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ABSTRACT

The document presents a summary description of the Air Force Human Resource Laboratory's Flying Training Division (AFHRL/FT) research capabilities for undergraduate pilot training. One of the research devices investigated is the Advanced Simulator for Undergraduate Pilot Training (ASUPT). The equipment includes the ASUPT, the instrumented T-37 aircraft, the T-4G and T-40 trainers, and the formation flight trainer. Methodological considerations and the development of a research program are discussed. Instructional procedures and practices are described for three phases which will be used in establishing a technological base: equipment familiarization and operator performance measures for the T-40 study, ASUPT, and instrumented aircraft. One area of suggested research is visual display which will include investigation of visual cues, the use of a visual model as a research tool, and four studies on the content of visual display. Another area for suggested study is motion cue research which will attempt to determine the necessary axes of cockpit motion for training simulation. A third area of suggested research focuses on training methods in the areas of cognitive pretraining, feedback, sequencing of training tasks, contextual training, and individualized training. A list of reference is included. A list of AFHRL/FT research programs for 1975 is appended. (EC)

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HUMAN RESOURCES

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AFHRL/FT CAPABILITIES IN UNDERGRADUATE PILOT TRAINING SIMULATION RESEARCH: EXECUTIVE SUMMARY

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This technical report has been reviewed and is approved.

WILLIAM V. HAGIN, Technical Director
Flying Training Division

Approved for publication.

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This report presents an executive summary of a contractual effort by Life Sciences, Inc. It describes: (1) the research capabilities of AFHRL/FT, with particular emphasis upon the advanced simulator for undergraduate pilot training (ASUPT), (2) results of a prioritization of potential flying research issues by a panel of experts, (3) contractor recommendations for intitial AFHRL/FT experimental investigations, and (4) the AFHRL/FT facility utilization program for calendar year 1975.

The concept of "performance equivalence" between simulator and aircraft is presented along with a description of suggested studies designed to validate the concept. Utilization of automated performance measures on both system outputs and pilot control inputs forms an essential element of the model.

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PREFACE

This report was completed under Project 1123, USAF Flying Training Development; Task 112303, The Exploitation of Simulation in Flying Training; Work Unit 11230307, Handbook of Research Designs for Advanced Simulation in Undergraduate Pilot Training. Dr. William V. Hagin was project scientist and Dr. Thomas H. Gray was contract monitor.

AFHRL-TR-75-26(I) is based upon work done by Life Sciences, Incorporated (LSI) under USAF Contract F41609-73-C-0038 and documented in LSI Technical Report 74-2, "Training Research Program and Plans. Advanced Simulation in Undergraduate Pilot Training," (Matheny, 1974). The LSI report (AFHRL-TR-75-26(II)) was based upon work done *before* the Advanced Simulator for Undergraduate Pilot Training (ASUPT) was fully developed and was published shortly before ASUPT was formally accepted. AFHRL-TR-75-26(I) not only provides an executive summary for the LSI report, but also adds reality to what has been conceptual planning; Appendix A specifies the issues which will be investigated this year *and* depicts AFHRL/FT facility programming during the first calendar year of ASUPT operation.

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I. INTRODUCTION AND APPROACH

The mission of the Air Force Human Resource Laboratory's Flying Training Division (AFHRL/FT) is to "improve flying training" through the development and evaluation of innovative training methods and devices. A sophisticated facility housing a number of unique pilot training research devices has been developed at Williams Air Force Base, Arizona to accomplish this mission. Of these devices, the Advanced Simulator for Undergraduate Pilot Training (ASUPT) has the greatest potential for the investigation and resolution of flying training issues.

ASUPT has been designed to be a state-of-the-art research device with every advanced capability that flight simulator technology can provide. visual and motion cueing and advanced training features. It will be systematically used in research studies to validate the contribution of alternate hardware configuration and training methodology combinations to pilot training. Emphasis will be focused upon undergraduate pilot training (UPT), but generalizability to other pilot training programs is also considered highly important.

The exceptional capabilities of ASUPT and the broad spectrum of possible research tasks, coupled with heavy workload and an acute shortage of in-house manpower, justified a decision to contract for identification of the simulator design and training research problems considered most important on cost/benefit criteria and delineation of the AFHRL/FT efforts appropriate for efficient utilization of facility resources. In addition, methodological outlines of first priority studies were required.

There were three phases in the contractual work effort: (1) development of a list of priority research issues, (2) assessment of the research facility capability, and (3) recommendation of the initial investigations to be performed.

II. PRIORITY RESEARCH ISSUES

The inventory of priority research issues was developed in two steps. In step one, a list of research issues was generated by canvassing a "panel" of selected individuals recognized as experts in the field of pilot training and related research. AFHRL-TR-75-26(II), Appendix A lists their names and current organizational affiliation and provides a copy of the letter of instruction sent to each. Each of the twelve panel members submitted a list of issues believed to be most important for pilot training research. Their inputs, combined with data from the contractor's literature review, produced an initial listing of fifty-five possible research issues.

In step two, the research issues were clarified, consolidated and returned as an unordered list to each expert. The panel members were asked to rank the issues according to judged importance using a modified pair comparisons technique. AFHRL-TR-75-26(II), Appendix B lists the research issues evaluated and AFHRL-TR-75-26(II), Appendix C is a facsimile of the rater instructions. Ten of the twelve panel members responded with rankings of the research issues. AFHRL-TR-75-26(II), Appendix D depicts the full list of prioritized issues.

