Technical Paper 298

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EVALUATION OF A FLIGHT SIMULATOR (DEVICE 2B24) FOR MAINTAINING INSTRUMENT PROFICIENCY AMONG INSTRUMENT-RATED ARMY PILOTS

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HUMAN FACTORS IN TACTICAL OPERATIONS TECHNICAL AREA

U. S. Army
Research Institute for the Behavioral and Social Sciences

July 1978

U. S. ARMY RESEARCH INSTITUTE

FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency under the Jurisdiction of the Deputy Chief of Staff for Personnel

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NOTICES

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER Technical Paper 298	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EVALUATION OF A FLIGHT SIMULATOR (DEVICE 2B24) FOR MAINTAINING INSTRUMENT PROFICIENCY AMONG INSTRUMENT-RATED ARMY PILOTS		5. TYPE OF REPORT & PERIOD COVERED Technical Paper 6. PERFORMING ORG. REPORT NUMBER --
7. AUTHOR(s) Donald O. Weitzman, Michael Fineberg, and George L. Compton		8. CONTRACT OR GRANT NUMBER(s) --
9. PERFORMING ORGANIZATION NAME AND ADDRESS PERI-OT, Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Avenue, Alexandria, VA 22333		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2Q763743A772 Task D Work Unit 1
11. CONTROLLING OFFICE NAME AND ADDRESS Deputy Chief of Staff for Operations Washington, DC 20310		12. REPORT DATE July 1978 13. NUMBER OF PAGES 30
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) --		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE --

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

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

--

18. SUPPLEMENTARY NOTES

Presented at 9th NTEC/Industry Conference, Nov. 1976.

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

Flight Simulation
Transfer of Training
Aviation Unit Training

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

The research aims to evaluate the operational suitability of Device 2B24, which simulates the UH-1H helicopter, for facilitating UH-1H instrument proficiency training and proficiency assessment among instrument rated pilots. The present data indicate that substantial amounts of UH-1H time can be substituted by Device 2B24 time in instrument proficiency training and proficiency assessment. With simulators, the Army has the opportunity to establish an instrument training program that can maintain and assess →

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Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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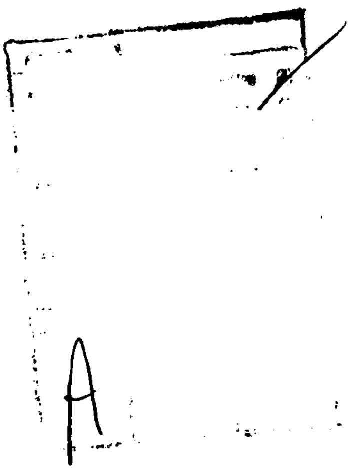
instrument proficiency year round and at a reasonable cost. A reasonable conclusion from this study is that a realistic instrument training program that includes simulator training would reduce accidents and enhance combat readiness among instrument rated pilots.



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HUMAN FACTORS IN TACTICAL OPERATIONS TECHNICAL AREA

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Department of the Army

July 1978

Army Project Number
2Q763743A772

Human Performance
Enhancement

FOREWORD

The Human Factors in Tactical Operations Technical Area of the Army Research Institute (ARI) is concerned with the improvement of aviation effectiveness and the maintenance of combat proficiency in operational aviation units. Programs in the Technical Area deal with systematic research over wide areas and with immediate and specific problems, in this case the utility of flight simulators in combat-readiness training.

The Army has the task of maintaining instrument flight proficiency for a large number of helicopter pilots. This goal imposes a significant demand on aircraft and aircraft instructor resources. Training alternatives, such as flight simulators, the analysis of the cost ratios of simulator training, and the optimum amount of training required annually in simulators and in aircraft to maintain acceptable proficiency need to be evaluated. The Deputy Chief of Staff for Operations was given responsibility for research in the area of flight simulation and proficiency maintenance training. ARI, under the Office of the Deputy Chief of Staff for Personnel, was assigned responsibility for assessing the utility of flight simulators in combat-readiness training.

This publication summarizes ARI research on the operational suitability of Device 2B24, a device that simulates the UH-1H helicopter, for facilitating UH-1H instrument-proficiency training and proficiency assessment among combat-ready pilots. ARI formulated the initial research program primarily as an applied effort to furnish information and guidance to the Army. Research is conducted under Army RDTE Project 2Q763743A772, "Aircrew Performance in Tactical Environment," FY 1976 Work Program. The research was conducted at Fort Campbell, Ky., with the help and support of the 101st Aviation Group, and is responsive to the needs of the Deputy Chief of Staff for Operations of the U.S. Army.

Joseph Zeidner
Technical Director (Designate)

EVALUATION OF A FLIGHT SIMULATOR (DEVICE 2B24) FOR MAINTAINING INSTRUMENT PROFICIENCY AMONG INSTRUMENT-RATED ARMY PILOTS

BRIEF

Requirement:

To evaluate the operational suitability of Device 2B24, which simulates the UH-1H helicopter, for facilitating UH-1H instrument-proficiency training and proficiency assessment among instrument-rated pilots.

Procedure:

Two groups of pilots, representing a broad range of instrument skills, were given instrument training as follows: 12 hours in Device 2B24; 12 hours in the UH-1H; or a combination of 6 hours in the simulator and 6 hours in the aircraft. The 12 hours of training were divided over a 9-month period into 4 hourly increments taken every 3 months. Instrument proficiency measures were obtained at the end of each 3-month period during a standardized instrument checkride in the UH-1H. A terminal checkride, identical in all essential characteristics with the aircraft checkride, was given in Device 2B24.

Finding:

Twelve hours of training in Device 2B24 produced a higher quality of instrument performance and a higher rate of improvement throughout the training period than did training in the UH-1H. The training mode that combined Device 2B24 and the UH-1H produced results intermediate between the two.

Checkride performance in Device 2B24 covaried with checkride performance in the UH-1H. The data indicated that high and low scorers in the simulator had similar scoring patterns in the aircraft.

