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ABSTRACT

This report documents the training effectiveness of a map interpretation and terrain analysis course (MITAC) developed to enhance the ability of helicopter pilots to navigate accurately during low altitude terrain following flight. A study comparing student aviators taught by the MITAC technique with a control group of students taught by conventional techniques showed MITAC to be sig icantly superior in enhancing the aviator's ability to navigate rap and accurately during low-level flight. (Author/RE)

Research Report 1198

EVALUATION OF A MAP INTERPRETATION AND TERRAIN ANALYSIS COURSE FOR NAP-OF-THE-EARTH NAVIGATION

Garvin L. Holman

ARI FIELD UNIT AT FORT RUCKER, ALABAMA

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

August 1978

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FOR THE BEHAVIORAL AND SOCIAL SCIENCES

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This report documents the training effectiveness of a map interpretation and terrain analysis course (MITAC) developed by the Army Research Institute to enhance nap-of-the-earth (NOE) navigation skills. A two-group transfer-of-training study showed that MITAC-trained student aviators could navigate along NOE routes at twice the speed and with one-third the errors of normally trained student aviators. Interviews with experienced NOE aviators exposed to the MITAC material indicated that their navigation skills and understanding of

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student problems were also increased. It has been recommended that all Army aviators with NOE flight requirements be given MITAC training.

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ARI Research Reports and Technical Papers are intended for sponsors of R&D tasks and other research and military agencies. Any findings ready for implementation at the time of publication are presented in the latter part of the Brief. Upon completion of a major phase of the task, formal recommendations for official action normally are conveyed to appropriate military agencies by briefing or Disposition Form.

FOREWORD

The Army Research Institute (ARI) Field Unit at Fort Rucker, Ala., provides support to the U.S. Army Aviation Center (USAAVNC) in the area of aviation training research and development. The research reported in this document and in Research Report 1197 was performed as a part of the field unit's nap-of-the-earth (NOE) research efforts. As part of these efforts, studies were designed and conducted to determine requirements for NOE flight. Prototype training programs were also developed and evaluated.

The entire program of aviation training research and development is responsive to the requirements of RDTE Project 2Q763743A772, Aircrew Performance in the Tactical Environment and the Directorate of Training Developments, USAAVNC, Fort Rucker, Ala. CPT Frank Van Hoy of the Directorate of Academic Training was instrumental in establishing MITAC in the ground school program of instruction. NOE instructor pilots of the Advanced Division of the Department of Undergraduate Flight Training gathered the necessary flight test data.

JOSEPH ZEIDNER
Technical Director (Designate)

EVALUATION OF A MAP INTERPRETATION AND TERRAIN ANALYSIS COURSE FOR NAP-OF-THE-EARTH NAVIGATION

BRIEF

Requirement:

To evaluate the training effectiveness of a course in map interpretation and terrain analysis (MITAC) developed to improve the navigation skills of trainees in nap-of-the-earth (NOE) flight and also to assess the desirability of using a self-instructional version of the exercise (MITAC II) throughout Army aviation units.

Procedure:

The main research evaluated transfer-of-training. One group of 70 Initial Entry Rotary Wing (IERW) trainees (the control group) received the standard tactical navigation course in ground school. For a second group of 67 IERW trainees, the 15-hour MITAC program was substituted for a part of the tactical navigation ground school course. These trainees were also given some additional training time. The NOE navigation skills of all trainees were measured inflight halfway through the NOE flight training course. Trainees were evaluated by instructor pilots (under ARI supervision) while navigating along fixed NOE routes according to a standard scenario.

In addition, NOE instructor pilots, operational aviators, and Army Reserve aviators tried the MITAC program and then were interviewed about its effectiveness.

Findings:

The MITAC-trained group navigated NOE routes at twice the speed of the control group and with one-third the error rate. The MITAC-trained trainees were better oriented and more certain of their position while navigating the NOE course. All trainees in the control group made at least one navigation error in the test, while 28% of the MITAC-trained students made no errors. These significant differences in performance indicate a substantial increase in NOE navigation skill due to MITAC training.

Those aviators interviewed were positive in their evaluation of the MITAC training material. Experienced NOE aviators reported that exposure to MITAC had made them more relaxed, increased confidence in their navigation, reduced the difficulty and workload, and gave them more time for the performance of other cockpit tasks. The instructor pilots also reported that through MITAC they could better understand the difficulties faced by their students. One instructor commented that he had learned more about NOE navigation in 3 days than in the previous 5 years.

Utilization of Findings:

The MITAC program continues as a major portion of Initial Entry Rotary Wing (IERW) training. MITAC training is also available to flight line instructor pilots and all other pilots whose assignment includes NOE flight requirements. MITAC II, the reformatted self-administered version of the program, is scheduled to be made available to all active and reserve Army aviators who may be required to make NOE flights.

EVALUATION OF A MAP INTERPRETATION AND TERRAIN ANALYSIS COURSE FOR NAP-OF-THE-EARTH NAVIGATION

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EVALUATION OF A MAP INTERPRETATION AND TERRAIN ANALYSIS COURSE FOR NAP-OF-THE-EARTH NAVIGATION

INTRODUCTION

For several years navigation during nap-of-the-earth (NOE) flight has been a major problem. Wright and Pauley (1971) drew attention to this problem, and Saathoff (1974) indicated the NOE navigation was a serious problem not only in initial training but in operational units as well. NOE navigation research by the U.S. Army Research Institute (ARI) pinpointed the problem and revealed that inadequate skills in map interpretation and terrain analysis were the basis of the NOE navigation difficulties (Fineberg, Meister, & Farrell, 1978).

At the low altitudes of terrain flight, map interpretation and terrain analysis skills are critical for maintaining orientation. Current maps represent terrain as it appears from several thousand feet of altitude, while the visual perspective from NOE altitude does not match that perspective. NOE navigators must therefore learn the visual referencing skills required for precise pilotage in a restricted visual field. They must be able to relate terrain features as seen from NOE flight to the counterparts portrayed in tactical maps. This ability requires far more than a study of the map symbols or examinations of simple terrain forms portrayed by contour lines. Based upon a map representation, the NOE aviator must be able to visualize how the terrain will appear from a lower perspective--the landforms, vegetation, hydrographic features, and man-made features. One particularly important and difficult requirement is to visualize the vertical development of terrain and vegetation from a flat map portrayal. It is this vertical development that masks the helicopter from the enemy (the whole point of NOE flight) while masking all but the closest terrain features from the navigator. Navigators must also be able to visualize a map portrayal from the terrain. To do this, they must analyze the terrain cartographically, using the cartographer's criteria for selection and portrayal. With skills in both map interpretation and terrain analysis, Army aviators should be able to navigate in NOE flight at a high proficiency level.

The map interpretation and terrain analysis course (MITAC) developed by ARI for Army aviators is designed to teach the special skills required for NOE navigation. MITAC has been implemented in the Initial Entry Rotary Wing (IERW) course at the U.S. Army Aviation Center (USAAVNC), Fort Rucker, Ala. The course entails a group presentation/classroom format and requires a skilled instructor. A second version, MITAC II, uses the same content material but is self-instructional and uses a self-paced format. MITAC II was developed for unit use and is intended for all Army aviators with an NOE or terrain flight requirement.

The MITAC program consists of 13 instructional units progressing from an easy introductory lesson through a series of increasingly difficult practical exercises requiring all actual NOE navigation skills. Most units follow the same pattern: (a) students receive some instructional material to be applied to the exercise; (b) they study maps in preparation for the navigation exercise; (c) they receive preexercise briefings covering points they should have noted in the map study; (d) students then perform the navigation exercise; (e) performance is scored and feedback provided; and (f) the exercise is thoroughly debriefed. A typical exercise requires that students study an NOE route on a map plate and be able to maintain orientation if "flown" over that route. Students then perform the navigation tasks as the route is "flown" using wide-angle motion pictures. During debriefing, the students review the filmed NOE route and point out those map and route features that should have been used for orientation. Appendix A provides a complete description of MITAC.

OBJECTIVES

Previous studies have indicated that most difficulties faced by Army aviators trained in nap-of-the-earth navigation were due to a lack of map interpretation and terrain analysis skills. Therefore, the major objective of this study was to evaluate the effectiveness of a map interpretation and terrain analysis course in training NOE navigation skills. A second objective was to evaluate the effectiveness of particular courses (MITAC and MITAC II) that taught these skills to different populations of Army aviators, instructor pilots, and operational aviators.

METHOD

The main study was a two-group transfer of training experiment. The control group consisted of 70 Initial Entry Rotary Wing (IERW) students who received the standard tactical navigation course in ground school. The experimental group consisted of 67 IERW students for whom MITAC had been substituted for a part of the tactical navigation ground school course. These students also received some additional training time. The MITAC portion of the course was 15 hours.