The top and bottom priority issues, abstracted from AFHRL-TR-75-26(II), Appendix D, are presented in Table 1 and Table 2, respectively.

III. CAPABILITIES OF THE AFHRL/FT RESEARCH FACILITY

The research equipment at AFHRL/FT (fully described in Hagin and Smith, 1974) are briefly summarized.

The Advanced Simulator for Undergraduate Pilot Training (ASUPT)

ASUPT is a two-cockpit, full-motion simulator with a wide-angle computer image generated (CIG) visual system. Motion cues are provided by a six-degree-of freedom synergistic motion platform and a

Table 1. Rankings of Top Priority Research Issues
(10 Raters)

Ranking	Item	Median Rank	Q
1	Content of the Visual Display	6.0	10.75
2	Motion-Vision Interaction	11.0	11.50
3	Quality of the Visual Display	12.5	19.75
4	Performance Measurement—System Output Measures	12.5	12.75
5	Sequencing of Training Tasks	14.0	11.00
6	Contribution of the Individual or Combined Degrees of Freedom of Platform	14.0	11.75
7	Instructor Training—Performance Evaluation	14.5	11.00
8	Cognitive Pre-Training	15.0	9.75
9	Contextual Training	22.0	9.00
10	Adaptive Training	25.5	10.75

Table 2. Rankings of Lowest Priority Research Issues
(10 Raters)

Ranking	Item	Median Rank	Q
46	Instructional Aids—Maneuver Demonstration	35.0	15.50
47	Extension of the Training Syllabus	35.0	14.75
48	Contribution of the Gravity Alignment Cue to Training	35.0	16.25
49	Disorientation Training	35.5	11.25
50	Feedback—Time Delay	36.0	10.00
51	Trainee Motivation	36.5	20.50
52	Performance Measurement—Observer Opinion Data	38.0	8.00
53	Determination of the Importance of the Auditory Spectra as a Means of Adding Realism to the Training Situation	40.0	5.50
54	Determination of the Importance of the Auditory Spectra as Interference or Noise	44.0	10.75
55	Aircraft Dynamics Simulation	45.0	18.75

The semi-interquartile range values (Q) reflect genuine differences of opinion among raters on the relative importance of the issues.

G-seat. The 7-faceted display provides a representation of the visual scene similar to that seen from the T-37 aircraft. ASUPT also has a number of advanced instructional features designed to increase its training effectiveness, including selective malfunction insertion, simulator freeze and rapid re-initialization; automated demonstration; self-confrontation, and a number of methods of providing student feedback.

Instrumented T-37 Aircraft

An instrumented T-37 aircraft is an important resource for obtaining basic data on pilot aircraft control behavior. It is essential to testing the concept of performance equivalence (Section IV) because it permits investigation of the relationship between pilot aircraft control and aircraft system response.

The T-4G Trainer

A T-4 instrument trainer on a two-degree-of-freedom-motion platform with an electronic perspective transformation (EPT) limited field-of-view visual system provides a high-quality scene of the approach, landing and take-off sequence.

The Formation Flight Trainer (FFT)

The formation flight trainer is a fixed-base, part-task trainer which provides some of the essential visual cues for teaching basic formation flight skills. The cockpit has a stick, throttle, rudder pedals, and simple instrument displays. The FFT simulates the rudimentary flight dynamics of the T-38 or T-37 aircraft. A spherical screen provides a 200-degree horizontal and 90-degree vertical field-of-view.

The T-40 Trainer

The T-40 is an instrument and procedures trainer on a two-degree-of-freedom motion system. It has a side-by-side seating cockpit with instrument panel configuration similar to that found in the T-39 aircraft.

Other Equipment and Devices within HRL/FT

(1) The automatic data acquisition and control system (ADACS) can be used with the T-4G, T-40 and FFT to record and process experimental data on up to 29 measurement parameters. (2) A helmet-mounted, eye-movement recorder can be used in aircraft or simulators to provide data on field of view and stimulus information used by the pilot (AFHRL-TR-75-26(II), Appendix F). (3) An audio-visual instructional facility includes a video laboratory for the production of instructional presentations, a series of learning center carrels, and the audio-visual instrument training (AVIT) device developed by Life Sciences, Inc. AVIT presents visual and aural information with programmable branching in either mode. The student interacts with AVIT through simulated aircraft controls and multiple choice response keys (AFHRL-TR-75-26(II), Appendix G).

IV. METHODOLOGY AND RESEARCH PROGRAMMING

In applied studies, research methodologies and resource utilization are inexorably intertwined. Procedures that may work well in the laboratory may be operationally infeasible if the equipment or techniques required are too "delicate" or costly. This issue will be briefly addressed in the following section.

Methodological Considerations

The classical transfer of training paradigm is often used for research on training methods and training effectiveness. Results are expressed as transfer ratios (TRs), or when cost/benefit concern exists, as either transfer effectiveness ratios (TERs), or incremental transfer effectiveness ratios (ITERs) (Roscoe, 1974). The "running time" and subject requirements of these methods present real problems in an operational environment such as UPT. The primary problem lies in the flight and calendar time required for demonstrating skill transfer to the aircraft after device training. The flexibility of ASUPT and the number of experiments possible demanded a search for alternative, more efficient methods. Otherwise, the real dollar costs per study would be excessive and the total information output from the AFHRL/FT $30 million facility relatively low.