Pilot acceptance of simulator training increased with simulator experience.

Utilization of Finding:

The present data indicate that substantial amounts of UH-1H time can be substituted by Device 2B24 time in instrument-proficiency training and proficiency assessment. With simulators, the Army has the opportunity to establish an instrument training program that can maintain and assess instrument proficiency year round at reasonable cost. One conclusion from this study is that a realistic instrument training program that includes simulator training would reduce accidents and enhance combat readiness among instrument-rated pilots.

EVALUATION OF A FLIGHT SIMULATOR (DEVICE 2B24) FOR MAINTAINING INSTRUMENT PROFICIENCY AMONG INSTRUMENT-RATED ARMY PILOTS

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EVALUATION OF A FLIGHT SIMULATOR (DEVICE 2B24) FOR MAINTAINING INSTRUMENT PROFICIENCY AMONG INSTRUMENT-RATED PILOTS

INTRODUCTION

Since the early days of flying, the value of flight simulators has been amply demonstrated. Flight simulators have evolved from the relatively simple Link Trainer to precisely engineered devices capable of accurately computing the aerodynamic responses of an aircraft to control inputs and realistically reproducing instrument indications for all flight situations. As Adams (1957) pointed out, flight simulators have many advantages over the operational situation.

First, the simulator provides users with greater control over ambient conditions. Whereas the "real" world is subject to unpredictable variations, a simulator can provide planned variation of various elements of the real situation and omit unessential elements.

Second, the simulator can more safely represent the dangerous elements in flight. Emergency procedures that would be too dangerous to teach in the air may be taught safely in ground-based simulators.

Third, simulators cost less than aircraft to operate. For these reasons, simulators continue to play an important role in pilot training for initial skill acquisition, transition training, and maintenance of flying skills. The importance attached to simulators in meeting training goals assumes, of course, that training given in the simulator will transfer to the aircraft.

Although the value of simulators to initial entry pilot training has never been seriously challenged, the utility of simulator training for maintaining the proficiency of experienced pilots has not been adequately established. The various studies that have assessed the training effectiveness of a specific flight simulator for maintaining pilot proficiency have sometimes produced contradictory results (Caro, 1971; Crook, 1965; American Airlines, Inc., 1969; TransWorld Airlines, 1969).

Three different explanations for these contradictory findings have been suggested. First, the variance in flying skill among experienced pilots is often greater than among student pilots, who bring little, if any, initial skills to the task (McGrath and Harris, 1971). In performance training, it is well known that the beneficial effects of training vary as a function of experience or skill level (Briggs, 1957; Roscoe, 1971); that is, the same training simulator may exhibit different effectiveness functions for different levels of pilot experience or skill. To the extent that experienced pilots are not carefully matched in terms of flying skill, the significance of assessing what can be learned in the simulator is diminished.

Second, most performance measures used in earlier studies were judgmental in nature and, thus, highly subjective evaluation instruments.

Third, instructional techniques may vary widely depending upon the ability and attitudes of the instructor pilots (IPs). In considering the possibilities of such instructional differences, the utility of simulator training must be determined independent of the instructor variable.

The training value of Device 2B24, a high-fidelity simulator, for maintaining instrument flight proficiency among instrument-rated Army helicopter pilots in the UH-1H aircraft needs to be determined. The need for maintaining a high degree of instrument proficiency is much greater today than in the past. Day and night low-level missions and training are required to maintain combat readiness. Visual contact can easily be lost because of darkness or poor weather, allowing the pilot only seconds to transfer to instrument flight to avoid catastrophic results. The inability to quickly and effectively transfer to instrument flight has been a factor in a number of fatal accidents involving Army helicopters.

This paper reports on the transfer effectiveness of Device 2B24 for use in maintaining instrument proficiency among rated pilots as compared to inflight training in the UH-1H helicopter. This study extends previous studies by more adequate control of pilot and instructor variability and through more objective measures of pilot performance, obtained both before and after training in Device 2B24.

METHOD

Pilots

The 36 pilots participating in this study were fully qualified, combat-ready Army aviators. The sample comprised both warrant and commissioned officers, who all had 400 to 600 hours of rotary-wing flight experience. Two groups of 18 aviators each were formed on the basis of a composite score on three instrument performance measures. A written test on instrument procedures (I), a standardized instrument checkride in the UH-1H helicopter (H), and a standardized instrument checkride in Device 2B24 (S) were the three measures making up the composite score (P). The a priori scoring formula adopted reads: $P = .5I + S + H$, where the written test contributes 20%, and both checkrides contribute 40% to the total score. The three performance measures were administered to 51 experienced pilots assigned to the 101st Aviation Group, Fort Campbell, Ky. Those aviators who received the 18 highest and 18 lowest scores were selected for group matching and for controlling differences in initial ability. The two groups will be referred to as "high" and "low," respectively.

Following the selection, pilots within each group were quasi-randomly assigned to one of three instrument-training modes under the following conditions: (1) simulator training with Device 2B24, (2) in-flight training in the UH-1H, and (3) a combination of simulator and inflight training divided equally. Twelve pilots, six from each group, were assigned to each training mode. This procedure provided an opportunity not only to evaluate training modes, but also to evaluate the modes with respect to initial skill level among pilots. Statistical analysis showed that the differences among pilots assigned to each training mode were not significant but revealed a significant difference between pilot groups; i.e., "high" vs. "low" (see Appendix B, Table 1, for a summary of the analysis). Thus, pilots appeared to be effectively matched among training modes but differentiated in terms of initial instrument skills.

Procedure

The pilots in each of the three training modes were given 12 hours of instrument training during 9 months of testing in each of the three training modes: Device 2B24, UH-1H, or combined Device 2B24 and UH-1H training. (The experiment was originally designed to provide 16 hours of training, divided into four quarterly increments. The last quarter was not completed because of the temporary transfer of pilots to a new duty station.) The 12 hours of training were divided into 4 hourly increments. At the end of each 3-month period, pilots were required to take a standardized instrument checkride in the UH-1H, identical to the instrument checkride given before training.

