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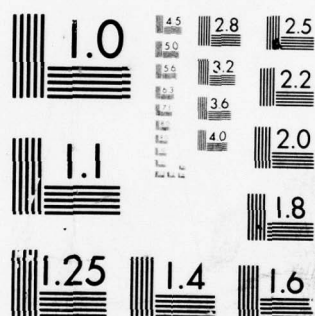


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**UNDERGRADUATE PILOT TRAINING:
VISUAL DISCRIMINATION PRETRAINING
FOR LANDING TASK**

By

Bernell J. Edwards
Douglas C. Weyer, Capt, USAF
Bruce A. Smith, Capt, USAF

FLYING TRAINING DIVISION
Williams Air Force Base, Arizona 85224

February 1979
Final Report for Period July 1976 - June 1978



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This final report was submitted by Flying Training Division, Air Force Human Resources Laboratory, Williams Air Force Base, Arizona 85224, under project 1123, with HQ Air Force Human Resources Laboratory (AFSC), Brooks Air Force Base, Texas 78235. Dr. Bernell J. Edwards (FTR) was the Principal Investigator for the Laboratory.

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DIRK C. PRATHER, Lieutenant Colonel, USAF
Technical Advisor, Flying Training Division

RONALD W. TERRY, Colonel, USAF
Commander

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PREFACE

This study was conducted in support of Project 1123, Flying Training Development, Mr. James F. Smith, Project Scientist; Task 112302, Instructional Innovations in the United States Air Force Flying Training, Dr. Bernell J. Edwards, Task Scientist.

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UNDERGRADUATE PILOT TRAINING: VISUAL DISCRIMINATION PRETRAINING FOR LANDING TASK

I. INTRODUCTION

Background

The discrimination of visual cues is a major aspect of learning to fly. A number of methods have been reported in the literature of visual discrimination which seem potentially applicable to flying training.

The objective of discrimination training is to bring the appropriate set of responses under control of relevant stimuli (discriminative stimuli). This can be accomplished by beginning at a gross level of contrast where differences are obvious and gradually increasing the difficulty level by reducing contrast until control of the desired response is transferred completely to the discriminative stimuli at a criterion level of difficulty.

Several successful techniques for accomplishing this type of transfer have been reported. A technique for modifying the to-be-discriminated stimuli so that critical features were emphasized or exaggerated was investigated by Bijou and Baer (1965). Subjects learned subtle differences in shapes and figures by first learning to identify exaggerated characteristics of various shapes. When these exaggerations were diminished gradually, subjects were able to transfer correct identification to the normal representations of shapes and figures.

Use of prompting and fading of prompts has been shown to be effective in teaching visual discriminations. Lumsdaine and Sulzer (1951) employed visual prompts to insure correct responding during a training task. Animated arrows, pointers, and labels were added to instructional film sequences to direct student attention to important characteristics of the display. In these studies of discrimination learning, student responses were initially controlled by specifically designed prompting stimuli. Results showed that the prompts could be gradually reduced until response control had been completely transferred to the discriminated stimulus.

A related concept, that of stimulus predifferentiation, has been described by Ellis (1965) as the facilitation of learning a new stimulus-response task as a result of some type of preliminary experience with the stimuli themselves. For example, a subject might be taught to recognize various parts of a machine by learning to associate correctly the names of the parts prior to learning to actually assemble the machine. Visual stimulus predifferentiation is an activity in which subjects learn first to respond mentally to visual stimuli, then later learn to perform a transfer task in which they must make differential responses to the same stimuli. In studies of visual stimulus predifferentiation, positive transfer effects from the preliminary task to the transfer task have been demonstrated repeatedly (Battig, 1956; Cantor, 1955; Gagne & Baker, 1950; Goss & Greenfield, 1958; Norcross & Spiker, 1958; Vanderplas, Sanderson, & Vanderplas, 1964). In the Vanderplas et al. study, it was demonstrated that the magnitude of transfer to perceptual motor tasks depend on the degree of similarity between the preliminary task and the transfer task.

Ellis and Muller (1964) found evidence that subjects given pretraining in stimulus predifferentiation (labeling) were superior to subjects given no labeling pretraining in transfer to motor responses. They have suggested the nature of the transfer task itself may influence the positive effects of stimulus predifferentiation pretraining. When the task requires the learner to make different responses to the same stimuli, negative transfer increases as responses become less similar.

Evidence from the literature, then, suggests that discrimination training of visual stimuli may be an effective method in training perceptual motor tasks provided that stimuli are the same in both pretrained

and transfer tasks. To summarize: (a) human subjects can be trained to discriminate very subtle differences in visual stimuli, (b) various methods have been shown to be effective in training these discriminations, such as exaggeration of stimulus characteristics, artificial cueing or prompting followed by fading, or labeling of critical characteristics using cues such as pointers, dots, and arrows, and (c) since positive transfer increases with increasing stimulus similarity, visual pretraining materials should resemble as nearly as possible those of the transfer task.

In a study related to concepts of visual discrimination pretraining, Smith, Waters, and Edwards (1975) demonstrated the effectiveness of cognitive pretraining associated with the transfer task of flying the T-37 overhead landing pattern in Undergraduate Pilot Training (UPT). Students who received pretraining in landing procedures via a preprogrammed text and films of the landing pattern subsequently performed the landing task significantly better than students who did not receive the pretraining.

Statement of the Problem

It is generally acknowledged that one of the most difficult training tasks in UPT is the T-37 landing pattern. The most difficult element within the pattern is the final turn. The maneuver is a descending 180-degree turn requiring precise skills and judgements in order to roll out of the turn aligned properly with the runway at proper altitude and ground position. The maneuver represents the integration of a number of complex skills within a brief time frame, and it has been a long-standing training problem. The ability to visually discriminate proper from improper aircraft position during the turn is an essential part of the task. The training of these visual skills is the subject of the present study.

During landing training, the student gradually learns proper responses to discriminative stimuli within the visual field through trial-and-error experience. As his discrimination skills improve, he recognizes when he is too high, too low, too long, or too short in the turn and learns to associate appropriate control inputs to reduce aircraft position error. The student must learn proper corrections from unacceptable flightpaths as well as how to hold the correct path. Consequently, the student must grope for visual cues related to correct airspeed, proper altitude, proper ground path, and so on. As training progresses, he attains the correct path more frequently, receives confirmation from the instructor pilot more frequently, and eventually associates correct aircraft position with required control inputs.

There are some potential drawbacks to this training approach. From a learning viewpoint, it may be inefficient. It is hard for the student to eliminate errors in judgment because it is difficult to extinguish responses to irrelevant or undiscriminated stimuli (incorrect flight paths). Training methods are needed that can reduce the learning complexities of the final turn task.

The approach to the final turn taken in the present study was the pretraining of salient visual skills; that is, teaching the students basic visual field references before they attempt to fly the maneuver in the aircraft.

II. OBJECTIVE AND APPROACH

The objective of this study was to develop and evaluate a methodology to pretrain visual discriminations for the final turn maneuver of the T-37 overhead landing pattern. This study was conceived as an investigation of visual pretraining as a cognitive rehearsal strategy and was conducted as a follow-on effort to a study by Smith, Waters, and Edwards (1975). The present study was accomplished in three steps as follows:

1. Using procedures derived from the literature of visual discrimination, a visual discrimination pretraining (VDPT) product was developed and evaluated.
2. The pretraining package was tested for transfer effects in simulated and real-time flying environments.
3. The results were evaluated, and refinements and follow-on efforts were suggested.

III. MATERIALS DEVELOPMENT

The final turn of the overhead pattern was analyzed from a variety of aspects before beginning the training product development. A number of instructor pilots were interviewed and maneuver data and instructions from the T-37 training syllabus were reviewed. The final turn as a part of the overhead landing pattern was discussed in detail with research instructor pilots and training psychologists. Those criteria used by Standardization and Evaluation pilots in examining final turn maneuver skills of student pilots were also examined. From this information an operational definition of the final turn was developed. The definition also included a detailed task description from the Task Taxonomy of Undergraduate Pilot Training Skills (Meyer, Laveson, Weisemann, & Eddowes, 1974).