Requirement for Alternative to Classical Transfer Approaches. A large number of studies can be done using ASUPT as the criterion device *if* it could be shown that it is a valid representation of the T-37 aircraft. For operational trainers, this has been partially accomplished by implementing the mathematical model of the aircraft's flight dynamics as accurately as possible and partially by pilot evaluations during acceptance testing. For ASUPT to be used as a research criterion instrument, it is essential that it be more quantitatively validated as "T-37 equivalent."

Performance Equivalence. The procedure for establishing ASUPT as T-37 equivalent has been termed "performance equivalence" (Matheny, 1974). This concept hypothesizes that if pilot and system output measures are statistically equivalent when simulator and aircraft are flown to specified tolerances, the two devices—simulator and aircraft—are equivalent for training purposes. Equivalence is assumed to be established upon demonstration that system performance (i.e., man and machine) under one set of conditions is not different from system performance under a reference set of conditions.

If ASUPT's performance equivalence becomes established, it can be the criterion system both for many transfer of training experiments and for research which is impractical or inadvisable in the aircraft (e.g., situations which impose safety hazards or unusual stresses on the aircraft). Establishing the utility and validity of this technique for ASUPT investigations will also provide the groundwork for its use in the evaluation and calibration of other training simulators within the Air Force.

The generalizability of the findings on training methods and devices obtained in this manner might be questioned: it could be that results obtained using ASUPT as the criterion system are not valid for inferring transfer of training to the aircraft. If this were true, the results would also not be valid in other simulators and methods used effectively in one training aircraft would not be generalizable to another. Either contention is contrary to long standing practice in education and training: many training methods and techniques developed in one context have proved valid when used across a variety of training situations. Thus, training on simpler systems which transfers positively to the criterion ASUPT would be effective training for the aircraft, although no training method, procedure, or equipment can be "proved" effective until positive transfer to the aircraft has been demonstrated.

Research Program

The research program was developed from a conceptual model in conjunction with considerations of resource utilization and training evaluation.

Program Model. The two major elements in the suggested research program (Figure 1) are: (1) the development of procedures, methods, and measurement techniques as a technology base for ASUPT, and (2) exploratory experiments and validating experiments in the research phase. Development of a technological base is fundamental to research generalizable to other training research programs and future simulator procurement.

The research phase of the program is divided into two parts: investigations of training methodology, and investigations of simulator hardware requirements. Each of these areas is further divided into screening and validating phases. The exploratory, (or screening) phase will systematically reduce the number of variables and will be performed prior to formal experimentation. Results of exploratory experiments could form the basis for recommendations for improving training effectiveness without going through the formal experimental stage.

Training methodology and simulator hardware requirements are not mutually exclusive areas of research. Certain training methodologies require unique simulator characteristics. Conversely, certain simulator characteristics necessitate specific methodologies.

Research Program Considerations. There were two primary considerations used in the development of the model.

Resource Utilization Programming. For efficient resource utilization, research dealing with training methodologies and student progression should utilize the least complex and most inexpensive devices. For example, the use of the T-40 and T-4G simulators in the T-37 UPT program demonstrated the worth of such devices in determining the contribution of different training approaches (Woodruff & Smith, 1975; Woodruff et al., 1974). These inexpensive simulators can also be valuable in the investigation of system and operator output performance measurements.

Dimensions for evaluating training. A distinction is made between efficient training, economical training, and effective training. *Efficient* training brings the student to the immediate training goal in the shortest training time. In many situations, however, criteria other than time must be considered. Economic and human resources, noise abatement, and many other factors affect the evaluation of proposed training strategies. The decision maker must weigh these costs in terms of *economical* training apart from the time dimension used in assessing efficient training. If the skills acquired in attaining the immediate training goal can be applied in a larger training objective, the training is *effective*. For example, if the cues used in approach and landing can be taught more quickly using a highly abstract display, we have an efficient training technique. It will be an effective technique *only* to the extent that the skills acquired using that technique can be applied in the larger, more realistic situations; i.e., positive transfer takes place.