The students' NOE navigation skills were measured inflight halfway through their NOE flight training. Instructor pilots (IP's) performed the evaluation under ARI supervision. The IP's collected data while the students were navigating along fixed NOE routes according to a standard scenario. Collected data included navigation and orientation errors, elapsed time on the NOE routes, and length of routes.

In addition to this formal transfer of training experiment, other aviators were given the MITAC program and interviewed for their reactions and opinions. These aviators were NOE IP's from the U.S. Army

Aviation Center (USAAVNC) at Fort Rucker, Ala., operational aviators from the 2nd Armored Division Aviation Battalion and other units at Fort Hood, Tex., and Army Reserve aviators from the Orlando, Fla., area.

RESULTS AND CONCLUSIONS

Inflight Measures

The MITAC-trained group navigated NOE routes at twice the speed of the control group. The large difference in performance due to training accounted for 46% of the variance in the speed data. These data indicate that there was less uncertainty on the part of the navigators about their location and that they were well oriented. The very low average speeds of the control group were due to time spent at a hover or in slow flight while navigators scanned the terrain, studied their maps in an attempt to orient themselves, and backtracked after course deviation. The higher speeds of the MITAC-trained group indicate better orientation and less time spent trying to make terrain-map associations.

The navigation error rate of the MITAC-trained group was 36% lower than the control group's error rate. The fact that 28% of the MITAC-trained navigators made no error at all is also operationally significant. According to the NOE instructors, before MITAC was in use, students with twice the NOE experience (at the end of their NOE flight training) were still making course errors and missing checkpoints.

The average size of the navigational errors of the experimental group was 94% of the size of the control group errors. Although this difference is statistically significant, operationally it is not important.

The terrain navigation (TENAV) composite score is compiled from speed, number of errors, and error magnitude. The lower the TENAV score, the better the navigation performance is. The MITAC-trained group averaged a TENAV score of 9.0, a good performance for a student although not acceptable for a fully trained and experienced NOE aviator. The control group averaged a TENAV score of 50, a poor performance.

The difference in instructor pilot ratings for the two groups was statistically significant but operationally insignificant.

Interviews

All aviators and instructor pilots interviewed were positive in their assessment of MITAC and MITAC II. The NOE instructors, most of whom were highly experienced NOE navigators, claimed that they learned a great deal from MITAC. One instructor commented that he had learned more about NOE navigation in 3 days than he had in the previous 5 years. Many of the instructor pilots were interviewed again after they had been flying NOE and teaching students in MITAC. They believed that they were better navigators as a result of MITAC and that they could understand more clearly the difficulties faced by their students in learning NOE navigation.

The group of Army Reserve pilots who took MITAC II expressed enthusiasm for and satisfaction with the course. They felt that they learned valuable skills that would be applied to NOE qualification training. A few months later, when they were at Fort Rucker for NOE flight training and qualification, they again expressed their high evaluation of the training. The Reserve aviators stated that all Reserve units should have access to MITAC II.

When this report was prepared, aviators from the 2nd Armored Division at Fort Hood had been using MITAC II for several months and were satisfied with it. In their view, the course helps train inexperienced aviators in NOE navigation and saves aircraft time in field exercises. The experienced aviators also claimed that they had learned valuable skills from the course. They said they were much more confident and relaxed when navigating NOE and that the task did not seem as difficult or attention demanding as it did before MITAC II.

IMPLICATIONS FOR OPERATIONAL USE

MITAC

MITAC has demonstrated its training value at the Army Aviation Center. MITAC should be taught at Fort Rucker to all Initial Entry Rotary Wing pilots and to their flight line NOE instructor pilots. Further, all pilots with terrain flight or NOE flight requirements who are trained at the Aviation Center should be required to take MITAC training.

The academic measures currently used in the MITAC classroom should be replaced with an examination that tests MITAC skills. To this end, ARI has already begun the development of such a test.

Navigation evaluation procedures used in NOE flight during training should be improved. The TENAV system, or perhaps a simplified version, could be used to increase the objectivity of inflight evaluations by instructors during training and in check rides.

MITAC II

MITAC II should be made available to all Army Reserve and regular operational aviation units. MITAC II should be reproduced in sufficient quantity to make such distribution feasible.

Additional MITAC II units should be developed to supplement the current units. Additional units would allow training on additional varied terrain such as mountains, snow-covered lands, and deserts. It would also extend the continuing training value of MITAC II by providing lessons to which MITAC-trained aviators have not previously been exposed.

PROCEDURES

General Method

The main study involved a two-group transfer of training experiment. The control group consisted of IERW classes which had received the standard pre-MITAC tactical navigation course in ground school. The experimental group consisted of IERW classes that had received MITAC training. This training replaced a part of the tactical navigation ground school course. NOE navigation skills were later measured inflight halfway through NOE flight training.

In addition to this formal transfer of training experiment, other aviators were exposed to MITAC or MITAC II and interviewed for their reactions and opinions.

Subjects

The control group consisted of 70 IERW students selected randomly from a pool of 90 students in the officer and warrant officer candidate classes. The experimental group consisted of 67 IERW students selected randomly from a pool of 117 students also in the officer and warrant officer candidate classes. To meet statistical analysis requirements, both groups were required to navigate the same NOE routes. Because of changes in the NOE route structure between groups, data from many subjects could not be used. In addition, several subjects were disqualified on other grounds, i.e., having previously flown the particular route on which they were tested.

Subjects for the less formal interview evaluation were NOE instructor pilots from the USAAVNC at Fort Rucker, Ala, operational aviators from the 2nd Armored Division Aviation Battalion and other units at Fort Hood, Tex., and Army Reserve aviators from the Orlando, Fla., area.

Independent Variables

The main variable in this experiment was the course of instruction (COI) each group received in ground school. The control group completed a Tactical Navigation COI. This COI lasted 15 hours (3 hours per day for 5 days) and covered a variety of subject matter related to tactical navigation. These materials included standard map-reading information, terrain profiling, analysis of an area of operations, terrain flying, and one 4-hour period devoted to a terrain walk exercise. (See Appendix B for an outline of the course.)

The experimental group completed a Terrain Flying Operations COI. This COI lasted 21 hours (3 hours per day for 7 days) and included subject material from the control COI and MITAC. Subject material from the control COI, such as analysis of the area of operations, was taught in the first 6 hours of the course. Other material, such as the terrain walk, was replaced by MITAC. The last 15 hours was devoted to MITAC training. (See Appendix C for an outline of the course.)

Aviators interviewed at Fort Rucker, Ala., completed MITAC as it is presented at the Aviation Center. The unit-level aviators went through MITAC II. ARI personnel presented MITAC II to an Army Reserve unit in Orlando, Fla., and provided the MITAC II material to the 2nd Armored Division at Fort Hood, Tex.

Performance Measures

Academic Measures. Tests already used in the Tactical Navigation course were used to measure each group's academic performance. One test entailed a 10-item, multiple-choice exam requiring map interpretation. Two versions of this test were produced so that it could be used as a pretest and posttest. The final exam covered all materials presented in the control Tactical Navigation course.

Inflight Measures. Current Army doctrine (FM 1-1, Terrain Flying, 1975) requires that aviators navigate NOE within 100 m of selected course line and be able to locate their positions to within an accuracy of 100 m at all times. In addition, an NOE flight should be carried out at the highest speeds possible consistent with navigation, masking, safety, and mission objective.

The data recorded in flight were the number and magnitude of course deviations over 100 m, errors in locating the initial point and endpoint of the NOE route, errors in locating required checkpoints, orientation errors, length of the route flown, and time spent in navigating the route. These data were recorded by the instructor pilot on each flight on a form designed to be used while flying NOE. (See Appendix D for the complete data collection sheet.) In addition, the instructor pilots answered a short series of debriefing questions after each flight (Appendix D).

Derived measures were average speed, error per kilometer, mean error magnitude, and a composite measure of terrain navigation skill (TENAV). The TENAV score combines number of errors, their magnitude, speed of flight, and length of the route into a single score according to the following equation:

$$TENAV = \frac{\Sigma E^{1.3} + 100^{1.3}}{D \times S^{.8}}.$$

E = a navigational error (course deviation; orientation error; initial, endpoint, or checkpoint error) in meters.

D = length of the course navigated in kilometers.

S = average speed of NOE flight in kilometers per hour.

The exponents were derived from the results of a magnitude estimation study with NOE instructor pilots as subjects (Holman, 1978).

Operational Procedures

Pretest and Posttest. Each class of IERW students was given the pretest during the first 30 minutes of the navigation ground school. The test was given in two equivalent forms: Half the students in each class received one form and half the other form. At the end of the course, each class took the course final exam and the posttest. The posttest was the alternate form of the pretest. This procedure was followed for both the control and the experimental group classes.

Briefing the Instructor Pilots. The inflight data were recorded by the instructors teaching the student navigators NOE flight. The day before each scheduled NOE navigation evaluation flight, these instructors were briefed by ARI personnel to insure their familiarity with the program and the evaluation procedures. These briefings frequently required 2 hours.