As depicted in Figure 1, the turn was segmented into five points as follows: starting point, one-quarter turn point, one-half turn point, three-quarter turn point, and end point or rollout. These points were chosen as data loci where the aircraft could be characterized as being on the normal flightpath or when it could be depicted as deviating from the correct path in terms of altitude and ground track.

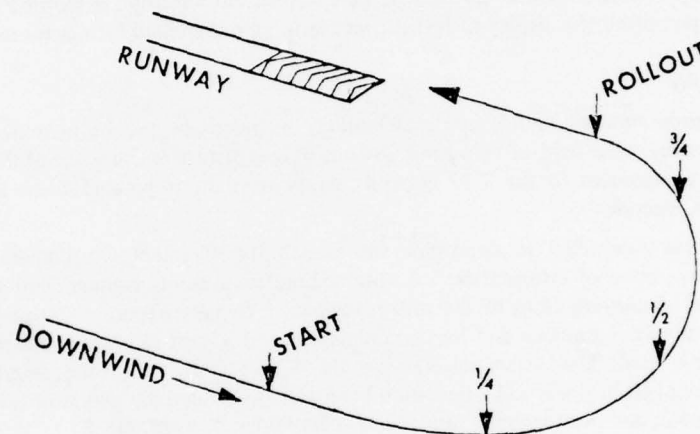


Figure 1. Photo points for Final Turn.

The objective of the pretraining program was to train the student to identify the basic visual elements of the correct path as opposed to the various possible incorrect flightpaths. Figure 2 shows the scheme for the development of a three-dimensional photographic matrix to teach the student the required visual discriminations. Altitude deviations were arbitrarily set at 100-foot increments from normal pattern altitude. Lateral flightpath deviations were set at one-quarter mile deviations as measured at the mid-turn point.

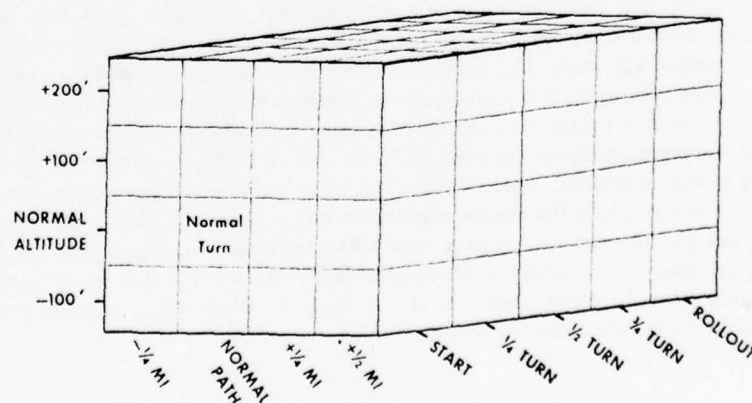


Figure 2. Visual Discrimination Matrix for Final Turn.

By extracting any combination of cells from the matrix for a given point in the turn, comparisons of visual elements between normal and deviant turn paths could be made. As can be seen in the matrix, no deviation references for 200 feet below normal pattern altitude were developed because of the extreme proximity to the ground (plus 100 feet) at the rollout point represented by such a turn path. Similarly, the matrix contained no lateral deviation paths closer to the runway than one-half mile (one-quarter mile short turn), since no practical value in a deviation of this magnitude was realistic for training purposes. Consequently, the final conceptual matrix became a 4 x 4 x 5 array of turn paths with the normal path depicted immediately below and to the left of the horizontal and vertical centerlines.

Photographic Development

Since photographs of the final turn were to be used as vehicles by which the visual discriminations were to be taught, it was important that the photographs contain representative information about the real environment. A sufficiently wide-angle field of view in the photos was required in order to display important ground reference points and spatial perspectives. In addition, a method of photography was required which permitted the display of realistic visuals in a programmed format for instructional purposes.

Initial Photography

Initial consideration of photographic technology included the requirements for color, high picture resolution, extremely wide field of view, and absence of lens distortion. The size of the camera system was limited by the environment of the T-37 cockpit: safety regulations precluded the use of a fix-mounted camera within the aircraft.

A search was conducted to determine the availability of cameras or camera systems with these capabilities. A large body of information was obtained on lens systems, camera combinations and methods for collecting and displaying films of the turn maneuver. Extensive experimentation was conducted with both 16mm motion film cameras and lens combinations and 35mm cameras and lenses. Multiple camera combinations were tried. The system selected was the Wide Lux F-7, a 35mm camera with an extremely wide field of view (140 degrees) and other useful features. A detailed discussion of the F-7 camera system, mounting equipment, and photographic procedures is contained in Appendix A.

Photograph Collection for VDPT Matrix

A series of 35mm wide angle photographs were collected in the T-37 aircraft representing each cell in the final turn VDPT matrix. The camera was positioned in the cockpit at average eye-level height above the left seat to correspond with the field of view seen from the student position. Film was exposed by an experienced research instructor pilot who was proficient in still camera photography. The aircraft was flown from the right seat by an experienced research instructor pilot with 2,300 hours of T-37 flying time. Each turn path within the matrix was photographed repeatedly until a satisfactory series of slide photographs was produced, and the pilot was satisfied that each turn path had been flown and photographed within deviations specified by the matrix. The adequacy of photos for instructional purposes was determined by subjecting sets of turn path photos to comparison screenings by a panel of experienced instructor pilots. Comparability between corresponding turn position (starting point, quarter point, etc.) was also checked by instructor pilots to ascertain that visual differences between various flightpaths were indeed discernible and represented varying levels of discrimination difficulty. Quality of the photos was also cross-checked for correct exposure, angle of view, and other technical characteristics. During the filming periods, the time of day at which the photos were taken was controlled closely to eliminate differences in ground shadows. All photos used for training were taken within a 3-week period to preclude noticeable changes in the appearance of agricultural fields surrounding Williams AFB. The instructor pilot panel also judged the adequacy of each of the photos in representing the salient visual references used in the turn maneuver and in exhibiting differences between turn paths.

Multiple copies of the final series of slides were required for the instructional program. Replication of photos was accomplished using an Elinchrome Diaduplicator slide copier. The contrast and density of slide reproductions were closely controlled to ensure uniformity and comparability to originals. In some cases, pointer arrows were added to duplicated slides as attentional cues.

Multi-Image Slide Display System

A specially designed multiple projector/rear screen system was required to display the photographic materials used in the VDPT instructional sequences. For the student sitting in front of the screen, a wraparound visual effect was created. The purpose of the rear screen and multiple projectors was to recreate a visual environment closely approximating that of the T-37 cockpit.

The projection system was comprised of six automatically actuated, random access Eastman Kodak Carousel 35mm slide projectors mounted behind a divided angle, translucent 4 by 8 foot rear screen. All six projectors were controlled from a single rotary disc selector unit which permitted the student to select and view simultaneously a six-element composite image combined into a single frame display. As the student selected a specific frame number from the 80-slide magazine system, the composite display corresponding to that frame number from each of the projectors was shown on the screen.

Figure 3 shows the screen arrangement of the projection elements. The images from projectors A and B were used to project composite wide-angle pictures of the normal flightpath. Projectors D and E displayed composite pictures of the various deviant flightpaths so that the student could compare and contrast the flightpaths turn point by turn point. Textual information and cockpit instrument displays corresponding to each flightpath picture were displayed on projectors C and F to complete the multi-image array for each frame. Detailed information on the visual display system is contained in Appendix B.

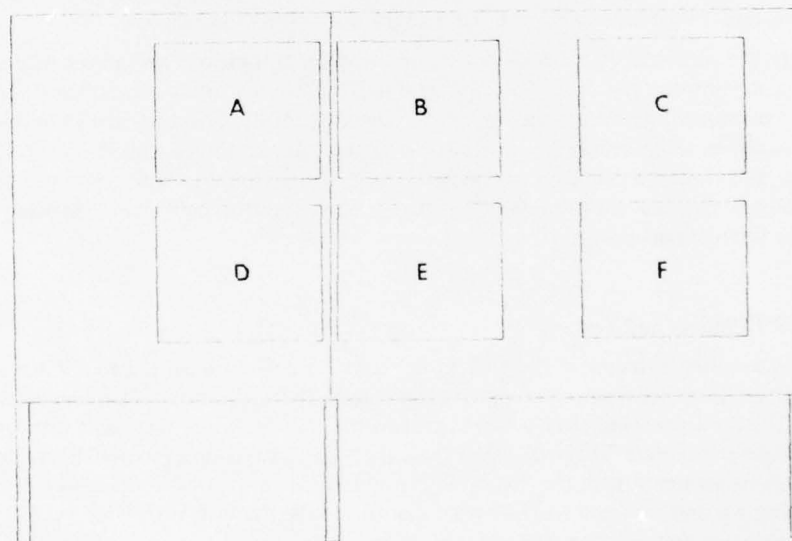


Figure 3. Rear screen system image arrangement for VDPT program.