Prior to testing, a precisely defined checkride inventory was developed to insure that all pilots were evaluated in the same way. The decisions to include items were based upon desired terminal flight behavior for experienced Army pilots. Evaluated tasks were arranged into a standard flight sequence, including objective and subjective items. Performance was evaluated on each of five quantitative variables, with one to four items for each variable scored on an appropriate scale. Equal weights were given to each objective variable measured, namely: (1) flight planning, (2) departure and enroute procedures, (3) holding and arrival procedures, (4) ATC procedures, and (5) aircraft control. All scored items were completed during flight. A score of 100 represented "errorless" performance. (The inventory is given in Appendix A.)

To minimize the effects of instructor differences, six IPs were given familiarization training on the use of flight inventory before each checkride. The order in which IPs were assigned to provide checkrides was varied systematically among all 36 pilots. In addition, knowledge of an individual pilot's proficiency ranking and group assignment was withheld to prevent such information from influencing the IPs' judgment. Examination of mean inventory scores assigned by each IP revealed little, if any, difference.

Instrument flight training began soon after the two groups of pilots were formed. Training sessions lasted 1 hour, and four sessions completed a training period. At the end of the period, each pilot was given an instrument checkride in the UH-1H, using the flight inventory for scoring pilot performance. In addition to checkrides in the aircraft, each pilot was required to complete a second instrument ride in Device 2B24 at the completion of the study. Scoring procedures in Device 2B24 were identical to those in the UH-1H. This paper reports on the findings of the transfer effectiveness of Device 2B24 among the 36 instrument-rated pilots.

RESULTS

Aircraft Performance

The main results deal with checkride performance following training in the three training modes and the percentage change in performance representing the difference between checkride performance before (i.e., baseline) and after training.

The curves in Figure 1 compare mean inflight performance for each training mode over the three test periods, with baseline performance plotted separately. Two features of the curves stand out. First, checkride performance was, in general, superior for pilots in both groups given all their training in Device 2B24. Thus, transfer of training benefits was greater when the simulator was used for all instrument training in the present study. Second, changes due to learning were, in general, greater for the low pilot group; that is, while the curves for the low group show marked improvement over test periods, the high group gave very little evidence of learning. This observation is a familiar one in the psychology of learning. By the end of training, therefore, inflight performance was much the same for both pilot groups. Percentage change scores for the three training modes are shown in Figure 2.

The curves in Figure 2 plot the difference, in percent, between checkride performance before training and after training in each mode and each test period. The curves show that the level of change in checkride performance was quite distinct, with Device 2B24 training producing the highest degree of positive transfer for both groups. The plot of these scores shows that most of the observed improvement in performance occurred by the second test period. It may be noted that all of the transfer for Device 2B24 training occurred after 8 hours of training in the simulator. The loss of the fourth test period, then, does not appear to be crucial to the interpretation of these results.

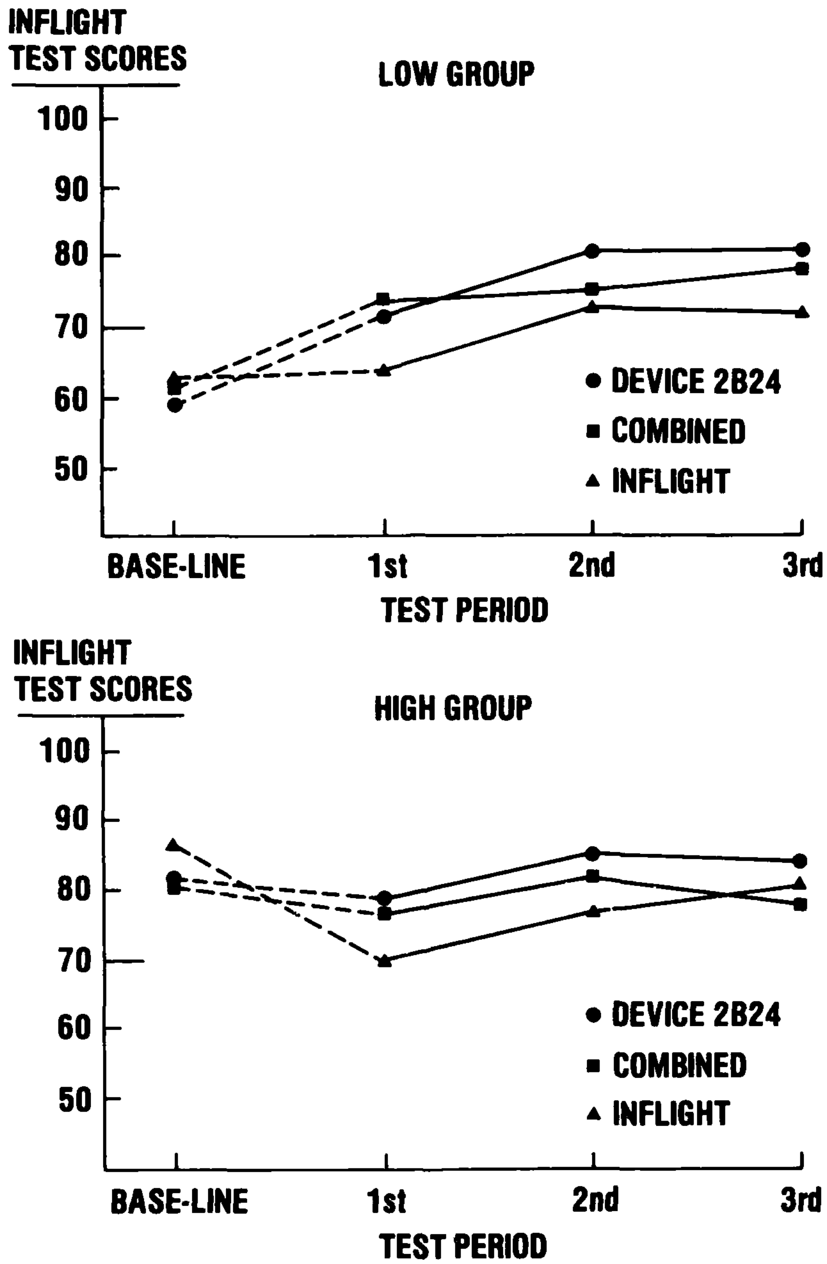

Figure 1. Learning curves of checkride performance for the three training modes and two pilot groups.