Inflight Data Collection. Subjects in both groups were required to fly a standard training operation order requiring NOE flight along a fixed and predetermined route. This evaluation occurred in the ninth hour of the 15-hour NOE flight training program. It was the last NOE training flight that required navigation along a standard route. With few exceptions, subjects had never seen this particular route. Where a subject had been exposed to the test route, the data were omitted from the analysis. Standard procedure required that the student fly the aircraft from the pilot's seat with an instructor in the copilot's seat as a safety pilot. The experimental or control subject navigated from a jump seat in the midline of the aircraft just behind the pilot's seat. The route was known to the subject at least 1 day in advance to allow time for map study. These maps were 1:50,000-scale tactical maps of the photo-base type.

In flight, the subject navigated in low-level flight to the initial point of the NOE routes. The subject then instructed the pilots to fly down to NOE level and proceeded to navigate the aircraft along the NOE route. If the navigator discovered he was off course, he would orient himself, return to the route at the point of departure, and continue on course. If the error exceeded 1,000 m and the subject did not realize the error, the instructor would order the aircraft to hover and ask the subject to reorient and return to course. Along the route the subject was required to call out certain checkpoints so that command ships flying at higher altitudes could keep track of several NOE aircraft. At the endpoint the subject identified the target landing zone and the mission was completed.

The instructor pilots began recording navigation performance by noting the time the student navigators approached the initial points of the routes and descended to NOE altitude. If a student missed the initial point, the error was indicated in meters on the data sheet. Throughout the rest of the NOE flights, the instructor pilots recorded the navigators' deviations from course, checkpoint errors, errors in off-course orientation, and endpoint errors, if any. At the endpoint, the time was again noted to establish the elapsed time for the NOE route. Length of the routes was measured from those maps used for navigation and recorded on the data sheets. After the training missions, subjects were debriefed and the rest of the instructor pilots' data sheets were filled in.

Aviator Interviews. At Fort Rucker, Ala., instructor pilots were interviewed after they had completed MITAC and had an opportunity to fly NOE. The interview situation was informal and designed to elicit candid opinions of the course. The aviators from operational and reserve units were interviewed after they had completed MITAC II. Again, the interview situation was informal and frank remarks encouraged.

RESULTS

Inflight Measures

The inflight data were analyzed using the Statistical Package for the Social Sciences (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975), which contains subprograms for the descriptive statistics required and the analysis of variance. The analysis of variance used was a two-way stepwise multiple regression for unequal cell sizes. The treatment, MITAC training versus control training, was one major factor. The 11 NOE routes used in the NOE navigation evaluation were the second major factor. Homogeneity of variance was demonstrated with the F max test (Kirk, 1968). One variable, the TENAV scores, required a log transform to achieve homogeneity of variance.

Speed. The mean speed of the control group was 27 km per hour ($n = 70$). The mean speed of the experimental group was 53 km per hour ($n = 67$). Table 1 summarizes the analysis of variance for speed.

Table 1

Analysis of Variance for Speeds

Source	df	MS	F	p	ω^2
Training	1	23260	111	.001	.46
Routes	10	130	.62	.791	0
Training x routes	10	140	.67	.746	0
Error	115	208.8			

Number of Errors. The control group made a mean of 0.25 navigational errors per kilometer. The experimental group made 0.08 navigational errors per kilometer. Table 2 summarizes the analysis of variance for number of errors. All 70 of the control subjects made navigational errors, while only 48 of the 67 experimental subjects (72%) made any error (difference significant at $p < .001$, $\chi^2 = 20.7$, df = 1).

Table 2

Analysis of Variance for Number of Errors per Kilometer

Source	df	MS	F	p	ω^2
Training	1	1.010	145	.001	.50
Routes	10	.007	.973	.471	0
Training x routes	10	.010	1.447	.169	.02
Error	115	.007			

Magnitude of Errors. The mean magnitude of all navigation errors made by the control group was 359 m. The navigational errors made by the experimental group had a mean magnitude of 343 m. Table 3 summarizes the analysis of variance for error magnitude.

Table 3

Analysis of Variance for Error Magnitude

Source	df	MS	F	p	ω^2
Training	1	441889	9.185	.003	.06
Routes	10	72277	1.502	.147	0
Training x routes	10	27240	.566	.838	0
Error	115	48109			

TENAV Scores. The mean TENAV score for the control group was 49, and the score for the experimental group was 9. The TENAV scores were subjected to a log transform to achieve homogeneity of variance before the analysis of variance was performed. Table 4 summarizes the analysis of variance for TENAV scores.

Table 4

Analysis of Variance for TENAV Scores

Source	df	MS	F	p	ω^2
Training	1	22.27	156	.001	.52
Routes	10	.27	1.89	.053	.03
Training x routes	10	.118	.825	.605	0
Error	115	.143			

Instructor Ratings. Ratings on items 2, 3, and 4 of the IP rating form were quantified and analyzed (Table 5). The mean rating on item 2 was 3.5 for the control group and 3.9 for the experimental group. The mean rating on item 3 was 4.0 for the control group and 4.4 for the experimental group. The mean rating on item 4 was 3.2 for the control group and 3.7 for the experimental group.

Table 5

Analysis of Variance for IP Judgments

Source	df	MS	F	p	ω^2
		Item 2			
Training	1	5.390	6.374	.013	.04
Routes	10	.987	1.168	.320	.01
Training x routes	10	.695	.821	.609	0
Error	115	.846			
		Item 3			
Training	1	6.016	5.866	.017	.03
Routes	10	.890	.868	.565	0
Training x routes	10	.769	.750	.676	0
Error	115	1.025			
		Item 4			
Training	1	9.712	11.188	.001	.07
Routes	10	.861	.992	.455	0
Training x routes	10	.209	.241	.991	0
Error	115	.868			

Academic Measures

Pre- and Posttest Comparisons. The control group pretest mean was 4.9, while the posttest mean was 5.1. A correlated t test indicated no difference ($p < .5$). The experimental group pretest mean was 5.0, while the posttest mean was 5.9. A correlated t test indicated a significant difference ($p < .01$). Control pretests versus experimental pretests and control posttests versus experimental posttests when analyzed by t tests indicated no significant differences.

Academic Final Exam Comparisons. The final examination mean scores of the two groups were compared by t test and were not significantly different ($p < .8$). The means of 15 selected items from the final examination ($p < .8$) also were not significantly different.

DISCUSSION

Inflight Measures

Speed. The MITAC-trained group navigated NOE routes at twice the speed of the control group. Table 1 shows that the large difference in performance due to training accounts for 46% of the variance in the speed data.

The ω^2 statistic in the analysis of variance tables indicates the proportion of the variance in the data accounted for by the experimental factors. These data indicate that there was less uncertainty on the part of the navigators about their location and that they were well oriented. The very low average speeds of the control group were due to time spent at a hover or in slow flight while navigators scanned the terrain, studied their maps in an attempt to orient themselves, and backtracked after course deviation. The higher speeds of the MITAC-trained group indicate better orientation and less time spent trying to make terrain-map associations.

Number of Errors. The navigation error rate of the MITAC-trained group was 36% lower than the control group's error rate. This result, as well as the speed difference, indicates a substantial increase in navigation skill due to MITAC training. Table 2 shows that MITAC training accounts for 50% of the variance in the error rate data. The fact that 28% of the MITAC-trained navigators made no error at all is also operationally significant. According to the NOE instructors, before MITAC was in use, students with twice the NOE experience (at the end of their NOE flight training) were still making course errors and missing checkpoints.

Magnitude of Errors. The average size of the navigational errors of the experimental group was 94% of the size of the control group errors. Although Table 3 shows that this difference is statistically significant, the effect accounted for only 6% of the variance and, operationally, is not important.

TENAV Scores. The terrain navigation (TENAV) composite score is compiled from speed, number of errors, and error magnitude. (See Holman, 1978, for a description of its development.) The lower the TENAV score, the better the navigation performance is. As an example, consider a 15-km NOE course flown at 60 km/hour with no errors. Such superior performance achieves a TENAV score of 1.0. A relatively good score of 4.8 could be obtained by flying the same NOE route at 40 km/hour and making one error of 200 m. The MITAC-trained group averaged a TENAV score of 9.0. This would be earned by flying a 15-km NOE route at 50 km/hour with one error of 435 m. This is still a good performance, especially for a student. But an error that large would not be acceptable for a fully trained and experienced NOE aviator.

The control group averaged a TENAV score of 50, indicating poor navigation performance. Such a score could be obtained by flying a 15-km NOE route at the slow average speed of 26 km/hour with four errors of 250 m, 350 m, 450 m, and 550 m.