Development of Programmed Visual Instruction

The initial frames of the program were devoted to the basic flightpath characteristics, relevant flight parameters, and associated ground references at Williams AFB. Orientation to the downwind leg of the landing pattern as a starting point for the turn, and basic procedures used in the turn maneuver were also treated.

The program, which comprised a 130-frame sequence, was an expository treatment of the VDPT matrix. The program followed a logical flow from the most grossly apparent visual differences between normal and highly deviant flightpaths (easy to recognize) to the most subtle differences between paths (difficult to recognize). The normal path was displayed for each deviant path comparison. Thus, the student was given repeated exposure to the appearance of the normal path compared to the deviant paths in order to develop his visual discrimination skills. Slide sequences were always presented in complete turn units; that is, in five-slide units with each point from the start to the rollout. At the conclusion of the instruction, a review was presented to the learner. The review consisted of presenting a single slide of a given turn path (normal or deviant) and at one of the five turn points. The student was required to identify the direction of the deviation from the normal path (or the fact that the slide represented the normal path) by marking with an x the appropriate square of a blank three-by-three grid. Test pictures were presented in increasing order of difficulty and were representative of all deviation paths trained in the program. Normal path frames were interspersed among deviant path frames on a random basis. The ratio was six deviant path frames to one normal frame. The student was permitted to control the rate of presentation as with the rest of the program. When the student had completed the review testing, an instructor scored the answer sheet and provided knowledge of results and feedback. Feedback consisted of pointing out the specific cues in the picture and relating these to the correct turn path.

VDPT Test

A comprehensive test was constructed to determine the effectiveness of the program. The test items provided a representative cross-section of the original matrix photos. A pool of 71 slide photographs was assembled for the test tryout. The slides were arranged in order of difficulty and in turn sequence progressions. Photos showing grossly deviant differences were placed at the beginning of the test with increasingly difficult items following. Photos of the normal turn path were randomly interspersed with deviant path slides on a 1 to 9 ratio to correspond with the path ratio of the matrix.

The test station consisted of a display screen of the same proportions and angles used for the instructional sequence display and slide projectors remotely controlled by an advance-only control switch. The test display arrangement permitted the student to view slides of the final turn matrix in the same visual perspective and angles as those available in the instructional display and to control the rate of presentation of the test items. The sequence could not be reversed, however, so that the student received only one trial per test item. The test response sheet contained a three-by-three grid for each item, following the practice testing used in the instructional program.

Validation of VDPT Product and Test

Six students awaiting entrance in the UPT program at Williams AFB participated in the validation of the training materials. They had received no previous training in the T-37 overhead landing pattern and final turn maneuver. The students were given a brief textual introduction to the final turn maneuver covering procedures and flight parameters. They were then given the VDPT programmed materials and were asked to note any problems encountered with the instruction or questions not treated in the material. The students completed the program and returned the following day to receive the test. Following the instruction and testing, each student was debriefed on the exercise and asked to suggest ways in which the program might be improved.

Five experienced instructor pilots also participated in the materials validation. The above procedure was repeated for each of the five instructor pilots except that they were queried at length following training and testing regarding the methods and content of the instruction.

An item analysis was completed using test scores from both student and instructor pilot tryout groups. Items were scored as being completely correct, partially correct (either altitude or lateral deviation correct), or incorrect. Discrimination and difficulty item analysis procedures modified from Attneave (1950) were applied. As a result of this analysis, eight items were found unacceptable and deleted, making a total of 63 items in the final version of the test.

As a result of the tryout, a number of revisions were made in the instructional program. Changes included textual revision in wording, spelling, and minor sequence changes. The rate of presentation of levels of discrimination between flightpath progressions was found to be more detailed and slower paced than desirable. Accordingly, the pace of the instruction was increased by omitting selected deviation flightpaths contained in the matrix which were judged superfluous for training of discriminations.

IV. EXPERIMENTAL PROCEDURES

The purpose of this phase of the study was to test the effectiveness of the VDPT product as a facilitator of flying skill acquisition for the final turn of the landing pattern as flown in simulated and real-time environments.

Subjects

Thirty-eight male students from Class 77-08 at Williams AFB participated as subjects in an experiment to determine the effectiveness of the pretraining. These students had completed an average of 19 flying hours in the T-41 trainer prior to arriving for UPT at Williams AFB, and all but three were graduates from the Air Force Academy. At the time of the study, they had completed all of UPT Phase I academics (aircraft systems) and had received an average of 5 hours of T-4 simulator instruction. They had also received an average of seven T-37 rides but had received no training in the aircraft relative to the overhead landing pattern or final turn maneuver. Prior to the VDPT, all subjects received a self-paced orientation to the landing pattern via a programmed text and achievement test. The material treated pattern segments, flight parameters and procedures (see Smith, Waters, & Edwards, 1975). All subjects received passing scores of 85 percent or better on the landing pattern program achievement test.

VDPT Transfer Dependent Measures

The effectiveness of the cognitive (VDPT) pretraining was measured in the Advanced Simulator for Pilot Training (ASPT) and in the T-37 aircraft. The objective of these measures was to determine whether the VDPT would enhance the acquisition of perceptual-motor skills required to fly the final turn.

A maneuver trial scenario was developed for the ASPT training in which the student pilot was given an opportunity to execute final turns under controlled conditions and with the aid of an instructor pilot. A description of this scenario is contained in Appendix C.

To assess student acquisition of flying skills for the final turn in the T-37 aircraft, an instructor rating system was used as part of the regular flightline landing pattern training phase, (ATC syllabus P-V4A-A, July 1975). This phase corresponds to the B1701-U4 Basic Sequence in the T-37 syllabus. Each instructor pilot used a knee pad type card to score the first 10 final turn trials flown by each student/subject in the aircraft. Each trial was to be scored by the instructor pilot immediately after the maneuver had been executed. Instructor pilots received orientation and instructions on rating form procedures during two training sessions conducted shortly before the beginning of landing pattern training for the class. Score cards for all training rides were collected from instructor pilots following all training flights.

Assignment of Subjects to Experimental Groups

Subjects were randomly assigned to one or five treatment groups as shown in Table 1.

TABLE 1		
Treatment Group Assignment		
<u>Group</u>	<u>N</u>	<u>Treatment Description</u>
1	7	Control (No pretraining)
2	7	Procedures only (no VDPT)
3	8	VDPT
4	8	ASPT training only
5	8	VDPT and ASPT

Group 1 (control) received no pretraining, group 2 received cognitive pretraining on procedures and parameters relative to the final turn and thus served as a second control group (to isolate the specific effects of VDPT as opposed to cognitive procedural training on the maneuver), group 3 received the VDPT, group 4 received no VDPT but received ASPT training for the final turn, and group 5 received both VDPT and ASPT training. All groups were tested in the T-37 aircraft using the rating system of instructor pilots already described.

Administration of Instructional Materials (VDPT)

VDPT was administered to subjects as a scheduled part of flightline training. Subjects from groups receiving pre-training (2, 3, and 5) were scheduled as flightline conditions permitted. Each student was brought to the training room and given an orientation booklet which explained the basic information about the final turn (parameters, procedures, and rules). Subjects were also shown a brief video tape which elaborated the T-37 landing pattern. After receiving the textual and video taped material, the subjects received the VDPT program (groups 3 and 5). Group 2 received a form of the program which was shortened to include pictorial information about the normal turn sequence only. No material showing differences between flightpaths was included. In order to control for the difference in the presentation time between the two versions of the pretraining, group 2 subjects were shown additional video tapes of the normal landing pattern which presented repeated segments of information about traffic pattern procedures. Average completion times for groups receiving the VDPT training materials is shown in Table 2.