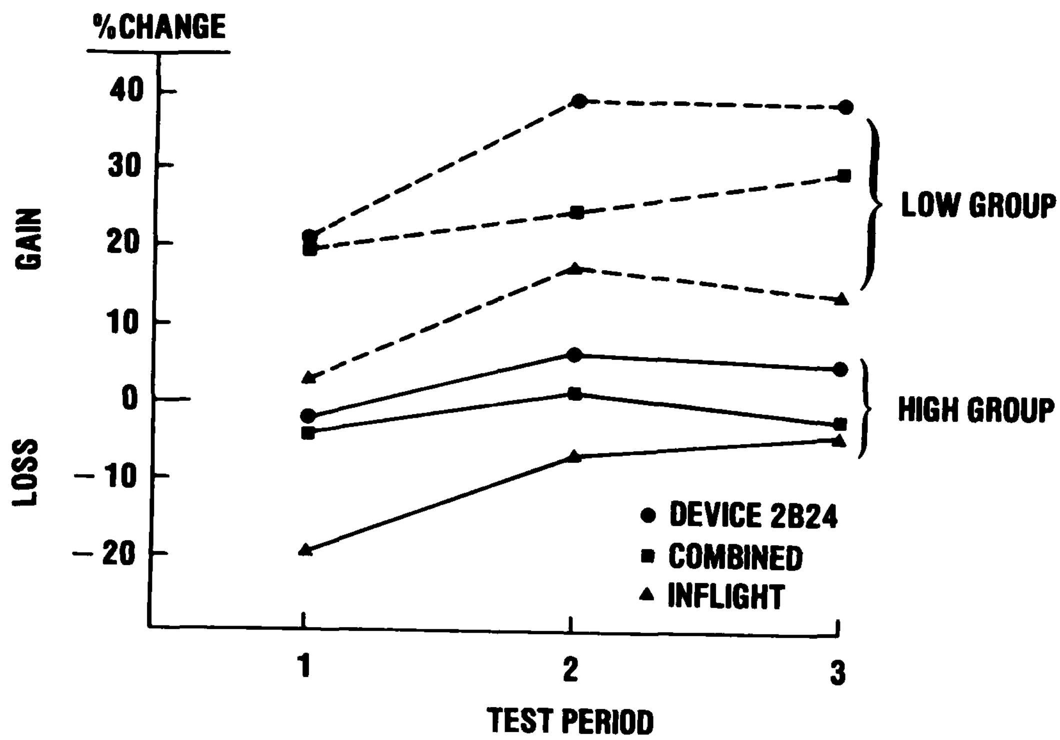

Figure 2. Change scores in checkride performance for the two pilot groups as a function of training mode and test periods.

Statistical Analysis

A two-way analysis of variance, encompassing training modes and test periods, was carried out on the inflight test score data (see Figure 1) for each group separately. (Details of these analyses are presented in Appendix B, Tables 2 and 3.)

Results of these analyses indicated that only low-group variations due to test periods were statistically significant, $F(2, 30) = 17.9$, $p < .001$, consistent with the evidence of differential rates of improvement among the two pilot groups during training. Although Device 2B24 training appeared to result in better performance throughout most of the training periods, F tests of the training mode means for each group were not significant.

In an effort to assess independently the terminal effects after 12 hours of training, two further analyses were run. The first analysis, a two-way analysis of variance encompassing training mode and pilot group means during the third test period, confirmed the lack of differences among the three training modes and between the two pilot groups after 12 hours of training (see Appendix B, Table 4, for a summary of the analysis). Duncan's multiple range test (Duncan, 1955), a second test, was carried out on the training mode means of the third test period to determine which, if any, of the differences among the three training modes were or were not significant. Results of these tests are summarized in Table 1.

Table 1

Results of Range Tests of the Differences Between Performance Score Means for Training Mode and Pilot Group

Group	Device 2B24	Combined	Inflight
High	84	78	81
Low	82	78	71

Note: Significant at the .05 level. Common lines underlying two or more means indicate that these means are not significantly different from one another.

The results shown in Table 1 indicate that the mean differences between inflight training in the UH-1H and simulator training in Device 2B24 were significant, but for the low pilot group only. All other comparisons were not significant, indicating that the advantages of simulator training were most apparent for the least proficient pilot group.

A three-way analysis of variance, encompassing groups, training modes, and test periods, was carried out on the change score data of Figure 2 (see Appendix B, Table 5, for a summary of the analysis). The analysis revealed that training modes $F(2, 25) = 4.12$, $p < .05$, pilot groups; $F(1, 25) = 8.32$, $p < .01$, and test periods; $F(2, 65) = 4.22$, $p < .025$ were a significant source of variance.

Duncan multiple-range tests were carried out on the training mode change scores for the last test period to determine the source of the differences that account for the significant overall variations in the training mode means. Results of these tests are summarized in Table 2.

Table 2

Results of Range Tests of the Differences Between Percent Change Score Means for Training Mode and Pilot Group

Group	Device 2B24	Combined	Inflight
High	5	-3	-7
Low	38	28	14

Note: Significant at the .05 level. Common lines underlying two or more means indicate that these means are not significantly different from one another.