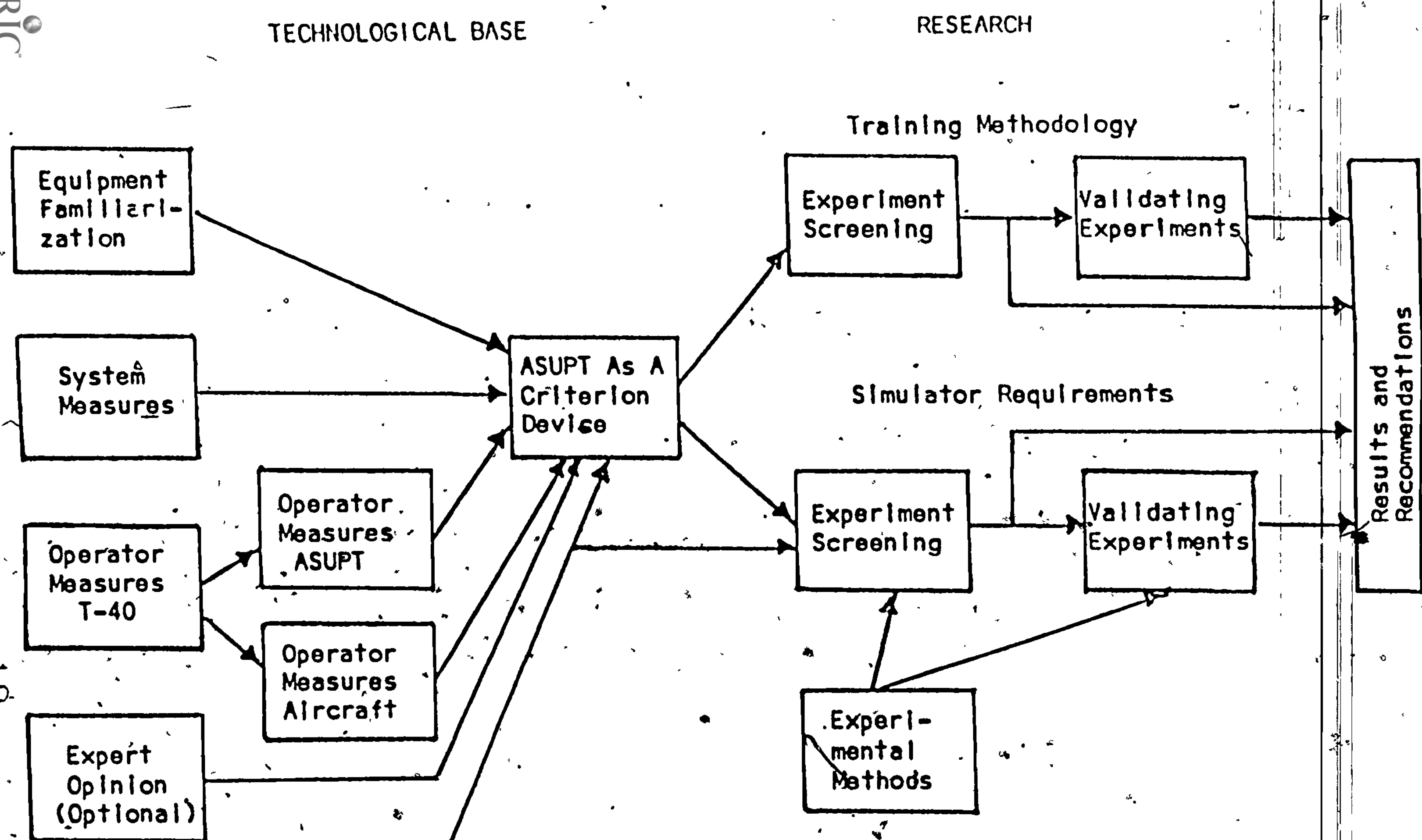

Figure 1. Major elements in a recommended training research plan.

V. ESTABLISHMENT OF A TECHNOLOGICAL BASE

Establishing a technological base involves the development and test of procedures, measurement techniques, and equipment operation necessarily antecedent to carrying out the research program. Although the technological base entails establishing ASUPT as the criterion device for the conduct of experiments, it may also provide data supporting simulator design recommendations.

Equipment Familiarization. During this phase, research personnel will gain familiarity with the equipment and establish operating procedures for ASUPT. Information obtained on the most economical way of changing from one equipment condition to another will save valuable resources in later research.

Small preliminary studies and investigations will collect data on the reliability of the equipment and identify idiosyncrasies within the system to aid planning future experiments. The type and frequency of calibration necessary to keep the equipment functioning at an acceptable level will be established during this phase. The determination of experimenter and the instructor functions at the ASUPT console and instructor stations is an important task to be accomplished during this phase. Since the two instructor/operator stations differ in terms of information available, the procedures and practices for providing instruction from each must be defined.

System Measures

A complex system such as an aircraft or simulator may be evaluated at two points, system outputs (e.g., heading, airspeed and altitude measures) and control inputs measuring control movement (e.g., throttle, stick and rudder). This model and the measurement points (MP) are shown symbolically in Figure 2.

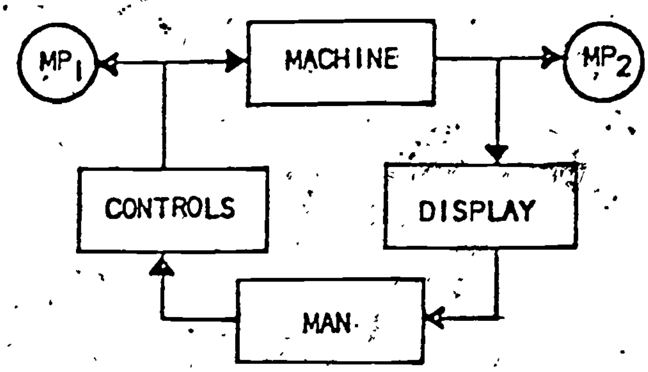

Figure 2. Performance measurement points (MP) in the man/machine system.

System output measures are referred to MP_2 in Figure 2 and reflect the performance of the total man-machine system. In the aircraft, MP_2 parameters are airspeed, heading, altitude, pitch or roll angle, etc. These measures must be developed and specified for each of the AFHRL/FT research devices (ASUPT, the instrumented airplane, the T-40 and T-4G trainers). The specification of these measures is important throughout all phases of experimentation, although their use varies between training methodology and simulator requirements research.