As a composite score, the TENAV is more sensitive to variations in navigation performance and is a more valid measure than single scores such as speed or errors. The large differences between the TENAV scores for the two groups more clearly point out the effectiveness of MITAC in training aviators to navigate NOE. Table 4 shows that 52% of the variance in the data is accounted for by the MITAC training. The table also indicates that the main effect of the route variable is marginally significant ($p = .053$). Because this variable accounts for only 3% of the variance, it is not operationally important.

Instructor Pilot Ratings. Though statistically significant, the difference in instructor pilot ratings of the two groups is operationally insignificant. Although the navigation performances of the students in the two groups differed in terms of objective criteria, the IP's rated them as almost identical, with only a .4 average difference on each scale. On item 2, both groups received an average evaluation of "always oriented but had difficulty." On item 3, both groups were compared to past students taught by the IP's and were rated "middle 50% but above average." Item 3, navigator-pilot coordination, showed the largest difference. Here the control group was rated "average" while the experimental group was rated "good." It is believed that the IP's rapidly became accustomed to the improved navigation skills of their students and regarded improved performance as the norm. This shift probably would not have been the case if IP's had rated a member of each group on the same day. However, the two groups were evaluated several months apart after the gradual introduction of MITAC into the ground school.

Academic Measures

Of all academic measures used in this experiment, only one detected the improved skills of the MITAC-trained group. The only test comparison that was statistically significant was between the pre- and posttest scores of the MITAC group. This difference, .9 out of a 10-point test, is operationally insignificant. None of the academic tests used in the ground school at this time assesses the skills being taught.

REFERENCES

Farrell, J. P. Measurement Criteria in the Assessment of Helicopter Pilot Performance. Conference Proceedings: Aircrew Performance in Army Aviation. U.S. Army Office of the Chief of Research, Development, and Acquisition, Washington, D.C., 1974.

Fineberg, M., Meister, D., & Farrell, J. P. Navigation and Flight Proficiency Measurement of Army Aviators under Nap-of-the-Earth Conditions. ARI Research Report 1195, 1978.

Holman, G. L. The Development of a Composite Score for Evaluating Nap-of-the-Earth Navigation. ARI Research Memorandum 77-32, February 1978.

Kirk, R. E. Experimental Design: Procedures for the Social Sciences. Belmont, Calif.: Brooks/Cole, 1969.

Nie, N. H., Hull, C. H., Jenkins, J. G., Steinbrenner, K., & Bent, D. H. Statistical Package for the Social Sciences. New York: McGraw-Hill, 1975.

Saathoff, Don I. Initial Entry and Unit Training Requirements for Nap-of-the-Earth Helicopter Flight. Conference Proceedings: Aircrew Performance in Army Aviation. U.S. Army Office of the Chief of Research, Development, and Acquisition, Washington, D.C., 1974.

U.S. Army Field Manual FM 1-1, Terrain Flying, 1975.

Wright, R. H., & Pauley, W. P. Survey of Factors Influencing Army Low Level Navigation. Alexandria, Va.: HumRRO 71-10, 1971.

APPENDIX A

COURSE DESCRIPTION

Following is a summary of the training materials and procedures that were developed for this course. The facilities and equipment required to implement the course are also specified.

INSTRUCTIONAL AIDS

TEXT: Map Interpretation in Nap-of-the-Earth Flight

A monograph on map interpretation as it applies to Army aviation was especially prepared for this course and serves as a basic text. The instructional content of this text will not be found in any existing manual. It is not intended to replace existing manuals, but supplements them by focusing on the use of maps in the specific application of visual pilotage during terrain flight.

The special text was needed mainly because cartographers apply a great many conventions and selection criteria in compiling any kind of map, and they have a direct impact on the Army aviator's ability to interpret the information shown on the map. However, few map users, even highly experienced aviators, have any idea of what these conventions and criteria actually are. For example, the basis for the selection and classification of roads, the coding criteria for vegetation cover, the ground rules followed by the cartographer in delineating relief and drainage, the conventions used for grouping cultural features under standard symbols, the generalization and displacement practices in cartographic drafting, the geodetic accuracy limitations, the seasonal base, and many other factors that enter into the process of compiling a topographic map are all largely unknown to Army aviators. None of this information will be found in map legends or existing texts on map reading. Yet, without such knowledge, accurate map interpretation cannot be performed. Furthermore, the factors that influence how the map is designed must then be related to the factors that influence the visibility and appearance of features seen on the ground during terrain flight. The text supplied with this course is designed to fulfill this need.

Copies of the text should be distributed for assigned reading at the very outset of the course. The instructor can then review and amplify the main points in his initial lectures.

Lecture Aids

A series of 131 35-mm color transparencies are provided for use as teaching aids in lectures on map interpretation. These may be supplemented by slides from the school's files and by slides made from the figures contained in the instructional text.

The slides were selected mainly to illustrate the variations in actual appearance of features which are portrayed by standard symbols on topographic maps. They also illustrate some of the factors that influence the visibility of certain kinds of features and which provide cues to their detection and identification. Some of the slides are included to illustrate the manner in which certain features are portrayed on topographic maps.

The slides cover the following subjects:

- o hydrography (Part 1: streams),
- o hydrography (Part 2: ponds and reservoirs),
- o vegetation,
- o railroads,
- o roads,
- o buildings, and
- o miscellaneous cultural features.

The selection of slides should by no means be considered a complete set of visual aids for map interpretation lectures. This collection of slides can be supplemented by additional photography or from existing slides and map samples.

A suggested narrative is included with the slides. The instructor may either use it directly or as a frame of reference from which he prepares his own narrative.

It should be noted that these lecture aids do not deal with the subject of contour analysis or other aspects of the interpretation of terrain relief. That subject is covered in the text and is amplified in the special exercise described below.

Contour Analysis (Route H-1)

This exericse is designed to supplement instructional lectures on contour analysis by exercising the student's skill in correlating landforms in the visible terrain with the contour-line portrayal on conventional topographic maps. A 35-mm slide showing the forward visual field as seen from a helicopter at NOE altitude is presented on one screen. A vu-graph transparency of a map of the general area is presented on an adjacent screen. Five alternative positions are marked on the map, one of which is the correct position from which the photograph was made. The students are told the heading and MSL altitude of the aircraft. Their task is to study the landforms appearing in the slide presentation, correlate them with the contour portrayal on the map, and decide which of the five choices marks the correct position. Each student in the class independently makes his choice and marks it on a response sheet. After all five items are completed, the choices are compared, and students who reached different conclusions discuss or defend their choices. The instructor guides the discussion, gives the correct answer, and presents the main map-interpretation points (if these have not already been raised by the students themselves) that should lead the student to the correct answer or to the rejection of the wrong answers. The five alternative positions are selected so as to illustrate basic principles of contour interpretation. A tape-recorded commentary is provided for each item, which describes the general principles illustrated by the item and the specific contour analysis cues that apply to that item. The tape can be directly played in the feedback session or can be used by the instructor to guide his own commentary.

Five sets of contour interpretation problems have been prepared for this exercise. The 35-mm slides are blowups of individual frames from a 16-mm film of a flight over the area. At the conclusion of the feedback session, a vu-graph is presented in which the five correct answers are connected with a course line and, on the adjacent screen, the 16-mm film of the entire flight is presented to illustrate how the contour interpretation task fits into the dynamic mission context. The time required to run the exercise is a direct function of the amount of time allotted for each problem set.

PRACTICAL EXERCISES

The bulk of the program consists of materials and procedures for developing map interpretation skills through practical exercises using simple cinematic simulation methods. After an introductory session, the practical exercises proceed through four stages. The first deals with the skills involved in preflight map study, the second introduces the student to enroute orientation by requiring him only to maintain orientation along a prescribed route of flight and to identify preselected checkpoints along that route, the third escalates the orientation task to a more difficult level by requiring the student to recognize when, and by how much, the simulated flight deviates from a planned route, and the final level presents the student with the more formidable map-interpretation task of maintaining orientation within a corridor of operations, a task that approaches the operational requirement. Following are brief descriptions of these exercises.

Introductory Film and Practice Session (Routes H-3 and H-4)

An introductory film has been prepared which should be presented before the practical exercises are undertaken. This film consists of two short flights over routes that are only a few hundred meters apart in lateral separation. The film and a tape-recorded commentary that accompanies it illustrate how the terrain can appear totally different at very low altitudes as a consequence of small navigational errors, and should reinforce the student's appreciation of the need for precise, continuous orientation during terrain flight. In addition, the film introduces the student to the field-of-view and resolution characteristics of the films themselves, since these are important considerations in some of the subsequent training exercises.

Preflight Terrain Analysis (Routes R-29 and H-10)

The first series of exercises is designed to develop the student's ability to select useful checkpoints and orientation cues during preflight planning. It is especially aimed at teaching the student to predict, on the basis of map study, which of the portrayed features will be visible and which will not be visible from a helicopter flying NOE along a specified route.

