (7) Instrument Landing Switch[5]
   (8) To-From Switch[4,5]
   (9) Glide Path Control[5,7]
   (10) Off-Flight-Land Switch[5,7]
   (11) Inner-Outer-Range-Tower Selector Switch[5,7]
   (12) Voice-Both-Range Switch[5,7]
   (13) Volume Control
   (14) Pilot's Tuning Control[5,7]
   (15) Microphone Button

D. Auxiliary Equipment Controls
   (1) 8-Day Clock Set and Control Knob
   (2) Trainer Lock-Release Lever[4]
   (3) Instrument Lights Off-On Switch
   (4) Cockpit Lights Rheostat
   (5) Door Knob

[1] Indicator displays and controls found in fewer than 80% of the rotary wing modified 1-CA-1s.

[2] The Standby Compass is functional but incorporates error typically as high as 60° and is not used.

[3] The Engine Tachometer registers 0 RPM when the Master Switch is off and a fixed operational value when the Master Switch is on. Its function is related to no other controls or displays.

[4] Indicates displays and controls which are present in the rotary wing modified 1-CA-1 and perform functions for which there are no counterparts in the TH-13T.

[5] Indicates displays and controls which are inoperative or nonfunctioning.

[6] Approximately 25% of the rotary wing modified 1-CA-1s have a Fuel Quantity Gage; the remaining 75% have a Radio Compass Indicator in its place.

[7] Indicates controls which are present in the rotary wing modified 1-CA-1 but for which there are no counterparts in the TH-13T; the function performed by these controls, however, can be performed by other means in the TH-13T.

Appendix C

MODIFIED 1-CA-1 DISPLAYS AND CONTROLS WHICH ARE OPERATIONAL IN A MAJORITY OF THE AVAILABLE DEVICES

I. Displays
   A. Attitude Instruments
      (1) Airspeed Indicator
      (2) Attitude Indicator
      (3) Altimeter
      (4) Turn and Slip Indicator
      (5) Radio Magnetic Indicator Heading Card
      (6) Vertical Velocity Indicator
   B. System Status Instruments
      (1) Manifold Pressure Gage
   C. Radio Navigation Instruments and Displays
      (1) Army Cross Pointer Center Line Deviation Indicator
      (2) Army Cross Pointer To-From Indicator
      (3) Radio Magnetic Indicator ADF Pointer
      (4) Radio Magnetic Indicator Omni Pointer
      (5) Course Selector Display
      (6) Marker Beacon Indicator Light
   D. Miscellaneous Instruments and Displays
      (1) 8-Day Clock
      (2) Radio Call Label

II. Controls
   A. Flight Control System
      (1) Cyclic
      (2) Pedals
      (3) Collective Pitch Stick
      (4) Attitude Indicator Horizontal Adjustment Control
      (5) Altimeter Adjustment Control
      (6) Turn and Bank Gyro-Off Switch[1]
   B. Aircraft Systems Control
      (1) Ignition Switch
      (2) Master Off-On Switch
      (3) Pitot Heater Off-On Switch[1]
   C. Radio Navigation/Communication Control
      (1) Army Cross Pointer Center Line Deviation Indicator Adjustment Screw[1]
      (2) Army Cross Pointer To-From Indicator Adjustment Screw[1]
      (3) Course Selector Knob
      (4) Volume Control
      (5) Microphone Button

D. Auxiliary Equipment Controls
   (1) 8-Day Clock Set and Control Knob
   (2) Trainer Lock-Release Lever[1]
   (3) Instrument Lights Off-On Switch
   (4) Cockpit Lights Rheostat
   (5) Door Knob[1]

[1] Indicates displays and controls which are present in the rotary wing modified 1-CA-1 and perform functions for which there are no counterparts in the TH-13T.

Appendix D

ANALYSIS OF A REPRESENTATIVE FLIGHT MANEUVER PERFORMED DURING A TACTICAL INSTRUMENT MISSION IN THE TH-13T AIRCRAFT

MANEUVER: INSTRUMENT TAKE-OFF (ITO) AND CLIMB TO A SPECIFIED ALTITUDE
(Maneuver begins with the aircraft in position for ITO and all engine gages in the green)

Task[1]	Display	Stimulus	Information	Responses
Communications:				
	Radio	1. Clearance from base airfield to destination	1a. Aircraft (A/C) identification 1b. Clearance limit 1c. Route of flight 1d. Altitude data 1e. Departure procedure 1f. Holding instructions 1g. Any special information	1a. Copy clearance (adjust audio volume if required) 1b. Transmit repeat of clearance (push-to-talk switch)
		2. Take-off clearance	2a. Direction of take-off 2b. Sequence of take-off 2c. Altimeter setting 2d. Time 2e. Wing direction and velocity	2a. Set heading on Bearing Heading Indicator (BHI) using magnetic compass 2b. Set barometric pressure on altimeter 2c. Set time on clock 2d. Transmit acknowledgment
Take Off:				
Verify Heading	Bearing Heading Indicator (BHI)	1. Heading card reading	1. Take-off heading	1. Twist throttle counter-clockwise (CCW)
Control Rotor and Engine RPM	Tachometer	1. Needles moving clockwise (CW) to 3200 (engine) RPM	1. Engine and rotor RPM	1a. Stop throttle when needle reaches 3200 RPM 1b. Raise collective pitch lever

(Continued)