Valid, reliable measures have been developed for evaluating the precision of aircraft control in the simulator and aircraft. However, criteria against which performance may be measured remain to be established for the majority of piloting tasks. System output measures are being established by AFHRL/FT in-house and through contract efforts. The AFHRL/FT effort (Waag, 1974) emphasized that the major thrust in present performance measurement development will produce measures which reflect system output performance. The AFHRL/FT in-house work will also define the objectives for particular maneuvers or sequences of training tasks and develop criterion measures for those particular objectives. These measures will. (1) determine the degree to which the criterion objectives are met, (2) be useful to the student and the instructor pilot, and (3) be generated on a real-time basis to provide immediate feedback.

Operator performance measures define pilot inputs into the system and depict behavioral responses to stimuli. They are distinguished from system performance measures which are composed of pilot response plus the variability within the system he is controlling.

Simple system output measures are necessary, but insufficient, since the human operator can adapt his control behavior to produce the same system output. Thus, the simulator could reinforce control input behavior not positively transferable to the aircraft if the simulator system differs significantly from the aircraft system. Concern with the control input parameters reflects the desire to train in a simulator the skills required for precise control of the aircraft.

Measuring operator behavior at the control input point is fundamental to investigating the validity of the concept of performance equivalence. If the experienced pilot is to be a "calibrated" control element and is observed to determine under what conditions his control input behavior changes while system performance remains constant, a reliable description of pilot control behavior is necessary. This measure must be sensitive to changes in task conditions such as the dynamics of the system (e.g., changes in simulator motion parameters).

Previous work has shown that measures such as the power density spectrum, the breakpoint frequency of the transform of that spectrum and the percentage of power in selected portions of the spectrum are summary measures which reflect meaningful changes in operator behavior as functions of changes in the conditions of the task (Norman 1973; Matheny et al., 1974). The reliability of these summary measures and their inter-relationship needs to be established. An examination and analysis of pilot control output behavior across a range of conditions of system disturbances and of requirements for control (i.e., maneuvers or tasks) is needed. The behavior of the human controller in a complex closed-loop system is exhibited as a complex time varying output through the controls of the system. A simple, direct and preferably "on-line" summarization of this output is desired.

For experiments in which operator output measures are being examined, the pilot must control the system to a prescribed level of performance. System performance must be constant so that pilot input changes are reflected in changes in the operator's control output. If such changes do not result in changes in the experienced operator's control behavior, the conditions being studied are concluded to be behaviorally equivalent.

Technological Base Experimentation

The ASUPT, T-40 and T-4G simulators, and the instrumented T-37 aircraft are systems which have the capability for manipulation of system dynamics and can provide answers to practical questions regarding simulation requirments. The specific studies, outlined subsequently, are subject to modifications based upon hardware and software constraints and the results of prior experiments.

Operator Performance Measures. T-40 Study. Investigations using the T-40 simulator will examine procedures for summarizing time-varying operator output from the controls, for examining individual differences in pilot output measures, and for determining the stability of these measures. The conditions of the experiment are given in Table 3.

Table 3. Experimental Conditions for Investigating Performance Measures in the T-40 Trainer

	Variables		
Condition	Turbulence Level	Trainer Motion	Maneuvers
1	Low	On	St & Level
2	Moderate	On	St & Level
3	High	On	St & Level
4	Low	Off	St & Level
5	Moderate	Off	St & Level
6	High	Off	St & Level
7	Low	On	30° bank turn
8	Moderate	On	30° bank turn
9	High	On	30° bank turn
10	Low	Off	30° bank turn
11	Moderate	Off	30° bank turn
12	High	Off	30° bank turn

Five experienced instructor pilots will serve as subjects, trials are two minutes in duration. Subjects practice straight and level and 30° left bank maneuvers under each condition until they reach criterion performance on the system output measures of heading, altitude, airspeed, bank angle and pitch angle.

The order of trial conditions will be counterbalanced between subjects to reduce order effects. Subjects will repeat the trial the following day and again after one week.

The dependent measures are pilot control and system outputs after criterion performance has been reached. The pilot control input measures are derived from fore-and-aft and lateral movements of the stick, and movement of the throttle.

Dependent variable measures should reflect practice effects and stabilize after criterion performance is achieved. Proposed measures are stick force (mean and mean square value), stick Z score and throttle Z score (Waag et al., 1975); and, cross-over power (Norman, 1973).

The results of these analyses will be used to guide the development of operator performance records in ASUPT and the instrumented aircraft.

Operator Performance Measures. ASUPT. This ASUPT experiment will essentially repeat the T-40 study described above with "visual display" as an additional independent variable, final selection of conditions will be guided by results of the T-40 experiment. This experiment examines the question of the interaction between the motion and visual display in the simulator. For planning purposes, the variables and levels listed in Table 4 will be investigated.

Table 4. Experimental Conditions for Investigating Operator Performance Measures in ASUPT

Condition	Variables			
	Turbulence	Platform Motion	Visual Display	G—Seat
1	Low	On	On	Off
2	High	On	On	Off
3	Low	On	Off	Off
4	High	On	Off	Off
5	Low	Off	On	Off
6	High	Off	On	Off
7	Low	Off	Off	Off
8	High	Off	Off	Off
9	Low	On	On	On
10	High	On	On	On
11	Low	On	Off	On
12	High	On	Off	On
13	Low	Off	On	On
14	High	Off	On	On
15	Low	Off	Off	On
16	High	Off	Off	On

The experimental paradigm is the same as the T-40 experiment. Experienced pilots will practice each experimental condition to criterion at which time control outputs will be recorded over a two-minute trial.