The student is given a map plate on which is drawn a planned route. Various features portrayed on the map in the vicinity of the route are designated by means of a numbered overlay. The student is required to study the map, paying particular attention to the probable masking effects of terrain and vegetation, and to indicate on a checklist which of the numbered features he predicts would be visible during NOE flight along the designated route. He also selects the features that he believes would be the most reliable checkpoints for a mission along that route. Then the student is stationed in a rear-projection chamber and the film simulating flight over that route is presented. During the flight, the student marks on the map the features that he actually is able to see and identify. The instructor then scores the student's prediction checklist by means of a special template key and derives two types of scores: the percentage of features the student predicted would be visible but which were not, and the percentage of features he predicted would not be visible, but in fact were visible. In addition, the student compares his map marked with the features he actually saw and identified with his preflight predictions.

Following a discussion of his performance with the instructor, the student goes to the debriefing room, which has two projection screens. On one screen the filmed flight is replayed in slow motion and stop action; on the other screen a vu-graph of the map and inscribed route is presented. A tape-recorded commentary is played which relates the visual scene to the map portrayal and shows how the general principles of map interpretation apply to this specific mission simulation. The commentary focuses on how the visibility of various features (or lack of visibility) could have been predicted from proper map interpretation, the various physical appearances of features portrayed in standard form on the map, and the manner in which features are selected for portrayal. In the final step of this exercise, the student is returned to the rear-projection chamber and the filmed flight is presented again (in real-time simulation), so that he can reexperience the flight from an enlightened perspective.

In the terrain analysis exercise described above, geographic orientation is not an important requirement, the actual track of the flight is portrayed and exact groundspeed information is provided, the emphasis is on preflight map study and the basic objective is to teach the student to make realistic appraisals of the checkpoint features he can expect to see during terrain flight operations.

Two complete terrain analysis exercises have been prepared, one for the Fort Rucker area (R-29) and one for the Hunter Liggett area (H-10). The former can be conducted using either the pictomap or the Air Movement Data (AMD) map. The latter can be conducted using either a conventional 1:50,000-scale topographic map or various forms of orthophotomaps

Along-Track Orientation (Routes R-28a and H-11b)

The student is given a map plate on which a route of flight is marked and is told that he will fly that route at a given speed, plus or minus five knots. Along the route a series of preselected checkpoints has been marked. The student first performs a preflight terrain analysis and map study, after which a tape-recorded commentary provides feedback on the adequacy of his preflight study and points out the conclusions that should be reached (and why) from the map portrayal along the planned route. Then the student is stationed in the rear-projection chamber and a film is presented which simulates flight over the designated route. The student's task is to record the projector frame count the instant the flight passes over each designated checkpoint in turn. (Some of the preselected checkpoints will not actually be visible in the film, but if the student has learned from the preceding terrain analysis exercise, he will be able to predict this and respond on the basis of associated cues or time-distance estimates of position.) The response record indicates the frame count at the moment of the student's response and, by referring to a scoring table, the instructor records the student's along-track orientation performance in terms of meters discrepancy between the actual and designated positions of each checkpoint. These discrepancies are then plotted in graphic form on a special performance score sheet.

Following the simulated flight, a knowledge-of-results and debriefing session is conducted similar to that described above for the terrain analysis exercises. The debriefing commentaries emphasize the type of features that are most useful for time checks or along-track position fixes. Two complete along-track orientation exercises have been prepared, one in the Fort Rucker area (R-28a) and one in the Hunter Liggett area (H-11b).

Cross-Track Orientation (Routes R-30a and H-14)

The student is given a map plate on which a route of flight is marked and is told to assume that it represents his planned route. He is further informed that his actual track in the simulated flight may be offset to the right or left of the planned route marked on his map, but will always be parallel to it. The student's task will be to determine as quickly and accurately as possible the cross-track deviation (if any) between his planned route and actual track. He is given an accurate groundspeed and allowed a period of preflight study. Following a feedback commentary on his preflight map study, he is stationed in the rear-projection chamber and the film is presented which simulates flight over a parallel, but offset, route. At one-minute intervals, the instructor calls for a "mark," at which time the student responds by marking on the map a numeral that indicates his estimate, in hundreds of meters right or left, of any cross-track deviation between his planned and actual routes of flight. If he should conclude that there is no deviation, he marks a zero to indicate "on course." If he is disoriented or otherwise cannot determine his actual route or flight, he marks an X on the map to indicate "no call."

When the simulated flight is completed, the instructor enters the student's responses on a graphic score sheet, which also shows the correct responses to provide knowledge of results to the student concerning his performance. Then the flight is replayed in the debriefing room, along with a tape-recorded commentary that points out the key features that should have been used for determining cross-track deviations. During the replay, a map is projected which shows both the "planned" course and the actual track of the filmed flight. Two complete cross-track orientation exercises have been prepared, one in the Fort Rucker area (R-30a) and one in the Hunter Liggett area (H-14).

Corridor Orientation (Routes R-25, R-27, H-7, and H-13)

The two preceding classes of orientation exercises are designed to introduce the student to the elements of geographic orientation by restricting the position-fixing task to only one dimension at a time. The third class, corridor orientation, is considerably more difficult and requires the student to exercise the full range of his map-interpretation skills.

The student is given a map plate on which is marked a corridor of operations 3,000 meters in width. At one end of the corridor is marked a starting vector which designates the initial position and heading of the aircraft. He is informed that the simulated flight will proceed from the starting vector through the corridor. He is given the groundspeed of the aircraft and told that the flight may go anywhere within the corridor, but will not double back on itself and will not go outside the bounds of the corridor. The student's task will be to maintain geographic orientation during the flight by means of visual pilotage and to mark, on demand, the position of the aircraft at various intervals during the flight.

A period of time is provided for the student's preflight terrain analysis and map study, during which he may mark time hacks or any other preflight annotations he wishes on the map. At the completion of his preflight map study, a briefing is presented which reviews the procedures the student should have followed and discusses the conclusions he should have reached. The briefing includes a terrain analysis, the identification of major orienting cues within the corridor, potential barrier features and funnels, probable visibility ranges of features including major terrain features outside the corridor boundary, the hierarchical ordering of potential checkpoints, and a general orientation plan.

After the briefing, the student is stationed in the rear-projection chamber and the film simulating the flight is presented. Periodically during the flight, a position mark is called for, at which time the student marks his present position on the map as accurately as he can. The student is also periodically informed of the aircraft's heading. Following the simulated flight, the instructor scores the student's performance by means of a plastic map overlay on which are inscribed concentric circles at 100-meter intervals around the actual position of the aircraft at each response-demand point. The student's performance score is the absolute discrepancy between his mark and the actual position of the aircraft. (Additional scores for along-track and cross-track orientation errors can also be measured.) A feedback session in which the instructor and student compare the student's reported positions with the actual positions is followed by the debriefing.

During this debriefing, the filmed flight is replayed in slow motion and stop action, while a tape-recorded commentary describes the main orienting cues along the route and explains how the visible features can be related to the map portrayal. Specific examples or applications of those map-interpretation principles used for precise and/or general in-flight orientation are highlighted. Following the debriefing, the student reenters the rear-projection chamber; this time with a map plate which shows the actual track and the mark points (position-demand points); and the filmed flight is presented again in real time so that the student experiences the flight under completely oriented conditions, thus reinforcing the instructional points made earlier.

Four complete exercises in corridor orientation have been prepared, two in the Fort Rucker area (R-25 and R-27) and two in the Hunter Liggett area (H-7 and H-13). The exercises can be conducted using pictomaps or AMD maps in the Fort Rucker area and with conventional topographic line maps or orthophotomaps in the Hunter Liggett area.

FACILITY AND EQUIPMENT REQUIREMENTS

Following is a specification of the facilities and equipment that would have to be supplied by the training unit to use the materials and implement the program described above.

Briefing/Debriefing Room

An ordinary classroom that can be darkened for movie and slide projection is needed for the debriefing phases of the training exercises and for the instructional sessions. The room should be equipped with two front-projection screens mounted side by side. The following equipment will be needed.

- o 35-mm slide projector with carousel and remote control cord.
- o Vu-graph transparency projector.
- o LW Photo-optical Data Analyzer 16-mm projector Model 224-A-Mk IV. This unit should be equipped with a frame-count readout and a remote control cord which permits variable frame-rate operation of the projector plus stop action and manual single-frame advance. The focal length of the lens should be sufficiently short to permit an image of at least three feet wide to be projected within the confines of the classroom. The Somco No. 6270 1" f/1.9 lens would probably be suitable.
- o Cassette tape playback unit.

The classroom should be arranged so that the group of students can view both screens, one of which will present the motion-picture film or 35-mm slide while the other presents a vu-graph of the map plate. The instructor will have to be stationed so that he can operate the control unit for the Analyst Projector and point out features on the projected map. This latter function can be performed either directly on the vu-graph transparency or by means of a flashlight pointer on the projected image.