TABLE 2					
Mean Pretraining/Testing Completion Times					
<u>Group</u>	<u>N</u>	<u>Pretraining</u>		<u>Test</u>	<u>Range</u>
		<u>hrs</u>	<u>min</u>		
2	7	1	32	32.3 min	21-52
3	8	1	54	29.6 min	20-37
5	8	1	52	29.4 min	17-42

The VDPT data phase was scheduled to coincide as closely as possible with the start date of the B1701 flightline phase of the T-37 syllabus (landing pattern training). Flightline scheduling precluded the possibility of controlling syllabus phases to tolerances of less than 3 days due to normal operational contingencies. As it turned out, the requirement to accomplish pretraining for all subjects prior to B1701 did not pose a problem. No cases were reported in which a student received a pattern ride before receiving the VDPT. However, minimizing the time delay between VDPT and the first pattern ride for every student did present an experimental control problem. Some students received the first pattern ride in as little as 2 days after pretraining while some were delayed for up to 8 days.

When scheduling problems surfaced, a precautionary measure was taken to attempt to control for the effects of the time lapse. The two groups (3 and 5) who had received the VDPT were given a brief refresher exercise on the VDPT just prior to their first pattern rides; that is, within 1 day of the time they were to start pattern training. The exercise was a randomly abbreviated (30-item) version of the VDPT test, which was administered at the flightline using the same equipment setup as that used for the original testing.

V. RESULTS

VDPT Transfer to ASPT

Table 3 shows the results of the VDPT Phase of this study as indicated by scores for each of the groups on the VDPT test. Both VDPT groups 3 and 5 scored significantly higher (mean 80.7 and 81.78, respectively) ($p < .01$) than did group 2 (procedures training only), as would be expected from the design of the training materials.

TABLE 3 Visual Discrimination Pretraining (VDPT) Recognition Test for Final Turn				
<u>Group</u>	<u>N</u>	<u>Mean</u>	<u>S.D.</u>	<u>Outcome</u>
2 Procedures Only	7	73.52	7.31	
3 VDPT	8	80.7	3.15	$t = -3.50^*$
5 VDPT/ASPT	8	81.78	3.76	$t = -3.03^*$
* $p < .01$				

Following the completion of VDPT, group 4 (ASPT only) and group 5 (VDPT/ASPT) were subjected to a sequence of final turn performance trials in ASPT. The purpose of this phase was to determine the transfer effects of VDPT upon execution of the final turn in the simulator. Each student was placed in the left seat of the ASPT T-37 cockpit. The instructor pilot was in the right seat. Full motion and visual features of ASPT were used during the exercises (Bell, 1974). Each student was given two flights of .8 hour each in ASPT following a detailed scenario (see Appendix C). Briefly, the student was given a short orientation to the final turn maneuver and the basic procedures used in its execution and was then given

three trials without prompting by the instructor pilot. The purpose of the three initial no-prompt trials was to assess any effects of the pretraining from the VDPT phase. Next the student was shown a model demonstration of the final turn maneuver as preprogrammed in the simulator. The student flew several turns with limited prompting given by the instructor pilot. Overall, each student flew 12 trials per day for a total of 24 trials during the two ASPT rides. Training prompts given to students during the trials were carefully controlled. Since the ASPT trials were intended as a test for the transfer of skills from the VDPT phase, instructions to the student were kept to a minimum. Instructors were allowed to give a subject no more than four cues or prompts per trial as monitored and tabulated by the experimenter. The number of prompts given to students in both groups was compared. T-test results verified the number of prompts was not significantly different between groups.

As shown in the ASPT final turn trials scenario (Appendix C), the first three trials were accomplished by the student without aid from the instructor pilot, this was done in order to assess any direct effects of the pretraining upon the final turn task as performed in the simulator. As the student performed each trial, deviations from a mathematically defined flightpath in terms of altitude, bank angle, and airspeed were recorded on the automated performance measurement (APM) system. Comparisons of group means for the first three trials for the flight parameters are shown in Table 4. The lack of statistically significant differences for all three parameters suggests the VDPT did not facilitate initial performance of the turn maneuver in the simulator.

TABLE 4			
Automated Performance Measurement (APM) for Final Turn			
RMS Error (First Three Trials in ASPT)			
<u>Parameter</u>	<u>Group</u>	<u>Mean</u>	<u>T-Value</u>
Altitude	Pretrained	192.7	-1.36*
	Non-Pretr.	159.6	
Bank	Pretrained	12.42	.02*
	Non-Pretr.	12.46	
Airspeed	Pretrained	7.78	.05*
	Non-Pretr.	7.03	
* Non-significant difference, two tailed t-tests			

To assess transfer effects across the complete ASPT trials sequence, RMS error score data were analyzed. The 24 trials flown by each student (12 trials per sortie) were grouped into three-trial groups making a total of eight groups for each parameter condition. Two by eight repeated measures ANOVAs (Winer, 1971) for RMS mean scores of altitude, bank angle, and airspeed are contained in Tables 5, 6, and 7, respectively. Error comparisons for bank angle and airspeed showed no significant differences. However, the between-group comparison of ($F = 3.85$) altitude error was significant ($p < .05$) in favor of the pretrained group.

TABLE 5				
RMS Error Altitude During Final Turn in ASPT				
ANOVA Summary				
<u>Source</u>	<u>ss</u>	<u>df</u>	<u>ms</u>	<u>F</u>
Treatment	42205.	15	2813.66	
Between	6311.40	1	6311.40	3.85***
Within Gp4*	13187.0	7	1883.86	1.148
Within Gp5**	22706.6	7	3243.8	1.976
Error	183804.9	112	1641.44	
Total	226009.9	127		
* Non-pretrained				
** Pretrained				
*** $p < .05$				

TABLE 6				
RMS Error Bank Angle Final Turn in ASPT				
ANOVA Summary				
<u>Source</u>	<u>ss</u>	<u>df</u>	<u>ms</u>	<u>F</u>
Treatment	143.80	15	9.59	
Between Grp	27.78	1	27.78	3.42
Within Grp 4*	61.49	7	8.78	1.08
Within Grp 5**	54.53	7	7.79	.96
Error	909.84	112	8.12	
Total	1053.64	127		
* Non-pretrained				
** Pretrained				

TABLE 7				
RMS Error Airspeed		Final Turn in ASPT		
ANOVA Summary				
<u>Source</u>	<u>ss</u>	<u>df</u>	<u>ms</u>	<u>14</u>
Treatment	80.62	15	5.37	
Between Grp	4.38	1	4.38	1.04
Within Grp 1*	39.04	7	5.58	1.33
Within Grp 2**	37.20	7	5.31	1.26
Error	471.26	112	4.21	
Total	551.88	127		
* Non-pretrained				
** Pretrained				

Group mean data for deviations from correct final approach path (as modeled by the system) were analyzed as an additional indicator of final turn aircraft positioning. On the third trial of each three-trial grouping of final turns, the student was permitted to extend the flightpath through the final approach. Data (eight trials per student) were analyzed to ascertain final approach groundpath position, course, and airspeed. The eight-trial mean score for each student was combined for each of the groups to derive the group means which are compared in Table 8. Table 8 presents these results, and as can be seen, no statistically significant effects of the pretraining were observed.

TABLE 8			
RMS Error for Indicated Parameters in Final Turn ASPT (Eight Trials)			
<u>Parameter</u>	<u>Group</u>	<u>Mean</u>	<u>Outcome</u>
Final Appr	Pretrained	1.44	t=1.0*
Ground Path	Non-Pretr	1.69	
Final Appr	Pretrained	105.0	
Course	Non-Pretr	96.9	t=.33*
Final Appr	Pretrained	7.4	
Airspeed	Non-Pretr	6.09	t=.60*
* Non-significant, two tailed t-test			

In addition to the automated simulator data comparisons, instructor pilot subjective rating data were analyzed for the ASPT trials phase. One of two instructor pilots rated the performance of each student on several critical aspects of the final turn maneuver: adherence to correct groundpath, correct starting position (ground track and altitude), and correct altitude and airspeed during first half and second half of the turn. The instructor pilot judged whether or not the student's performance was satisfactory or unsatisfactory for these performance parameters across all ASPT trials. Chi square test summaries for instructor pilot ratings are shown for ground track (Table 9), turn initiation accuracy (Table 10), altitude (Table 11), and airspeed (Table 12) for the starting point of the turn. No significant differences were found except for airspeed. Instructor pilot rated pretrained students significantly better ($p < .05$) than non-pretrained students in terms of attaining proper airspeed at the start of the final turn.