The visual display for contact maneuvers will use a full field of view with a definitive horizon line with distinguishing features used as external referents for heading.

Operator Performance Measures: Instrumented Aircraft. Data collected in the instrumented aircraft provide the technological base against which performance in ASUPT will be compared. Hopefully, the comparability of the two devices will be established with respect to the closed-loop dynamic tracking behavior required of the pilot in controlling the systems.

Pilot performance will be recorded in the instrumented T-37 aircraft across representative maneuvers and conditions. Summary measures of the time varying control output will be obtained. Population parameters of mean and variance in performance outputs will be estimated.

The measures to be recorded in the aircraft are given in Table 5. Data collection conditions are shown in Table 6. This table must be interpreted in conjunction with the flight pattern and sequence for recording trials depicted in Figures 3 and 4

Table 5: Measures Recorded in the Instrumented T-37 Aircraft

Parameter	Range	Accuracy	Sample Rate/Sec
Elev Stick Force	0-30 lb	±.1 lb	20
Aileron Stick Force	0-20 lb	±.1 lb	20
Rudder Force	0-30 lb	±.1 lb	20
Elevator Position	16° +24°	.5°	20
Aileron Position	±15°	.5°	20
Rudder Position	±24°	.5°	20
Throttle Position	Full	.5°	
Low Altitude	0–5m′	±20′	20
High Altitude	0-25m	±50′	20
G's	-1G – +5G	±.1G	20
Heading	0–360°	±1°	20
Yaw Rate	+70°/Sec	±1°/Sec	20
Trim Tab Position	On – Off		20
Pitch Rate	+90°/Sec	±1°/Sec	20
Airspeed	0-300K	±1K	20
Roll Rate	±100°/Sec	±1°/Sec	20
Roll Angle	0-260°	±1°	20
Pitch Angle	0-360°	±1°	20
Right Eng RPM	0-110%	±1%	20
Time	-----	-----	20
Event Marker	Actuated by IP		20
Linear Accelerometers (3)	0±3g	.01g	20
Angular Accelerometers (3)	± 2 rad/sec	4°/sec²	20

Table 6. Sortie Conditions Per Pilot in Aircraft

Sortie	Trial Order*	A/S	Inst/Contact
1	A	200	Inst
2	B	200	Inst
3	A	100	Inst
4	B	100	Inst
5	A	200	Contact
6	B	200	Contact
7	A	100	Contact
8	B	100	Contact

*See Figure 4 for trial order.

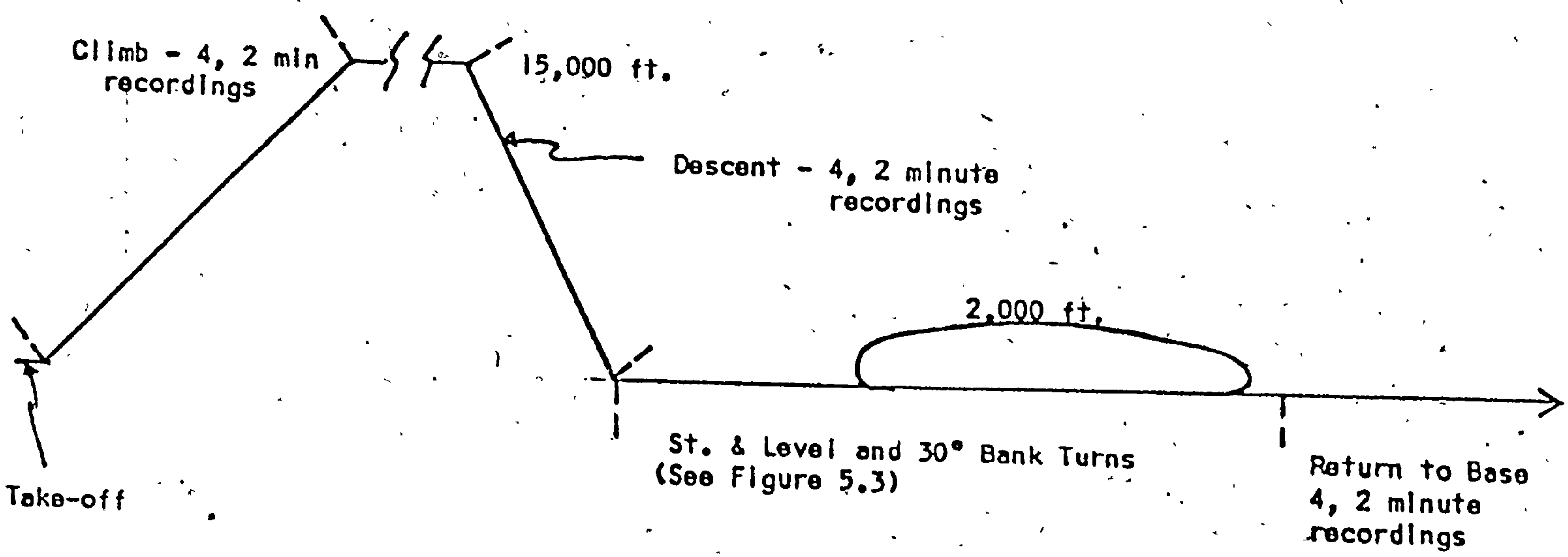

Figure 3. Flight profile for aircraft data collection.