Negative values in Table 2 indicate a percentage decrement in performance associated with training. This decrement is in line with normal variation in performance that may be expected with a pilot group already at a high level of instrument proficiency prior to training. The results indicate again that Device 2B24 training and UH-1H training showed the greatest number of significant differences, consistent with the evidence of increasing beneficial effects of Device 2B24 when compared to inflight training in the UH-1H.

Simulator Performance

Checkride scores in Device 2B24 for each group in each training mode are summarized in Figure 3.

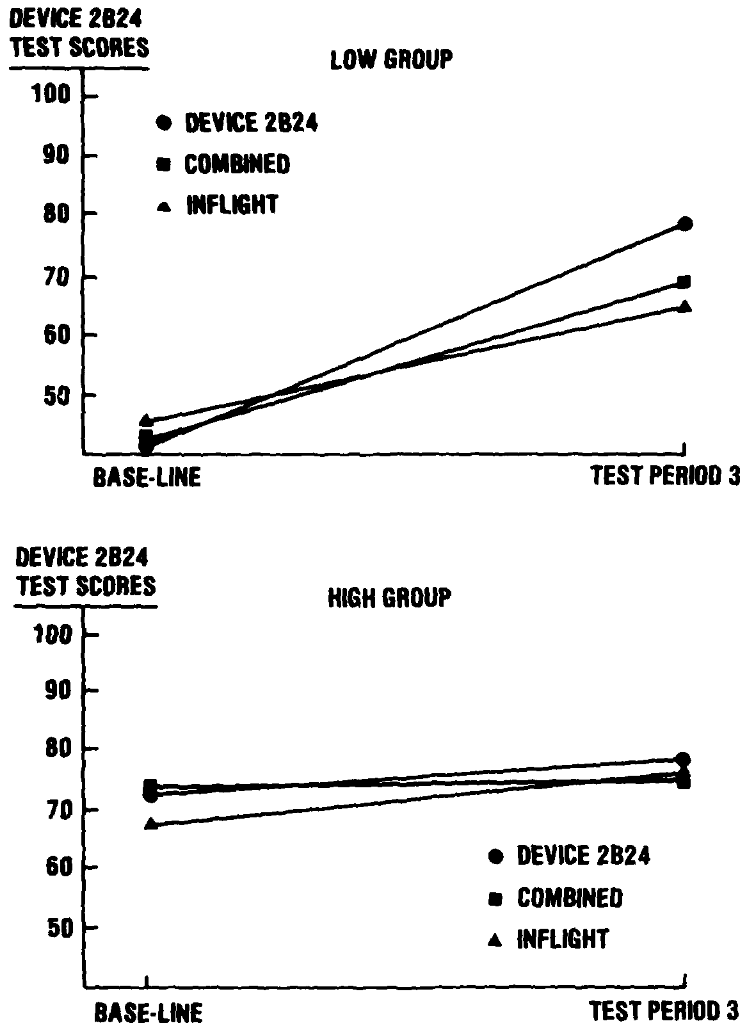

Figure 3. Learning functions of simulator performance for the three training modes and two pilot groups.

Mean scores in Figure 3 are plotted for baseline and final test period performance when checkrides in the simulator were administered. The curves show that most of the learning that occurred in the simulator took place in the low pilot group. For the high group, the extent of learning change was very limited. The curves reveal that checkride performance among the three training modes are are again distinct, with Device 2B24 training producing the highest degree of performance. That simulator training would best transfer to the simulator is hardly surprising. What is surprising is the finding of symmetrical transfer; that is, transfer from the aircraft to the simulator, as well as from the simulator to the aircraft, shown earlier. In fact, Figure 3 reveals that both groups showed improved performance in Device 2B24 following training in the UH-1H. A simple interpretation of this result is that specific tasks common to instrument flight in the simulator are also common to instrument flight in the aircraft. The fact that instrument flying in Device 2B24 and in the UH-1H are similar suggests that Device 2B24 may be substituted for the aircraft for certain instrument-proficiency evaluation tests.

Principal evidence for assessing the utility of Device 2B24 as a proficiency-evaluation instrument may be seen, however, in the degree to which final checkride performance in the simulator covaries with checkride performance in the aircraft. These data indicate that high and low scorers in the simulator had similar scoring patterns in the aircraft.

Although a similar pattern of results was observed prior to training, the relation between aircraft and simulator performance improved with training. A product-moment correlation coefficient computed between final aircraft and simulator checkrides provides a conservative estimate of the degree to which it would be possible to predict instrument performance in the UH-1H from performance in Device 2B24. Such a correlation was computed for all pilots as a group.

Checkride scores in Device 2B24 correlated 0.56 with checkride scores in the UH-1H. The standard error of estimate was 4.1. The correlation was statistically significant at the .001 level, indicating that Device 2B24 could serve as a useful predictor of performance in the UH-1H. To facilitate the application of the foregoing analysis, individual scores on the final UH-1H checkride (Y) were plotted against the final simulator checkride (X), as shown in Figure 4. Figure 4 reveals that aircraft performance was a linear function of simulator performance; in other words, increasing scores in the simulator result in a predictable increase in aircraft scores. A best-fit line was fitted to the points in Figure 4. The regression equation describing the line is: $Y = .51X + 41.17$.