TABLE 9			
Ground Track Position at Start of Final Turn in ASPT (IP Rating)			
Group	Sat	Unsat	Total
3	E = 173.5	E = 18.5	192
	O = 175	O = 17	
4	E = 173.5	E = 18.5	192
	O = 172	O = 20	
Total	347	37	384
$\chi^2 = .27, (p < .70)$			

TABLE 10			
Turn Initiation Accuracy in ASPT (IP Rating)			
Group	Sat	Unsat	Total
3	E = 149.5	E = 42.5	192
	O = 145	O = 47	
4	E = 149.5	E = 42.5	192
	O = 154	O = 38	
Total	299	85	384
$\chi^2 = .22 (p < .70)$			

TABLE 11			
Altitude at Start of Final Turn in ASPT (IP Rating)			
Group	Sat	Unsat	Total
3	E = 119	E = 79.5	192
	O = 118	O = 74	
4	E = 119	E = 79.5	192
	O = 112	O = 80	
Total	230	159	384
$\chi^2 = .73 \quad (p < .50)$			

TABLE 12			
Airspeed at Start of Final Turn in ASPT (IP Rating)			
Group	Sat	Unsat	Total
3	E = 134	E = 59	192
	O = 143	O = 49	
4	E = 134	E = 59	192
	O = 125	O = 67	
Total	268	118	384
$\chi^2 = 3.98 \quad (p < .05)$			

Tables 13, 14, and 15 show chi square test summary tables for instructor pilot ratings on ground track adherence, altitude, and airspeed during the first half of the final turn. No statistically significant differences between the two groups were observed from these data.

Tables 16, 17, and 18 show chi square test summary tables for instructor pilot ratings on ground track adherence, altitude, and airspeed during the second half of the final turn. A significant difference ($p < .05$) indicated that the non-pretrained group attained correct groundpath more frequently than the pretrained group during the second half of the turn. Rating comparisons for altitude and airspeed for the second half were not found to be significantly different.

Summarizing, there were no important statistically reliable differences in ASPT performance between the pretrained (group 5) subjects and those who had not been pretrained (group 4). On one measure, attainment of correct airspeed at the start of the turn, group 5 was rated better than group 4. However, group 4 was rated better than group 5 in acquiring the correct groundpath during the final half of the turn.

TABLE 13			
Ground Track First Half Turn in ASPT (IP Rating)			
Group	Sat	Unsat	Total
3	E = 158.5 O = 156	E = 33.5 O = 36	192
4	E = 158.5 O = 161	E = 33.5 O = 31	192
Total	317	67	384
$\chi^2 = .452$ (p < .70)			

TABLE 14			
Altitude First Half Turn in ASPT (IP Rating)			
Group	Sat	Unsat	Total
3	E = 109.5 O = 113	E = 84.5 O = 79	192
4	E = 109.5 O = 106	E = 84.5 O = 86	192
Total	219	169	384
$\chi^2 = .609$ (p < .50)			

TABLE 15			
Airspeed First Half Turn in ASPT (IP Rating)			
Group	Sat	Unsat	Total
3	E = 133.5 O = 128	E = 58.5 O = 64	192
4	E = 133.5 O = 139	E = 58.5 O = 53	192
Total	267	117	384
$\chi^2 = .498$ ($p < .50$)			

TABLE 16			
Ground Track Second Half Turn in ASPT (IP Rating)			
Group	Sat	Unsat	Total
3	E = 86.5 O = 77	E = 105.5 O = 115	192
4	E = 86.5 O = 96	E = 105.5 O = 96	192
Total	173	211	384
$\chi^2 = 4.65$ ($p < .05$)			

TABLE 17			
Altitude Second Half Turn in ASPT (IP Rating)			
Group	Sat	Unsat	Total
3	E = 84	E = 108	192
	O = 82	O = 110	
4	E = 84	E = 108	192
	O = 86	O = 106	
Total	168	216	384
$\chi^2 = .17$ ($p < .70$)			

TABLE 18			
Airspeed Second Half Turn in ASPT (IP Rating)			
Group	Sat	Unsat	Total
3	E = 101.5	E = 90.5	192
	O = 100	O = 92	
4	E = 101.5	E = 90.5	192
	O = 103	O = 89	
Total	203	181	384
$\chi^2 = .094$ ($p < .80$)			

Transfer of VDPT to Aircraft Training

Flightline instructor pilots rated student performance for the students from all five groups on selected critical elements of the final turn as a means of assessing the effects of pretraining upon student performance in the T-37. Performance was rated by instructor pilots as either satisfactory or unsatisfactory for specific task elements during the first 10 final turn trials in the aircraft. Appendix D contains a copy of the rating sheet used by instructor pilots. The five elements rated for each trial were: (a) altitude at start of turn, (b) ground track at start of turn, (c) ground track during turn, (d) altitude during turn, and (e) airspeed during turn.

The rating data for each element were analyzed across groups using chi square tests. Significant differences in group ratings were observed for the first three elements as shown in Tables 19, 20, and 21. Non-significant differences in ratings were found for performance elements four and five as reported in Tables 22 and 23. Post hoc chi squares tests were then used to determine significant between-group comparisons for each of the first three elements. Comparisons observed as statistically significant are contained at the bottom of Table 19, 20, and 21.

The obtained chi square (12.63) for overall group ratings for altitude at start of turn was significant at the .05 level with significantly better performance ratings, as revealed in post hoc chi square tests, for the following groups comparisons: group 1 (control) over group 3 (VDPT), $p < .005$; group 4 (ASPT) over group 3 (VDPT), $p < .05$; and group 5 (VDPT/ASPT) over group 3 (VDPT), $p < .01$.

In addition to the performance element ratings, the instructor pilots also judged their students' performance overall for each of the 10 final turn trials. The general rating for turn performance was based on a 9-point scale from unsatisfactory to excellent. A Kruskal-Wallis test (Siegel, 1956) was used to compare differences in group ratings. As summarized in Table 24, this test revealed no reliable differences in ratings between the groups.

To summarize transfer to aircraft data outcomes, it can be seen that VDPT did not aid student performance. While instructor pilot ratings for overall performance of the maneuver showed no differences across groups, three of the five specific performance elements analyses resulted in reliable differences. In all three of these comparisons, the VDPT group performance rating was inferior. Thus, there is some evidence of a negative transfer of pretraining effect. This does not hold for every comparison involving group 3, since non-significant differences were found for a number of such comparisons. More importantly, there were no inter-group comparisons where VDPT group performance was rated superior to another group, showing that the VDPT of itself did not produce the expected training benefits. Further, there are no data to show that either the ASPT training or the combination VDPT/ASPT training aided student performance. That is, there are no comparisons to show that either of these groups performed elements of the turn better than the control group. Groups 4 and 5 were rated significantly better than the VDPT group on both the altitude and ground track at start of turn. In the case of group 5 (VDPT/ASPT), this may suggest that for these performance elements the ASPT training combined with the VDPT may have aided in overcoming the possibly deleterious effects of the VDPT.

VI. DISCUSSION

The results of this study do not demonstrate a clear benefit from the VDPT. Although inconsistent across all dependent measures, there is some evidence of a negative transfer of training effect. Since the results contrast with those obtained in other related investigations of cognitive pretraining as well as with a considerable body of theoretical data, some speculative considerations seem to be in order.