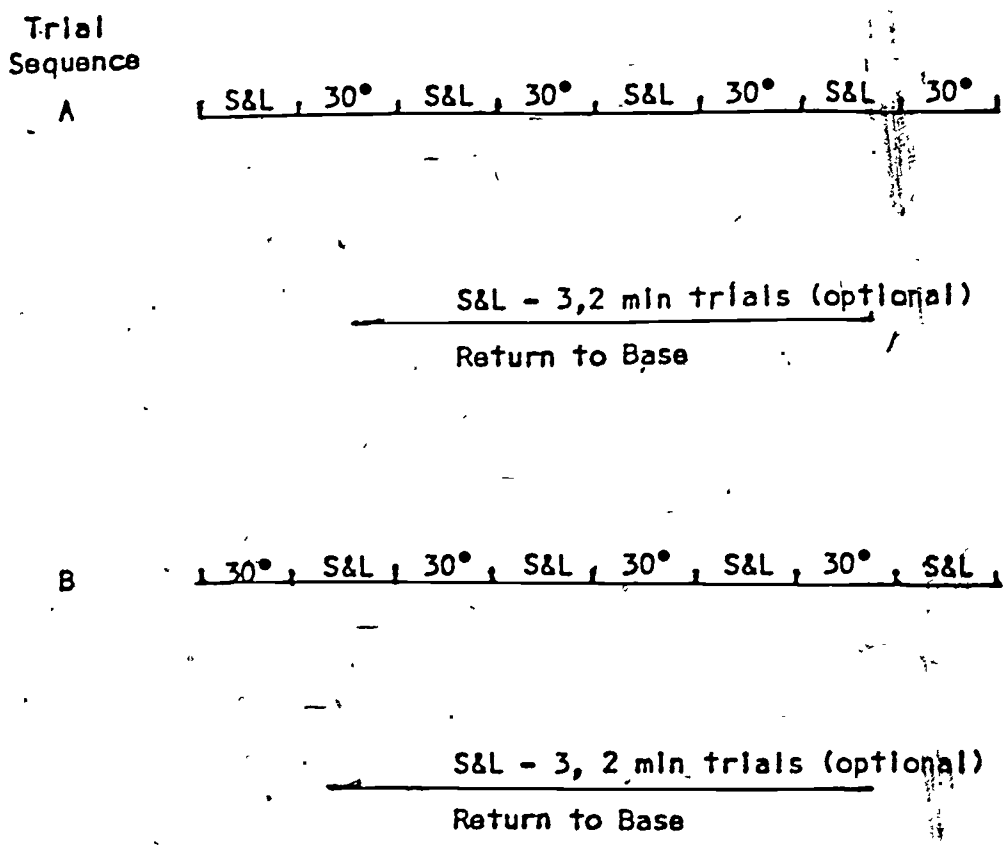

Figure 4. Order of trials for blocks of 2 sorties in Table 6.

Data from the instrumented T-37 will be collected on standard climb, straight and level, 30 degree bank and descent maneuvers. Maneuvers will be performed under instrument and contact flight conditions

In sortie one (AFHRL-TR-75-97(II), Appendix E), data will be collected cumulatively for alternating trials between straight and level flight and 30 degree bank turns. sortie two reverses the maneuver sequence for counterbalancing. Each pilot flies four instrument and four contact sorties. Five pilots will fly the aircraft sorties and repeat them in ASUPT.

After completion of the conditions, listed in Table 6, data will be collected on stalls and loops, during which the aircraft will be flown closer to the limits of its performance envelope. Each of the pilot-subjects will fly eight stalls and loops, maintaining as close tolerance to prescribed limits as possible, while the parameters, listed in Table 5, are recorded. It is estimated that this step will require two more sorties per pilot.

ASUPT–The Criterion Device

The development of system and operator performance measures are designed to provide objective data for trying to establish ASUPT as the criterion device. Validation of ASUPT as a criterion device not only would provide a means of increased ASUPT efficiency in UPT research, but also has major implications for future simulator validation procedures.

Projected Research

The following suggested research closely follows the list of top priority issues given in Table 1. The proposed research will address both simulator hardware requirements and training methodology.

VI. VISUAL DISPLAY RESEARCH

As shown in Table 1, the definition of visual display content for contact flight training received the highest median rating by the panel of experts. The importance of the outside world scene in the simulator is underscored by data collected by Brown & Rust (1975). The traffic pattern was found to be the most critical element of flight instruction, and the most difficult to teach and learn. Unfortunately, evidence on the specific features of the visual world which should be displayed in the simulator has not been published. Primary emphasis in ASUPT has been placed upon the content of the visual display and its effect upon training tasks and maneuvers under varying conditions of simulator motion.

Definitive research dealing with visual or motion cueing must, of course, consider the interaction between these cueing mechanisms; however, preliminary studies on motion and vision alone can be undertaken with one of the two variables held constant. Though the basis of emphasis in a given study may be motion or vision, this approach does not imply a neglect or unawareness of possible interaction effects.