Task[1]	Display	Stimulus	Information	Responses
Control Power	Manifold Pressure (MP) Indicator	1. Needle moving CW	1. Take-off power being applied	1. Stop collective ptich at take-off power 33" MP. Maintain 33" MP
Control Trim	Turn & Slip Indicator	1. Ball out to the left of center	1. Yaw to the right	1. Push on left pedal
Control Pitch	Attitude Indicator (primary for ITO)	1. Minature A/C nose on horizon bar	1. A/C in level attitude	1. Push cyclic forward to acceleration attitude 2 bar widths below horizon
	Airspeed Indicator (secondary for ITO)	1. Pointer moving CW to 50 knots (K)	1. Airspeed climbing	1. Pull cyclic back upper reaching 50K
		2. Pointer moving CCW from 50K	2. A/C climbing too rapidly	2. Push cyclic forward to maintain 50K
		3. Pointer moving CW from 50K	3. A/C climbing too slowly	3. Pull cyclic back to maintain 50K
	Vertical Speed Indicator (VSI) (secondary for ITO, primary for climb)	1. Pointer moving CW to 500 feet per minute (fpm)	1. Climb approaching standard rate	1. When 500 fpm reached, reduce power to climb setting 27" MP by lowering collective
		2. Pointer not moving CW to 500 fpm position	2. A/C climbing too slowly	2. Pull cyclic back
		3. Pointer moving CW from 500 fpm position	3. A/C climbing too fast	3. Push cyclic forward
Climb:				
Adjust Power	Manifold Pressure	1. Needle moving CCW	1. Approaching climb MP setting	1a. Adjust throttle to maintain 3200 RPM 1b. Ease off left torque pedal
	Tachometer	1. Needle moving CW from 3200 RPM	1. RPM high	1. Twist throttle CW
		2. Needle moving CCW from 3200 RPM	2. RPM too low	2. Twist throttle CCW

(Continued)

Task[1]	Display	Stimulus	Information	Responses
	Attitude Horizon (secondary for climb)	1. Minaiture A/C nose ½ bar width above horizon bar	1. 50K climbing attitude	1. Maintain with cyclic
	Altimeter (secondary for ITO)	1. Needle moving CW	1. Aircraft climbing	1. Cross check VSI for 500 fpm climb. Maintain with cyclic.
Control Bank	Attitude Indicator (primary for ITO, secondary for climb)	1. Miniature A/C wings parallel to horizon bar	1. Straight climb attitude	1. Maintain cyclic in center position laterally
		2. Miniature A/C wings slanted down to right	2. A/C in right bank	2. Move cyclic to the left
		3. Miniature A/C wings slanted down to left	3. A/C in left bank	3. Move cyclic to the right
	Turn Needle (secondary for ITO and climb)	1. Needle vertical	1. A/C in straight flight	1. Maintain cyclic in center laterally
		2. Needle moving CW from vertical	2. A/C in turn to right	2. Move cyclic to the left
		3. Needle moving CCW from vertical	3. A/C in turn to left	3. Move cyclic to the right
	BHI (secondary for ITO, primary for climb)	1. Heading card rotating CCW	1. A/C in turn to right	1. Move cyclic to the left
		2. Heading card rotating CW	2. A/C in turn to left	2. Move cyclic to the right
Control Trim	Turn & Slip Indicator	1. Ball to right of center when turn needle is indicating no turn	1. A/C is in left yaw	1. Push right pedal
		2. Ball to left of center when turn needle is indicating no turn	2. A/C is in right yaw	2. Push left pedal
Control Power	Airspeed Indicator	1. Needle moving CW from 50K	1. A/C climbing with power	1. Lower collective to maintain 50K
		2. Needle moving CCW from 50K	2. A/C climbing without enough power	2. Raise collective to maintain 50K

(Continued)

Task[1]	Display	Stimulus	Information	Responses
Level Off:				
Control Pitch	Altimeter (primary for pitch)	1. Needle moving CW	1. Reaching desired altitude	1. Push forward on cyclic 30 to 40 ft. before reaching desired altitude
	Altitude Indicator (secondary for pitch)	1. Minature A/C nose on horizon bar	1. Cruise altitude	1. Maintain with cyclic
	VSI (secondary for pitch)	1. Needle in horizontal position	1. A/C in level flight	1. Maintain with cyclic
Control Power	Airspeed Indicator	1. Needle moving CW to 60K	1. A/C approaching cruise speed	1. Reduce power with collective to maintain 60K airspeed
	Tachometer	1. Needle not indicating 3200 RPM	1. Throttle needs adjustment	1. Adjust throttle to maintain 3200 RPM
	Turn & Slip Indicator	1. Turn needle vertical but ball off center	1. Trim needs adjustment	1. Control yaw with torque pedal
Control Heading	BHI	1. Heading card turning	1. Heading not steady	1. Control heading with cyclic

[1] Many of the tasks indicated in this maneuver occur concurrently rather than sequentially as suggested by the format employed. In like manner, the sequence employed in viewing the listed displays to obtain information, the sequence of response made, etc., are not necessarily restricted to the sequence indicated here.

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13. ABSTRACT
Procedures were developed to enable training personnel systematically and objectively to determine the potential utility of training devices for teaching how to perform missions in operational equipment. The procedures allow comparison of operational task stimulus and response elements with corresponding elements in synthetic training equipment. On the basis of such information, training programs consistent with the psychological principles underlying transfer of training may be developed. The procedures may be applied to the potential use of training equipment in a training situation other than that for which it was designed, or in determining the applicability of "off-the-shelf" training devices to specific training requirements. The procedures, termed Task Commonality Analysis, were developed in connection with an Army rotary wing instrument flight training program. In an application of the procedures in that program, transfer of training predictions were generally consistent with empirical evidence collected earlier.

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