In this study an attempt was made to train the students to acquire and retain visual discriminations relevant to the flightpath of the final turn. Subsequently, they were required to recall and apply the visual skills while executing the turn maneuver in the simulator and/or the aircraft. The assumptions were that the

TABLE 19			
Performance Rating by IP for Aircraft Training			
(Altitude at Start of Turn)			
Group	Sat	UnSat	Total
1	E=36.8 1.41 O=44	E=33.16 1.55 O=26	70
2	E=36.8 .213 O=34	E=33.16 .243 O=36	70
3	E=42.11 3.48 O=30	E=37.89 3.87 O=50	80
4	E=42.11 .085 O=44	E=37.89 .094 O=36	80
5	E=42.11 .824 O=48	E=37.89 .916 O=32	80
Total	188	192	380
$\chi^2_4 = 12.00$ ($p < .05$)			

<u>Intergroup Comparison</u>	<u>χ^2</u>	<u>p</u>	<u>Superior Group</u>
1 - 3	9.59	.005	1
3 - 4	4.92	.05	4
3 - 5	8.1	.01	5

TABLE 20					
Performance Rating by IP for Aircraft Training					
(Ground Track at Start of Turn)					
Group	Sat		UnSat		Total
	E=34.63		E=35.37		
1	.328	O=38	.321	O=32	70
	E=34.63		E=35.37		
2	2.02	O=43.	1.98	O=27	70
	E=39.58		E=40.42		
3	5.37	O=25	5.26	O=55	80
	E=39.58		E=40.42		
4	.008	O=39	.008	O=41	80
	E=39.58		E=40.42		
5	.296	O=43	.289	O=37	80
Total	188		192		380
$\chi^2_4 = 15.85 \text{ (p} < .01)$					

Intergroup Comparison	χ^2	p	Superior Group
1 - 3	8.06	.01	1
2 - 3	13.72	.001	2
3 - 4	3.88	.05	4
3 - 5	8.28	.005	5

TABLE 21 Performance Rating by IP for Aircraft Training (Final Turn Ground Track)			
Group	Sat	Unsat	Total
1	E = 30.76 2.21 O = 39	E = 39.24 1.73 O = 31	70
2	E = 30.76 1.08 O = 25	E = 39.24 .85 O = 45	70
3	E = 35.16 1.08 O = 29	E = 44.84 .85 O = 51	80
4	E = 35.16 .97 O = 41	E = 44.84 .76 O = 39	80
5	E = 35.16 .13 O = 33	E = 44.84 .10 O = 47	80
Total	167	213	380
$\chi^2_4 = 9.76$ ($p < .05$)			

<u>Intergroup Comparison</u>	<u>χ^2</u>	<u>p</u>	<u>Superior Group</u>
1 - 2	5.64	.05	1
1 - 3	5.72	.05	1

TABLE 22 Performance Rating by IP for Aircraft Training (Final Turn Altitude)			
Group	Sat	Unsat	Total
1	E = 27.26 1.208 0.33	E = 42.74 .77 0 =37	70
2	E = 27.26 .02 0=28	E = 42.74 .013 0 =42	70
3	E = 31.16 2.137 0 =23	E = 48.84 1.36 0=57	80
4	E = 31.16 .150 0 =29	E = 48.84 .096 0=51	80
5	E = 31.16 .473 0 =35	E = 48.84 .301 0=45	80
Total	148	232	380
$\chi^2 = 6.528$ ($p < .20$)			

TABLE 23 Performance Rating by IP for Aircraft Training (Final Turn Airspeed)			
Group	Sat	Unsat	Total
1	E = 33.89 .0004 O= 34	E = 35.55 .006 O= 36	70
2	E = 33.89 1.10 O= 40	E = 35.55 .866 O= 30	70
3	E = 38.4 .002 O= 39	E = 41.26 .002 O= 41	80
4	E = 38.74 .546 O= 31	E = 41.26 .038 O= 49	80
5	E = 38.74 .041 O= 40	E = 41.26 .038 O= 40	80
Total	184	196	380
$\chi^2 = 4.05$ ($p < .50$)			

TABLE 24				
Overall Performance Rating				
by IP for Final Turn Trials in Aircraft				
Group 1 <u>Control</u>	Group 2 <u>Procedures Only</u>	Group 3 <u>VDPT</u>	Group 4 <u>ASPT</u>	Group 5 <u>VDPT/ASPT</u>
17	19	24	14	32.5
12	8	36	2	9
34.5	10	5	30	21
3.5		3.5	15.5	19
37	22.5	1	25	22.5
19	13	15.5	6.5	11
26.5	32.5	6.5	28	34.5
	38	30	30	26.5
$R^1=154.5$	$R^2=161.5$	$R^3=125.5$	$R^4=156.5$	$R^5=182$
$H=1.88 \quad (p < .75)$				

student/subject would be able to (a) learn to discriminate proper from improper flightpaths through visual representations, (b) retain and recall visual discriminations, and (c) apply visual skills during execution of the final turn maneuver. Only the first of these assumptions was supported by the data. VDPT subjects attained significantly higher proficiency scores on a visual discrimination test than did control group subjects.

Timing and Scope of VDPT in Landing Pattern Training

Administration of VDPT occurred at a very early point in training, well before students reached proficiency in basic aircraft control skills. The notion that minimal experience is a necessary condition for effective transfer seems supported by the outcomes of the present study. The intent of the VDPT, of course, was to aid the students in acquiring landing skills. But, adding to the prescribed UPT training a detailed elaboration of visual cues for the final turn appeared to hinder performance in some respects, rather than help. This outcome may suggest that novice pilots are not aided by contact cue training at this point because they are primarily oriented to instrument references. Training up to the landing pattern phase, including T-4 trainer rides, is instrument oriented. Instructor pilots commonly note that the novice flies with "his head in the cockpit." This being the case, even if outside references are rehearsed ahead of time, students may not be able to use them effectively. Attention may be predominantly on cockpit cues, leaving insufficient time to reference ground cues. If students do recognize the external cues, this alone may not guarantee that they can integrate the cues effectively with control inputs and cause the aircraft to respond appropriately.

In order to develop this integration, an extended period of visual discrimination training might be more effective than a single "dose" of pretraining. A distributed schedule of visual training integrated with landing maneuver sorties over a period of time might provide time for the student to associate visual references with required aircraft control inputs. In such an integrated visual training scenario, the transfer effects might be measured over the entire landing training sequence or substantial part thereof. The scope of training might also be expanded to include a larger portion of the more critical task elements such as the downwind and final approach, as well as the final turn.

The statistical reliability of data results in the present study is compromised by an extraneous variable of flightline training conducted at an auxiliary landing field (Headpin) for members of Class 77-08 participating in the study. This problem was unknown during the planning phase and did not surface until data collection had begun. The problem introduced by Headpin training was in the difference in ground references and type of landing patterns taught, which differed from those at Williams AFB proper. Headpin landing training involved substantial numbers of right-hand patterns as opposed to the standard left-hand pattern upon which the VDPT program was based. In effect then, the occurrence of Headpin training can be construed as a change in the final turn task, as well as a change in the conditions (landing field) under which the task was performed. The number of landings flown at Headpin by students assigned to the various treatment groups was unknown and was not available from flightline records. Although it was apparent from anecdotal evidence that Headpin training during the data collection period (first 10 pattern trials per student) was considerable, it could not be assumed that the incidence of Headpin training was equally distributed across groups. Since these effects cannot be directly assessed, reliable inferences from the transfer of training to the aircraft phase of the present study cannot be made.

VII. RECOMMENDATIONS

The results of the present study appear useful in a formative sense. What has been learned from the present study when combined with findings from related pretraining studies is useful in determining refinements in visual discriminating pretraining as a flying training technique.

Several recommendations for studies in visual pretraining appear in order. Levels of independent variables implicit in visual skill pretraining should be investigated under conditions in which the potential transfer of the training is not compromised by the lack of enabling flying skills. For example, rather than pretraining novice pilots in detailed visual cues of the landing pattern, a better test of the transfer of visual discrimination pretraining might be to train pilots who have mastered basic aircraft control skills in the visual elements of a totally new and unfamiliar flying task. In the latter instance, the lack of aircraft control skill would not be expected to interfere with the application of visual pretraining to the new task.

Future investigations of visual pretraining should be conducted under closely controlled conditions. Dependent measures of transfer should be restricted to performance measures in a simulated environment in lieu of more reliable methods of obtaining flightline performance estimates.

Visual pretraining should be developed and evaluated for those tasks which combine potentially high training dollar savings with demanding visual skill components. Air-to-ground and air-to-air tactical flying skills appear to be such an area.

Visual cue enhancement techniques through simulator visual systems or through other inexpensive media alternatives as augmentations to simulator visual systems should be included in future development of visual pretraining.