Rear-Projection Chamber

Most of the training exercises are designed to be conducted in a rear-projection chamber of the type illustrated in Figure A-1. As noted

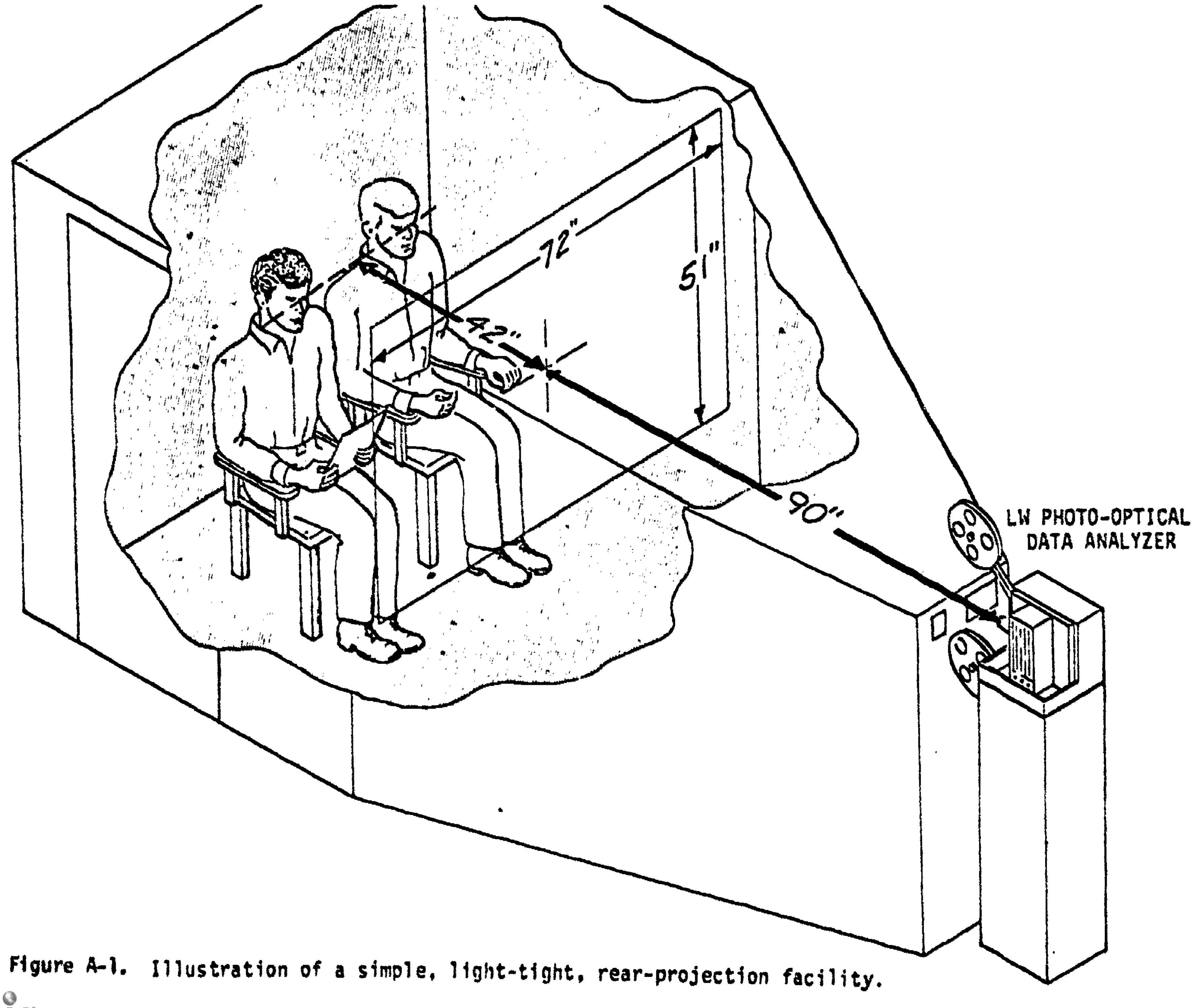


Figure A-1. Illustration of a simple, light-tight, rear-projection facility.

earlier, all of the 16-mm photography used in this program covers an 85° x 67° visual field that can be projected without distortion onto a flat screen. The purpose of the rear-projection chamber is to permit the students to view these films in such a way that the visual angles are correctly reconstructed. (It is possible to come close to the correct viewing angles by front projection of the films, but this would require a large auditorium and a specially constructed observer platform.)

The size of the rear-projection chamber is a function of the screen size and the focal length of the projector lens. The chamber illustrated in Figure A-1 is the most compact design that can feasibly be achieved. The rear-projection screen is 72" x 51", which is the minimum recommended size. The projector lens is a No. 3311 1/2" f/2.4 lens manufactured by Somco Infrared Industries, Inc., 6307 Carpinteria Avenue, Carpinteria, California (list price $135). Longer focal-length lenses can be used, but the lens-to-screen distance must be proportionally increased. For example, to use a standard two-inch lens, the lens-to-screen distance in the chamber would have to be about 30 feet.

The rear-projection screen should be a grain-free, high transmittance material, tension-stretched on its frame. Bodde transluscent projection screening, which has a plastic base and presents no perceptible grain, is recommended. The entire chamber should be light-tight and painted flat black on the inside. The projector is mounted at an aperture in the end of the light-tight chamber. Next to the lens aperture there should be a small viewing window through which the instructor can focus and monitor the projected scene. This easily constructed rear-projection chamber reduces the incidental light falling on the screen to a minimum and also permits the instructor to work in a lighted room.

The 16-mm projector should be the same type as specified for the briefing room, an LW Photo-optical Data Analyzer equipped with a frame-count readout and a frame-rate control to permit variations from one frame per second to 24 frames per second. A 1,000-watt FFD lamp should be used to obtain the brightest possible image. It is possible to conduct the training program using only one LW projector, switching it as required from the rear-projection chamber to the debriefing room. However, the availability of two projectors would permit more efficient processing of students.

Only one person can view the rear-projected film from the position that will precisely reconstruct the visual angles. In the chamber illustrated in Figure A-1, this point would be 40 inches from the center of the screen. Four students, closely positioned around that point should be considered the maximum-size group for the orientation exercises. Each student should be supplied with a lighted clipboard and a stopwatch.

The rear-projection chamber should also be supplied with a cassette tape playback unit and a projector frame counter for the along-track orientation exercises.

Film-Handling Station

A facility will be needed for storing and handling the motion-picture films. This should be located near the rear-projection chamber and should include storage racks, rewind table, a hot splicer, and film cleaning supplies. Spare projection lamps should also be on hand.

APPENDIX B

OUTLINE OF TACTICAL NAVIGATION COURSE.

Day One - Three Hours

Introduction

Pretest

Map Reading

Map sheet legend and marginal notes

Military grid designation system

Relief portrayal and profile drawing

Azimuth designations

Intersection and resection triangulation

Map scales

Day Two - Three Hours

Terrain Walk Exercise

Day Three - Three Hours

Analysis of Area of Operations

Mission planning

Enemy capabilities

Climate and weather

Terrain relief and drainage

Vegetation and surface materials

Observation and fire

Concealment and cover

Key terrain features and obstacles

Avenues of approach

Key Terrain and Avenues of Approach Practical Exercise

Day Four - Three Hours

Film on NOE Flying

Terrain Flying

Low-level, contour and nap-of-the-earth

Advantages and disadvantages

Terrain flying technique

Navigation aids

Hazards

Pre-flight planning

Flight execution

Film on High Speed Low Level Flying

Day Five - Three Hours

Practical Exercise

Planning of an NOE flight

Student presentation and discussion

Review of Course

Day Six - Three Hours

Final Exam

Final Exam De-brief

Post-test

APPENDIX C

OUTLINE OF TERRAIN FLYING OPERATIONS COURSE

Day One - Three Hours

<u>Introduction</u>

<u>Pretest</u>

<u>"The Small World of NOE" Film</u>

<u>MITAC Introductory Slide Lecture</u>

(See Appendix A)

<u>Analysis of Area of Operation</u>

(See Appendix B)

Day Two - Three Hours

<u>Map Reading</u>

(See Appendix B)

<u>Terrain Flying</u>

(See Appendix B)

Days Three Through Six - Three Hours Each

<u>MITAC Exercises</u>

(See Appendix A)

Day Seven - Three Hours

<u>MITAC Exercise</u>

<u>Review of Course</u>

Day Eight - Three Hours

Final Exam

Final Exam De-brief

Post-test

APPENDIX D

ARI
NOE NAVIGATION CHECK LIST

Navigator Name ______________________________

SSN ______________________________

Class ______________________________

Branch ______________________________

IP Name ______________________________

SSN ______________________________

Date ______________________________

NOE Route ______________________________

Has this student navigator ever flown over this NOE route before?