To predict aircraft performance from simulator test scores, the actual score achieved in the simulator (X) can be substituted into the regression equation. By solving the equation, the best estimate of a

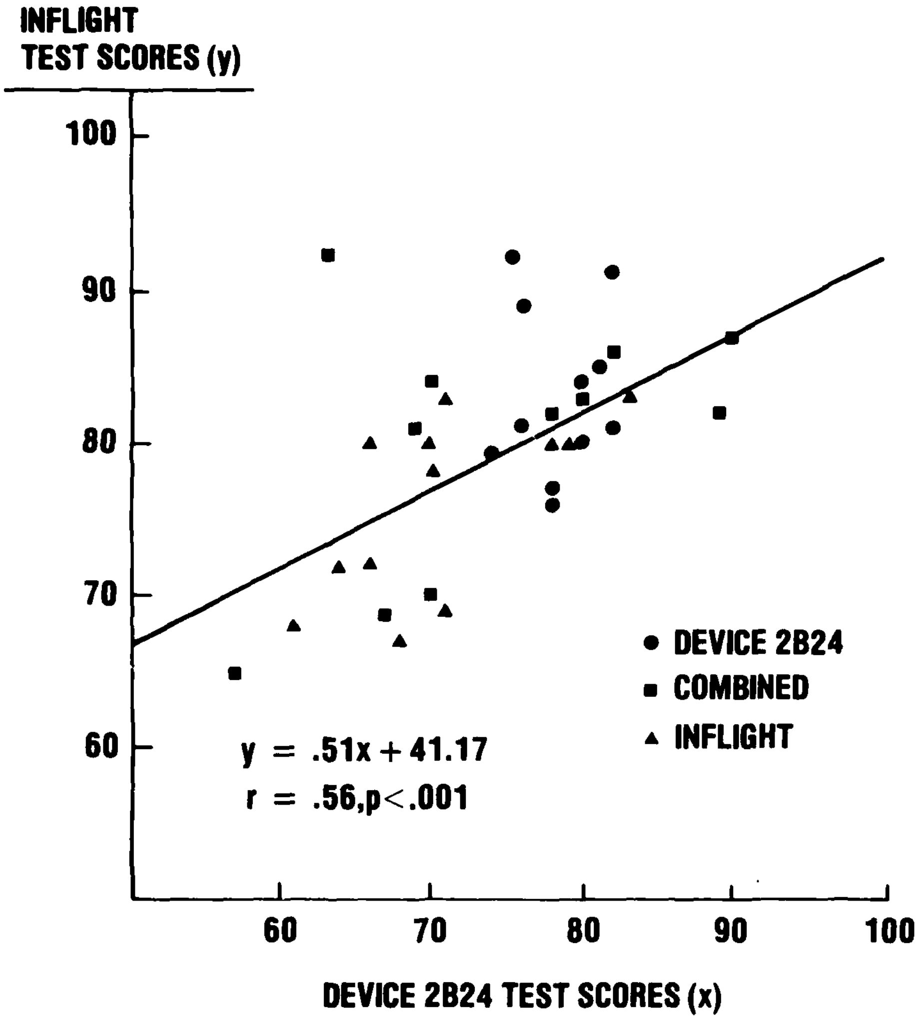

Figure 4. Inflight test scores plotted against simulator test scores obtained from all pilots on the last test period. Solid line: least squares, best-fit line.

pilot's inflight performance can be determined based upon the present data, plus or minus the standard error of estimate, 68% of the time. However, the present analysis should be interpreted with caution since the pilot sample is relatively small. For the present analysis to achieve practical significance, a larger sample size should be available. Nevertheless, the data suggest that Device 2B24 can be used to predict instrument flying in the UH-1H with some degree of confidence and may be used to substitute for the aircraft in testing instrument proficiency.

Questionnaire Survey

To obtain information about pilot experience with Device 2B24, pilots were asked about particular aspects of their training in the simulator and in the aircraft. It was felt that pilot assessments would be valuable in that the responses would indicate some level of acceptance of simulator training, a feature not readily available from the objective evidence.

A questionnaire was constructed (see Appendix C) to enable the pilots to express themselves in an easy and understandable way. Part I was essentially a series of rating scales. The pilot had to indicate on a five-point scale whether he agreed or disagreed with certain aspects of simulator training. Part II included a series of openended questions concerning the advantages and disadvantages of simulator and inflight training. The questionnaire was administered to all pilots at the end of training. Table 3 shows the percent response on the Part I questionnaire for each training mode.

Table 3

Percent Response Given on Part I Questionnaire by Pilots in Each Training Mode

Training mode		Question 1	2	3	4	5	6	7	8
Device 2B24	% agree (A + B)	45	73	73	9	63	54	100	73
	% disagree (D + E)	45	18	18	73	27	18	0	9
Combined	% agree (A + B)	36	91	54	9	54	27	90	90
	% disagree (D + E)	45	9	36	82	27	73	0	0
Inflight	% agree (A + B)	45	83	50	0	58	25	92	83
	% disagree (D + E)	54	8	33	80	25	42	0	0

The data in Table 3 indicate that simulator training is more acceptable among pilots who received all their current training in Device 2B24 (questions 3 and 6). Nevertheless, all pilots seemed to agree that Device 2B24 can be an effective training device (questions 4, 7, and 8). Increasing experience with Device 2B24 appears, however, to result in somewhat greater confidence that simulator training can maintain instrument proficiency among qualified UH-1H pilots (questions 1 and 5).

Table 4 shows the results of the Part II questionnaire for all pilots.

Table 4

Descriptions of the Training Value of Device 2B24 and the UH-1H

Device 2B24		UH-1H	
Disadvantages			
Over-sensitive controls	53	Unsafe	38
Lack of realism	29	Long preparation time	35
High workload	29	Poor training	35
Control lag	26	Unavailability of A/C	29
Unrealistic ITOs	26	Poor equipment	23
Poor training	12	Weather	18
Others	9	Cost	6
		Others	6
Advantages			
Good IFR procedural trainer	79	Realism	65
Good emergency procedural trainer	59	Good IFR procedural trainer	53
Individualized training	29	Realistic control touch	50
Others	9	Realistic control responses	29
		Realistic ITOs	24
		Others	6

From the descriptions in the Part II questionnaire, pilots described simulator training as safer, more accessible, and less time consuming. The UH-1H was usually described as providing realism in flight and at the controls. It is interesting to note, however, that 35% of the pilots tested considered the quality of inflight training poor. Among those pilots, half received all of their current training in the UH-1H. At the same time, only 11% of the pilots tested found the quality of simulator training poor. In fact, the individualized instruction available in the simulator was often perceived as an important instructional benefit. Nevertheless, no pilot was willing to give up training in the aircraft.