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APPENDIX A: PROCEDURES FOR PHOTOGRAPHIC DEVELOPMENT

WIDELUX F-7 Camera Data

The 35mm WIDELUX F-7 camera used in this project provides a 140° field of view, the same as that of human sight, without distortion. The camera has a 26mm rare earth LUX, f2.8 lens, fixed focus; 140° brilliant optical viewfinder; self-cocking, all-metal focal plane shutters; speeds of 1/15, 1/25, and 1/250 second. The WIDELUX F-7 does not have an extreme wide-angle lens. Instead, the camera uses a special lens of 26mm (1") focal length. To optically cover the 24 by 59 mm frame size, the lens actually travels across the film plane during exposure in an arc. At the same time, the narrow vertical slit of the all-metal focal plane shutter is moving across the film at the identical speed.

The film plane is curved to duplicate the travel arc of the lens.

The amount of light reaching the film is governed by the setting of the shutter speed and f-stop dials. The light passing through the lens and reaching the film is the same across the entire picture frame, edge to edge.

The WIDELUX F-7 system gives correct exposure over the entire film frame, edge to edge, with no distortion. The entire photographic image (picture subject) is of normal proportions, yet with a field coverage of 140°

Mounting Equipment

The camera was mounted on a fixed-platform attached to an adjustable single support which allowed the camera to be adjusted vertically to correspond to the pilot's focal point (eye point). To prevent horizontal and fore/aft movement of the camera assembly, two adjustable cables were attached from the platform (to which the camera was attached) to the aircraft instrument panel. In this manner, the pilot taking the photos could level the camera and stabilize it during flight, so that all photos were taken from the same position.

Photographic Procedures

Photos were taken inflight from the left seat of the T-37 aircraft using an F-7 (35mm) still camera with a 140° field of view. Successive photo sorties were flown as closely as possible to the same time each day so as to minimize the shadowing effects of the sun. Wind conditions were also considered, since strong winds could vary the ground track, as well as the visual perspective between the runway and the aircraft. Consistency of ground track was a major consideration in assembling the necessary series of slides. Photos were taken in the following sequence (Figure A1 shows Williams AFB Traffic Pattern).

1. Abeam the 3/4-mile point ("perch").
2. One-fourth of the way around the final turn.
3. Halfway around the final turn.
4. Three-fourths of the way around the final turn.
5. Rollout point (3/4-mile from the approach end of the runway).

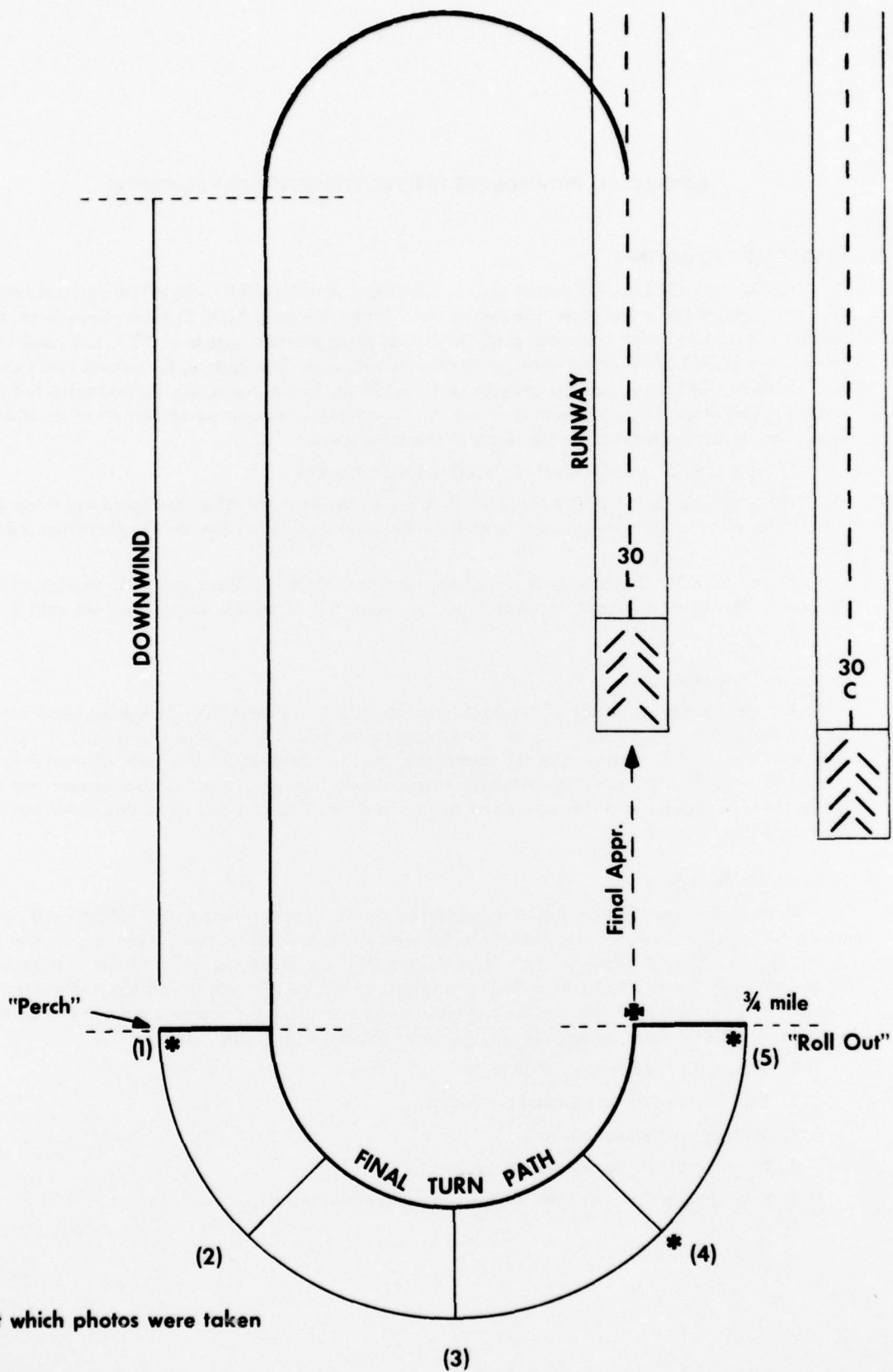
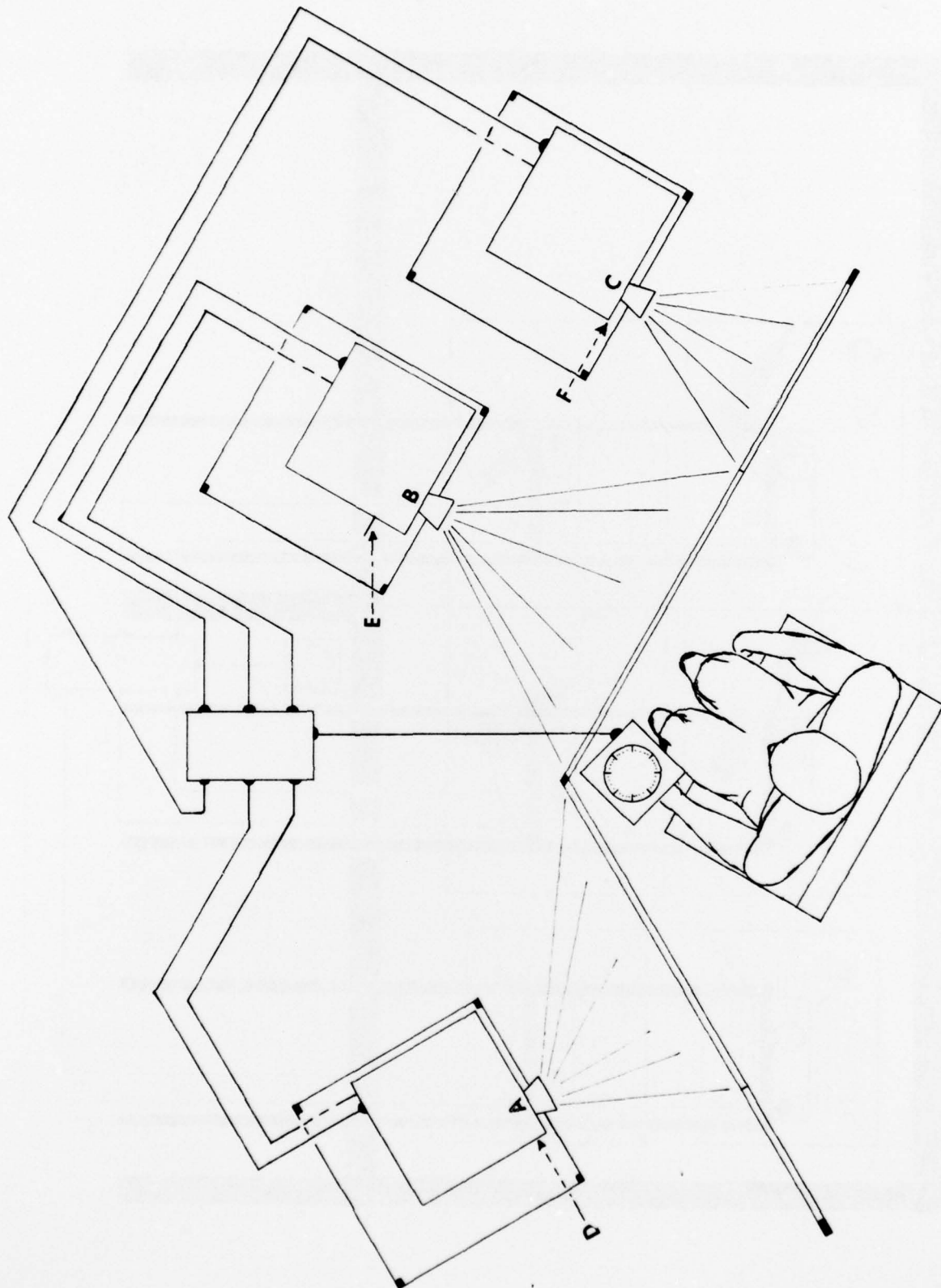