Yes /_7 No /_7

If yes, was it as: Pilot /_7

Navigator /_7

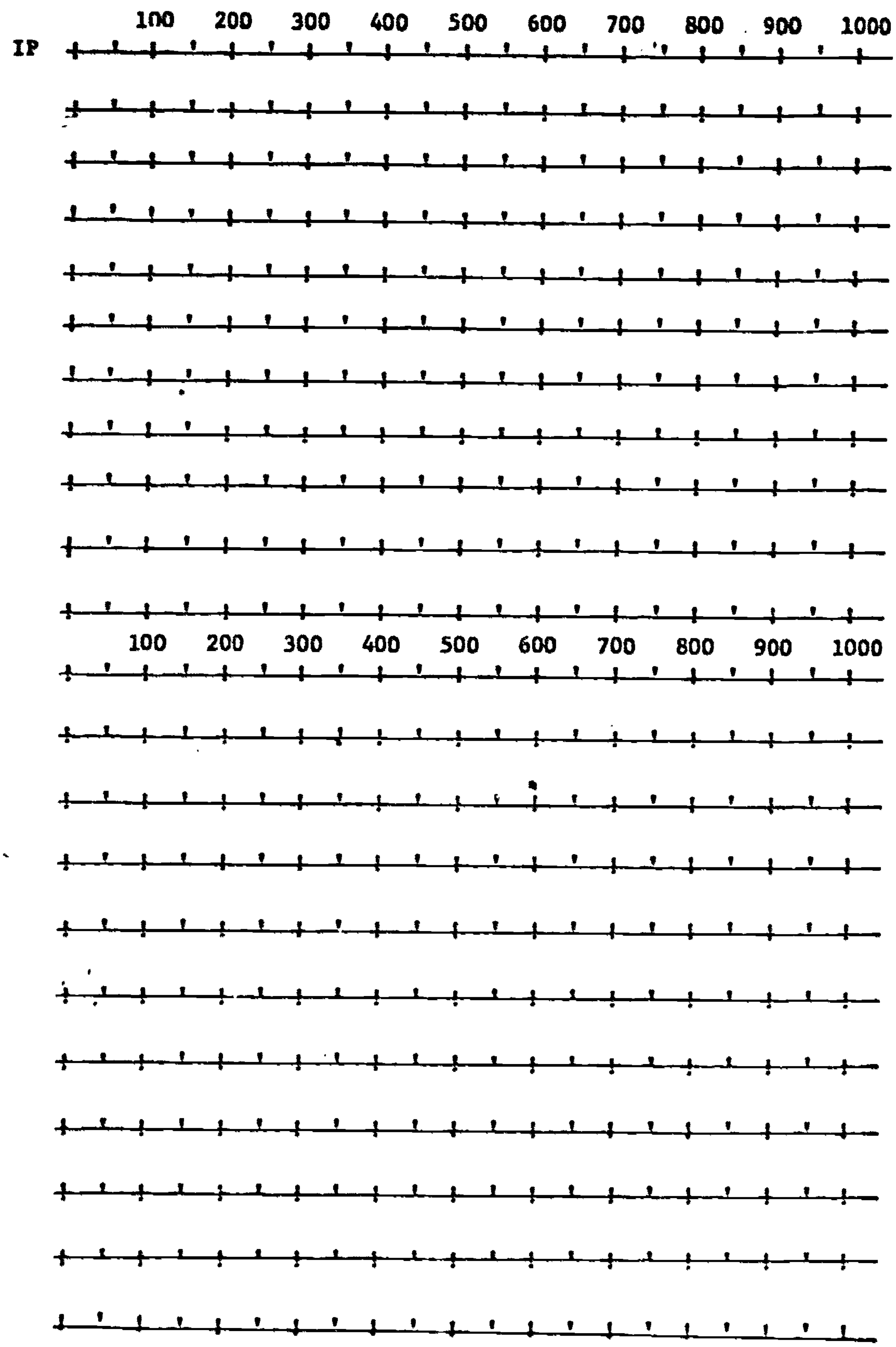
Return to:

Dr. Garvin Holman
Army Research Institute
Ft Rucker, AL

INITIAL POINT = IP
ROUTE DEVIATION = R
PHASE LINE A = A
PHASE LINE B = B
PHASE LINE C = C

OFF COURSE ORIENTATION = OC
RELEASE POINT = RP

Meters Deviation



ELAPSED TIME
NAV. NOE =

TOTAL DISTANCE
NAV. NOE =

PLEASE RATE THE STUDENT NAVIGATOR ON THE FOLLOWING POINTS:

(1) Today's performance was:

- /_7 better than usual.
- /_7 typical of this student.
- /_7 worse than usual.

(2) The navigator was:

- /_7 always oriented and had no difficulty.
- /_7 always oriented but had difficulty.
- /_7 occasionally disoriented.
- /_7 often disoriented.
- /_7 always disoriented.

(3) Of all the students you have taught, how would you rate this student's navigation skills?

- /_7 top 10%
- /_7 top 25%
- /_7 middle 50% but above average
- /_7 middle 50% but below average
- /_7 bottom 25%
- /_7 bottom 10%

(4) The Navigator-Pilot coordination was:

- /_7 very good.
- /_7 good.
- /_7 average.
- /_7 poor.
- /_7 very poor.

(5) The navigator's attitude was:

- ☐ very good.
- ☐ good.
- ☐ average.
- ☐ poor.
- ☐ very poor.

Additional comments on this student, today's flight or this evaluation:

DISTRIBUTION

ARI Distribution List

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1 HQDA (DAPE-PBR
1 HQDA (DAMA-AR)
1 HQDA (DAPE-HRE-PO)
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1 HQDA (DAPE-MPO-C)
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1 USATTC, Ft Clayton, ATTN: STETC-MO-A
1 USAIMA, Ft Bragg, ATTN: ATSU-CTD-OM
1 USAIMA, Ft Bragg, ATTN: Marquat Lib
1 US WAC Ctr & Sch, Ft McClellan, ATTN: Lib
1 US WAC Ctr & Sch, Ft McClellan, ATTN: Tng Dir
1 USA Quartermaster Sch, Ft Lee, ATTN: ATSM-TE
1 Intelligence Material Dev Ofc, EWL, Ft Holabird
1 USA SE Signal Sch, Ft Gordon, ATTN: ATSO-EA
1 USA Chaplain Ctr & Sch, Ft Hamilton, ATTN: ATSC-TE-RD
1 USATSCH, Ft Eustis, ATTN: Educ Advisor
1 USA War College, Carlisle Barracks, ATTN: Lib
2 WRAIR, Neuropsychiatry Div
1 DLI, SDA, Monterey
1 USA Concept Anal Agcy, Bethesda, ATTN: MOCA-WGC
1 USA Concept Anal Agcy, Bethesda, ATTN: MOCA-MR
1 USA Concept Anal Agcy, Bethesda, ATTN: MOCA-JF
1 USA Artic Test Ctr, APO Seattle, ATTN: STEAC-MO-ASL
1 USA Artic Test Ctr, APO Seattle, ATTN: AMSTE-PL-TS
1 USA Armament Cmd, Redstone Arsenal, ATTN: ATSK-TEM
1 USA Armament Cmd, Rock Island, ATTN: AMSAR-TDC
1 FAA-NAFEC, Atlantic City, ATTN: Library
1 FAA-NAFEC, Atlantic City, ATTN: Hum Engr Br
1 FAA Aeronautical Ctr, Oklahoma City, ATTN: AAC-44D
2 USA Fld Arty Sch, Ft Sill, ATTN: Library
1 USA Armor Sch, Ft Knox, ATTN: Library
1 USA Armor Sch, Ft Knox, ATTN: ATSB-DI-E
1 USA Armor Sch, Ft Knox, ATTN: ATSB-DT-TP
1 USA Armor Sch, Ft Knox, ATTN: ATSB-CD-AD
2 HQUSACDEC, Ft Ord, ATTN: Library
1 HQUSACDEC, Ft Ord, ATTN: ATEC-EX-E-Hum Factors
2 USAEEC, Ft Benjamin Harrison, ATTN: Library
1 USAPACDC, Ft Benjamin Harrison, ATTN: ATCP-HR
1 USA Comm-Elect Sch, Ft Monmouth, ATTN: ATSN-EA
1 USAEC, Ft Monmouth, ATTN: AMSEL-CT-HDP
1 USAEC, Ft Monmouth, ATTN: AMSEL-PA-P
1 USAEC, Ft Monmouth, ATTN: AMSEL-SI-CB
1 USAEC, Ft Monmouth, ATTN: C, Facl Dev Br
1 USA Materials Sys Anal Agcy, Aberdeen, ATTN: AMXSY-P
1 Edgewood Arsenal, Aberdeen, ATTN: SAREA-BL-H
1 USA Ord Ctr & Sch, Aberdeen, ATTN: ATSL-TEM-C
2 USA Hum Engr Lab, Aberdeen, ATTN: Library/Dir
1 USA Combat Arms Tng Bd, Ft Benning, ATTN: Ad Supervisor
1 USA Infantry Hum Rsch Unit, Ft Benning, ATTN: Chief
1 USA Infantry Bd, Ft Benning, ATTN: STEBC-TE-T
1 USASMA, Ft Bliss, ATTN: ATSS-LRC
1 USA Air Def Sch, Ft Bliss, ATTN: ATSA-CTD-ME
1 USA Air Def Sch, Ft Bliss, ATTN: Tech Lib
1 USA Air Def Bd, Ft Bliss, ATTN: FILES
1 USA Air Def Bd, Ft Bliss, ATTN: STFBD-PO
1 USA Cmd & General Stf College, Ft Leavenworth, ATTN: Lib
1 USA Cmd & General Stf College, Ft Leavenworth, ATTN: ATSW-SE-L
1 USA Cmd & General Stf College, Ft Leavenworth, ATTN: Ed Advisor
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: DepCdr
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: CCS
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCASA
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCACO-E
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCACC-CI
1 USAECOM, Night Vision Lab, Ft Belvoir, ATTN: AMSEL-NV-SD
3 USA Computer Sys Cmd, Ft Belvoir, ATTN: Tech Library
1 USAMERDC, Ft Belvoir, ATTN: STSFB-DQ
1 USA Eng Sch, Ft Belvoir, ATTN: Library
1 USA Topographic Lab, Ft Belvoir, ATTN: ETL-TD-S
1 USA Topographic Lab, Ft Belvoir, ATTN: STINFO Center
1 USA Topographic Lab, Ft Belvoir, ATTN: ETL-GSL
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: CTD-MS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATS-CTD-MS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-TE
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-TEX-GS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-CTS-OR
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-CTD-DT
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-CTD-CS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: DAS/SRD
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-TEM
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: Library
1 CDR, HQ Ft Huachuca, ATTN: Tech Ref Div
2 CDR, USA Electronic Prvg Grd, ATTN: STEEP-MT-S
1 CDR, Project MASSTER, ATTN: Tech Info Center
1 Hq MASSTER, USATRADOC, LNO
1 Research Institute, HQ MASSTER, Ft Hood
1 USA Recruiting Cmd, Ft Sherdian, ATTN: USARCPM-P
1 Senior Army Adv., USAFAGOD/TAC, Elgin AF Aux Fld No. 9
1 HQ USARPAC, DCSPER, APO SF 96558, ATTN: GPPE-SE
1 Stimson Lib, Academy of Health Sciences, Ft Sam Houston
1 Marine Corps Inst., ATTN: Dean-MCI
1 HQUSMC, Commandant, ATTN: Code MTMT 51
1 HQUSMC, Commandant, ATTN: Code MPI-20
2 USCG Academy, New London, ATTN: Admission
2 USCG Academy, New London, ATTN: Library
1 USCG Training Ctr, NY, ATTN: CO
1 USCG Training Ctr, NY, ATTN: Educ Svc Ofc
1 USCG, Psychol Res Br, DC, ATTN: GP 1/62
1 HQ Mid-Range Br, MC Det, Quantico, ATTN: P&S Div