DISCUSSION

The objective of this research was to determine the extent to which instrument skills acquired during simulator training, inflight training, or in combination maintained or even enhanced subsequent performance in the UH-1H among instrument-rated pilots. The procedure compares the performance on a criterion checkride of pilots who had received 12 hours of simulator training with the performance of similar groups who had received 12 hours of inflight training only or 6 hours of simulator and 6 hours of inflight training. In this research, the transfer effectiveness of the simulator was measured by determining the extent to which the performance of the simulator-trained group matched the performance of the inflight-trained group on the criterion checkride.

The results of this study indicate substantial positive transfer of training from Device 2B24 to the UH-1H helicopter, as evidenced by the fact that simulator training produced an overall performance in the aircraft that was as good if not better than inflight training. Of the three training modes studied, instrument flight performance and its rate of improvement was highest with Device 2B24 training. Performance was lowest with UH-1H training and next highest with training that combined Device 2B24 with the UH-1H. Thus, Device 2B24 appeared to be a major factor in maintaining instrument skills in Army pilots who already knew how to fly, at least for the periods of time tested. One implication of the results is that 12 hours of instrument training in Device 2B24 can replace 12 hours of training in the UH-1H with no measurable loss in training effectiveness. These findings were characteristic of both groups of pilots. Certainly the findings presented tend to support the notion that Device 2B24 would fare well in an operational cost comparison with the UH-1H. Based on an hourly cost of $20 for Device 2B24 instruction and $200 for the UH-1H, simulator training can reduce the overall cost of unit training, while serving as an effective training adjunct for instrument-rated pilots.

The results of this study further show that the beneficial effects of training were more apparent among pilots who demonstrated the poorest instrument skills (low group) as measured by our criterion checkride. The consequences of the training procedures were that the initial differences in instrument performance between the two groups of pilots were no longer significant by the end of the study. The importance of this finding lies in the implication that any training program is artificially constrained in a structured training situation with unyielding hourly limitations that are characteristic of present Army training procedures. The present 20-hour training requirement for the instrument flight may be too much for some pilots and not enough for other less-skilled pilots. Device 2B24 may be used to provide a less constrained estimate of the point at which each pilot's instrument proficiency approximates the performance required to pass the flight checkride.

Analysis of checkride performance in the simulator and in the aircraft suggested that a relatively high degree of prediction of flight proficiency in the UH-1H can be made from performance in the simulator. It may be concluded that Device 2B24 can be used not only for maintaining proficiency among pilots with instrument ratings, but also for evaluating the current effects of past training (proficiency assessment). The findings generally agree with the results of studies conducted by both TransWorld Airlines (1969) and American Airlines (1969), which indicate that performance evaluations of experienced pilots in the simulator accurately predicted performance in the corresponding aircraft. In particular, the present study indicates that the U.S. Army could modify proficiency-assessment requirements to allow increased use of simulators of proven effectiveness.

A primary consideration in evaluating the training contribution of any simulator is the factor of pilot acceptance. The responses to our questionnaire revealed nothing to indicate that pilot acceptance of Device 2B24 would be a significant problem. In fact, pilot acceptance of the simulator appeared to increase with simulator experience, suggesting little in the way of potential problems.

CONCLUSIONS

The fact that instrument training in Device 2B24 transfers to the UH-1H is not surprising since it is a high-fidelity simulator of the UH-1H helicopter. The results are also consistent with the record of commercial aviation, which has shown that simulators can provide an effective means of providing training for highly qualified pilots.

It should be emphasized, however, that the effectiveness of any training device depends upon how it is used; success is influenced by variables concerning conditions that are favorable and unfavorable to learning. Prophet (1966) has pointed out that a simulator is a training tool, and, as such, will produce results no better than the quality of the training program of which it is a part. The evidence of transfer in the present study may well be attributed to the training program rather than to simulator design alone. It is possible, for example, that if inflight training were conducted differently, that is, with a more systematic training program, some evidence of additional benefits might be found.

The findings of this study complement results of past studies that demonstrated the operational utility of simulator training (Caro, 1972; Woodruff and Smith, 1974). In particular, analysis of the data indicate that much of the instrument training now conducted in rotary-wing aircraft can be conducted more effectively on the ground. Although with Device 2B24, pilots may require approximately the same number of hours of training as in the aircraft, the total time required is actually reduced because of the greater availability of the simulator and the elimination of much of the aircraft preparation time. The safety associated with elimination of much of the inflight training time; the release of aircraft for operational flights; and the decreased cost of operating the simulator, rather than an aircraft for training all add up to a highly positive evaluation of Device 2B24 for the maintenance of instrument pilot proficiency. A reasonable conclusion is that evidence was found to support the assumption that simulator training administered in Device 2B24 can maintain, and perhaps improve, subsequent pilot performance in a tactical instrument situation. Furthermore, with Device 2B24, the Army has an opportunity to establish an instrument-training program that can maintain instrument proficiency year round at a reasonable cost. There is little doubt that a more realistic instrument-training program would reduce accidents and enhance combat readiness.

RECOMMENDATIONS

The results of this study permit the following recommendations with respect to the training value of Device 2B24 to instrument-rated pilots:

1. Substantial amounts of UH-1H time can be substituted by Device 2B24 time in instrument-proficiency training. General application of Device 2B24 toward the instrument requirement for Army instrument certification appears warranted on a one-for-one basis up to some limit that is equal to, or perhaps greater than, 12 hours.

2. The prediction of instrument flight proficiency in the UH-1H based on a pilot's performance in Device 2B24 appears promising. In this context, the Army can make greater use of Device 2B24 for certain instrument-proficiency evaluation checks. It is recommended, however, that pilots be permitted to take a checkride in the aircraft if they fail to pass a simulator checkride, as airline pilots are permitted. This procedure would enhance pilot acceptance and provide important additional data on the validity of assessing pilot proficiency in the simulator.