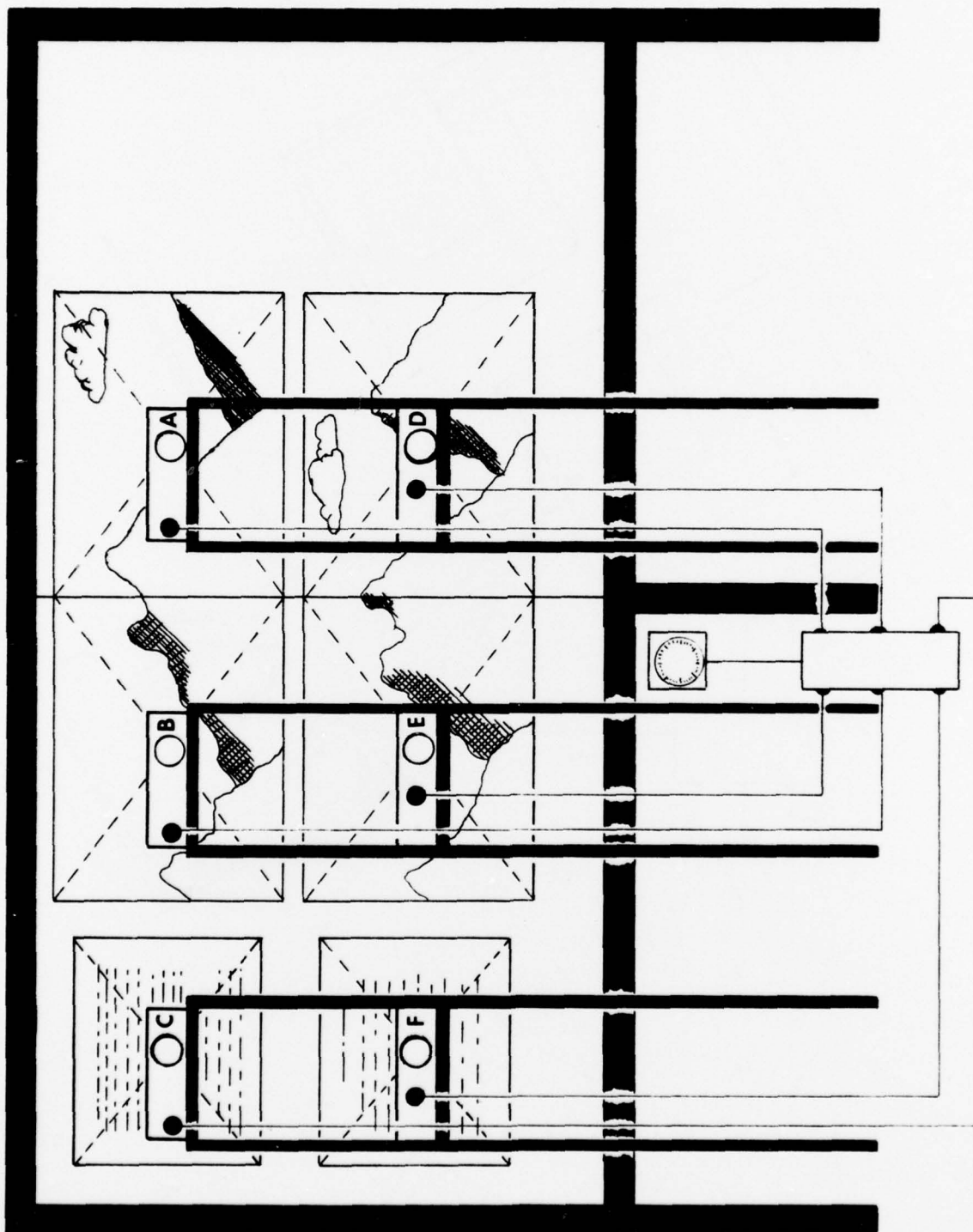
Figure A1. Williams AFB traffic pattern (left normal only).

APPENDIX B: VISUAL DISPLAY SYSTEM



TOP ELEVATION

REAR ELEVATION



APPENDIX C: VDPT MISSION SCENARIOS IN THE ASPT

Mission 1 (50 minutes)

1. Warmup (5 minutes):
 - a. Straight and level (2 minutes)
 - b. Configuration change (speedbrake, gear, flaps) and descending turns (landing configuration at 110 knots indicated airspeed) (3 minutes)
2. Final turn from mid-downwind:
Three repetitions using Automated Performance Measurement (APM); no instruction.
3. Final turn demonstration from mid-downwind.
4. Final turn from mid-downwind.
Nine repetitions (APM); instruction as needed, using selected cues (see Table C1).

Mission 2 (50 minutes)

1. Final turn from mid-downwind
One repetition (APM); no instruction
2. Final turn demonstration from mid-downwind
3. Final turn from mid-downwind
Eleven repetitions (APM); instruction as needed, using selected cues (see Table C1).

Table C1. Instructional Cues Tabulation Sheet

	STUDENT TRIALS											
PITCH CUES:	1	2	3	4	5	6	7	8	9	10	11	12
Lower the Nose												
Lower the Nose 5°												
Raise the Nose												
BANK CUES:	1	2	3	4	5	6	7	8	9	10	11	12
Turn (Right/Left)												
Roll into 25°-30° of bank												
Increase your bank												
Decrease your bank												
POWER CUES:	1	2	3	4	5	6	7	8	9	10	11	12
Add Power												
Reduce Power												
Set your Power at 70%												
Set your Power at 80%												
CONFIGURATION CUES:	1	2	3	4	5	6	7	8	9	10	11	12
Lower the Flaps												
Lower the Speedbrake												
Lower the Gear												
Trim												

(Console operators check the cues used under the appropriate pattern.)

APPENDIX D: INSTRUCTORS RATING SHEET

STUDENT	INSTRUCTOR			DATE	MISSION	WINDS
PERCH:						
GROUND TRACK/ RUNWAY DISPLACEMENT	TIGHT	ON	WIDE			
	1st 2nd					
AIRSPEED	LOW	ON (115-125)	WIDE			
	1st 2nd					
ALTITUDE	LOW	ON (2450-2550)	HIGH			
	1st 2nd					
POINT OF INITIATION	EARLY	ON (ABEAM 3/4 MILE REF)	LATE			
	1st 2nd					
Final Turn:						
GROUND TRACK	UNDERSHOOT	ON	OVERSHOOT			
	1st 2nd					
AIRSPEED	LOW	ON (105-115)	HIGH			
	1st 2nd					
ALTITUDE	LOW	ON	HIGH			
	1st 2nd					
OVERALL RATING (APPROACH PATTERN)	U	F	G	E		
	1	2	3	4	5	6
				7	8	9