1 US Marine Corps Liaison Ofc, AMC, Alexandria, ATTN: AMCGS–F
1 USATRADOC, Ft Monroe, ATTN: ATRO–ED
6 USATRADOC, Ft Monroe, ATTN: ATPR–AD
1 USATRADOC, Ft Monroe, ATTN: ATTS–EA
1 USA Forces Cmd, Ft McPherson, ATTN: Library
2 USA Aviation Test Bd, Ft Rucker, ATTN: STEBG–PO
1 USA Agcy for Aviation Safety, Ft Rucker, ATTN: Library
1 USA Agcy for Aviation Safety, Ft Rucker, ATTN: Educ Advisor
1 USA Aviation Sch, Ft Rucker, ATTN: PO Drawer O
1 HQUSA Aviation Sys Cmd, St Louis, ATTN: AMSAV–ZDR
2 USA Aviation Sys Test Act., Edwards AFB, ATTN: SAVTE–T
1 USA Air Def Sch, Ft Bliss, ATTN: ATSA TEM
1 USA Air Mobility Rsch & Dev Lab, Moffett Fld, ATTN: SAVDL–AS
1 USA Aviation Sch, Res Tng Mgt, Ft Rucker, ATTN: ATST–T–RTM
1 USA Aviation Sch, CO, Ft Rucker, ATTN: ATST–D–A
1 HQ, DARCOM, Alexandria, ATTN: AMXCD–TL
1 HQ, DARCOM, Alexandria, ATTN: CDR
1 US Military Academy, West Point, ATTN: Serials Unit
1 US Military Academy, West Point, ATTN: Ofc of Milt Ldrshp
1 US Military Academy, West Point, ATTN: MAOR
1 USA Standardization Gp, UK, FPO NY, ATTN: MASE–GC
1 Ofc of Naval Rsch, Arlington, ATTN: Code 452
3 Ofc of Naval Rsch, Arlington, ATTN: Code 458
1 Ofc of Naval Rsch, Arlington, ATTN: Code 450
1 Ofc of Naval Rsch, Arlington, ATTN: Code 441
1 Naval Aerospc Med Res Lab, Pensacola, ATTN: Acous Sch Div
1 Naval Aeros . Med Res Lab, Pensacola, ATTN: Code L51
1 Naval Aerospc Med Res Lab, Pensacola, ATTN: Code L5
1 Chief of NavPers, ATTN: Pers-OR
1 NAVAIRSTA, Norfolk, ATTN: Safety Ctr
1 Nav Oceanographic, DC, ATTN: Code 6251, Charts & Tech
1 Center of Naval Anal, ATTN: Doc Ctr
1 NavAirSysCom, ATTN: AIR–5313C
1 Nav BuMed, ATTN: 713
1 NavHelicopterSubSqua 2, FPO SF 96601
1 AFHRL (FT) William AFB
1 AFHRL (TT) Lowry AFB
1 AFHRL (AS) WPAFB, OH
2 AFHRL (DOJZ) Brooks AFB
1 AFHRL (DOJN) Lackland AFB
1 HQUSAF (INYSD)
1 HQUSAF (DPXXA)
1 AFVTG (RD) Randolph AFB
3 AMRL (HE) WPAFB, OH
2 AF Inst of Tech, WPAFB, OH, ATTN: ENE/SL
1 ATC (XPTD) Randolph AFB
1 USAF AeroMed Lib, Brooks AFB (SUL-4), ATTN: DOC SEC
1 AFOSR (NL), Arlington
1 AF Log Cmd, McClellan AFB, ATTN: ALC/DPCRB
1 Air Force Academy, CO, ATTN: Dept of Bel Scn
5 NavPers & Dev Ctr, San Diego
2 Navy Med Neuropsychiatric Rsch Unit, San Diego
1 Nav Electronic Lab, San Diego, ATTN: Res Lab
1 Nav TrngCen, San Diego, ATTN: Code 9000–Lib
1 NavPostGraSch, Monterey, ATTN: Code 55Aa
1 NavPostGraSch, Monterey, ATTN: Code 2124
1 NavTrngEquipCtr, Orlando, ATTN: Tech Lib
1 US Dept of Labor, DC, ATTN: Manpower Admin
1 US Dept of Justice, DC, ATTN: Drug Enforce Admin
1 Nat Bur of Standards, DC, ATTN: Computer Info Section
1 Nat Clearing House for MH–Info, Rockville
1 Denver Federal Ctr, Lakewood, ATTN: BLM
12 Defense Documentation Center
4 Dir Psych, Army Hq, Russell Ofcs, Canberra
1 Scientific Advsr, Mil Bd, Army Hq, Russell Ofcs, Canberra
1 Mil and Air Attache, Austrian Embassy
1 Centre de Recherche Des Facteurs Humaine de la Defense Nationale, Brussels
2 Canadian Joint Staff Washington
1 C/Air Staff, Royal Canadian AF, ATTN: Pers Std Anal Br
3 Chief, Canadian Def Rsch Staff, ATTN: C/CRDS(W)
4 British Def Staff, British Embassy, Washington
1 Def & Civil Inst of Enviro Medicine, Canada
1 AIR CRESS, Kensington, ATTN: Info Sys Br
1 Militaerpsykologisk Tjeneste, Copehagen
1 Military Attache, French Embassy, ATTN: Doc Sec
1 Medecin Chef, C.E.R.P.A.–Arsenal, Toulon/Naval France
1 Prin Scientific Off, Appl Hum Engr Rsch Div, Ministry of Defense, New Delhi
1 Pers Rsch Ofc Library, AKA, Israel Defense Forces
1 Ministerie van Defensie, DOOP/KL Afd Sociaal Psychologische Zaken, The Hague, Netherlands