3. All instrument training should be conducted on a proficiency basis. Since the level of instrument skill importantly influences transfer, the number of hours of training should depend upon pilot skill rather than upon fixed hours.

4. Since Device 2B24 can discriminate the level of instrument skills about as well as the UH-1H, the simulator can be used on an individual basis to assess skill level and, hence, determine training hours.

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APPENDIX A

SCORE SHEET
INSTRUMENT EVALUATION
UH-1

Name   Rank   SSAN   Unit

1. Flight planning — 20 points ______

   a. Weather requirements for departure enroute destination and alternative — 10 points ______

   b. Fuel management, planning, enroute, alternate fuel check enroute — 5 points ______

   c. DD 175 & FAA 7233-1 — 5 points ______

2. Departure and enroute procedures — 20 points ______

   a. Navigation and tracking — 10 points ______

   b. Radio reports — 10 points ______

3. Hold and arrival — 20 points ______

   a. Holding, entry, time, track, altitude airspeed — 10 points ______

   b. Approach and missed approach — 10 points ______

4. Air Traffic Control Center (ATC) procedures — 20 points ______

   a. Understanding and complying with clearance and procedures

5. Aircraft control — 20 points ______

   a. Airspeed ± 10 Kts — 10 points ______
      Altitude ± 100 feet
      Heading $\pm 10^{\circ}$

   b. ITO (Instant Take-off) — 10 points ______

      Aircraft turn (enroute, holding, approaches)
      General aircraft control

100 points maximum

SCORE ______ points

APPENDIX B

TABLES SHOWING VARIANCE OF PERFORMANCE SCORES

Table B-1

Analysis of Variance of the Composite Scores of Two Groups of Pilots Assigned to Different Training Modes

Source of variation	Sum of squares	df	Mean square	F	p
Groups (G)	3344.69	1	3344.69	17.91	<.001
Training Modes (M)	115.39	2	57.69	.31	
Interaction: G x M	15.72	2	7.86	.04	
Error:	5603.17	30	186.77		

Table B-2

Analysis of Variance of Inflight Performance Scores of the Low Pilot Group Tested under Different Modes with Three Test Periods for Each Pilot

Source of variation	Sum of squares	df	Mean square	F	p
Training Modes (M)	186.86	2	93.43	.66	
Error:	2108.25	15	140.55		
Test Periods (P)	4572.72	2	2286.36	17.9	<.001
Interaction: P x M	217.60	4	54.40	1.18	
Error:	3834.90	30	127.83		

Table B-3

Analysis of Variance of Inflight Performance Scores of the High Pilot Group Tested under Different Training Modes with Three Test Periods for Each Pilot

Source of variation	Sum of squares	df	Mean square	F	p
Training Modes (M)	82.10	2	41.05	.17	
Error:	3663.51	15	244.23		
Test Periods (P)	773.64	2	386.82	2.42	
Interaction: P x M	1018.00	4	254.50	1.59	
Error:	4801.50	30	160.05		

Table B-4

Analysis of Variance of Inflight Performance Scores of the Two Pilot Groups Tested under Different Training Modes during the Last Training Period

Source of variation	Sum of squares	df	Mean square	F	p
Training Modes (M)	730.40	2	365.20	2.38	
Between Groups (G)	61.43	1	61.43	.40	
Interaction: M x G	376.88	2	188.44	1.23	
Error:	4604.40	30	153.50		

Table B-5

Analysis of Variance of Change Scores of the Two Pilot Groups Tested under Different Training Modes during Three Test Periods

Source of variation	Sum of squares	df	Mean square	F	p
Groups (G)	943.17	1	943.17	8.32	<.01
Training Modes (M)	933.92	2	466.96	4.12	<.05
Interaction: G x M	614.30	2	307.15	2.17	
Error:	2833.50	25	113.34		
Test Periods (P)	628.78	2	314.39	4.22	<.025
Interaction: P x G	152.44	2	76.22	1.07	
Interaction: P x M	712.24	4	178.06	2.39	
Interaction: P x G x M	545.36	4	136.34	1.83	
Error:	4842.50	65	74.50		

APPENDIX C

SFTS STUDY QUESTIONNAIRE

NAME ____

PART I

The scale below applies to questions in Part I. Place the letter representing the description which best fits your opinion on the line following each question.

A	B	C	D	E
Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree

1. A qualified UH-1 aviator can maintain instrument proficiency, if all instrument training is completed in the Synthetic Flight Training System (SFTS). ______________________

2. The SFTS is more difficult to fly than the actual aircraft. ________

3. If you were (are) an instructor pilot, you would probably prefer teaching Instant Flight Rules (IFR) skills in the SFTS rather than in tha aircraft. ______________________

4. IFR proficiency can be achieved and maintained in the aircraft in less time than in the SFTS. ______________________

5. You can safely complete an IFR mission in the UH-1 aircraft, if you had received all of your training in the SFTS during the previous 3 months. ______________________

6. I prefer to do my instrument training in the SFTS. ________________

7. IFR training received in the SFTS can transfer to the aircraft. _____

8. IFR training is more effective when it is given in both the SFTS and aircraft. ______________________

PART II

1. How many hours of pilot time training do you think you may need per year to maintain instrument proficiency, if all your training is completed in the:

(a) aircraft ______________________

(b) SFTS ______________________

(c) SFTS and aircraft ______________________

2. What three characteristics do you most dislike concerning instrument training in the SFTS?

(a) ______________________

(b) ______________________

(c) ______________________

3. What three characteristics do you most dislike concerning instrument training in the aircraft?

(a) ______________________

(b) ______________________

(c) ______________________

4. What characteristic(s) of IFR flying can best be taught in the SFTS?

____

____

5. What characteristic(s) of IFR flying can best be taught in aircraft?

____

____

6. Are there any additional comments you would like to make concerning your instrument training in the aircraft and/or SFTS? ______________________

____

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