Visual Research Objectives

The overall objective of research in simulator visual displays is to identify essential visual cues which allow the pilot to control the attitude of his aircraft and to position it properly in three dimensional space. It is possible that the visual display for the naive pilot trainee should be composed of only features which enhance his control of the aircraft about its axes and the axes of three dimensional space. Later, he must learn to extract from the real world scene those objects which enhance his control and navigational functions. He must learn to discriminate these referents when they are obscured by visual "noise." (Visual noise denotes conditions which obscure the referents the pilot uses as cues. Atmospheric attenuation, smoke, haze or any condition which causes an object to have low definition consitutes such noise. To the extent that this noise degrades pilot discrimination of changes between the referents which he uses to control his aircraft, precision of control is degraded). The identification and discrimination of changes between objects are hypothesized to be functions of the level of detail of the object and background contrast. These factors are controllable as experimental variables in ASUPT and may be varied systematically by the number of lines used to define an object and the shades of gray used to provide contrast or between objects and background (figure-ground contrast).

A Visual Model as a Tool for Research

The visual model described in Thielges and Matheny (1971) served as a basis for generating hypotheses The model assumes that external referents in the real world and internal referents associated with the vehicle being controlled can be projected using perspective geometry upon a picture-plane perpendicular to the pilot's line-of-regard. The relationship between the internal and external referents provides information with respect to the aircraft's departures from desired positions in six axes of motion. It is hypothesized that different positions of referents on the picture-plane will differentially affect the pilot's ability to discriminate changes in aircraft position. For example, an external and internal referent picked near the vertical mid-line and on the horizon of the picture plane will not allow the pilot to discriminate as fine a change in bank position as if those referents were picked farther out on the horizon. Referents selected near the horizon do not allow as fine a discrimination of forward translation as do referents chosen closer to the aircraft on the earth's surface; i.e., downward from the horizon line on the picture plane.

The model assumes that it is necessary for the pilot to select internal and external referents in order to make discriminations of changes in the attitude and position of his aircraft in space. The model defines the pilot's learning process as the identification of the most appropriate external and internal referents for exercising closed-loop control. It investigates how the pilot extracts these cues from the appropriate referents in the real-world scene; and, how he filters out "noise" in the real world scene.

The model deals with five dimensions of aircraft control: (1) Pitch control alone requires only an identifiable reference object directly ahead of the aircraft on the vertical mid-line as near to the horizon as possible. For each maneuver, the optimum placement of the reference object relative to the ground or sky plane is maneuver specific. For straight and level flight, a pitch reference point ahead of the aircraft at the horizon line, or the horizon line alone, provides a reference against which the pilot judges pitch attitude. For a nose down attitude during approach to landing, a reference object lower on the ground plane is hypothesized to be preferable. (2) For bank control, objects displaced laterally from the longitudinal center line of the aircraft provide greater positional displacement per unit of bank, the farther they are from center line. An object placed on the horizon at the vertical mid-line exhibits little perceptible movement to the pilot per unit of bank. The same object placed 30 degrees from the vertical mid-line provides greater displacement per unit of bank and allows greater control precision. (3) For heading control, objects on the horizon in the forward viewing area which the pilot can relate to an internal referent provide equal displacement on the display per unit of heading change. For pilot ease of scan, the object should be directly foward on the vertical mid-line at the horizon. (4) For the detection of longitudinal motion of the aircraft, the pilot uses objects directly in front of the aircraft which appear to move toward it. Objects directly below the aircraft have the greatest perceived displacement while those directly foward and on the horizon have the least per unit of longitudinal movement. To maximize the pilot's detection of forward motion, objects nearly beneath the aircraft provide the greatest information for control. (5) Control of lateral displacement parallels that of longitudinal. For discrimination of displacement along the vertical axis, the pilot must discriminate changes in the size of objects by recognizing changes in the relative distance between one edge of an object and another or the change in distance between objects.

These visual cues allow the pilot to control the attitude of the aircraft about its three axes and to discriminate position changes in three dimensional space. The pilot must discriminate and identify objects which allow him to direct the aircraft purposefully from point to point in the fulfillment of some objective or mission.

Methodology

Two novel aspects to the methodology are proposed for investigating visual issues in simulation: (1) the use of eye-movement recordings, and (2) the utilization of "performance equivalence."

Eye-Movement Recordings. Eye-movement recordings will identify the external and internal referents used by the pilot in the performance of UPT maneuvers. The identification of these referents will define the major visual variables to be investigated in ASUPT. Eye-movement records provide data for identifying environmental factors which inject noise into the visual scene. The objects in the visual display which cue the pilot to exercise aircraft control can be quite abstract; but it may increase the value of the display if terrain features are recognizable. Eye-movement recordings of experienced pilots flying UPT maneuvers provide the method for obtaining information about the objects and features in the real world scene used by the pilot. A program for collecting and analyzing eye-movement data is given in AFHRL-TR-75-26(II), Appendix F.

Performance Equivalence in Visual Scene Investigations. The performance equivalence approach uses an experienced pilot to standardize input conditions. The effort will be made to define a visual display which is equivalent to the real world scene in terms of performance by systematically modifying the visual scene in ASUPT. If the simulator system and operator performance are statistically the same as in the aircraft, the two systems will be assumed equivalent.

Establishing a set of visual content conditions which provide equivalent performance (system and operator) for a specific task in the aircraft is of primary concern. The visual display configuration could then be taken as the criterion visual system for future experiments.

For training issues, an investigation of the relationship between visual display content and student progress will be made systematically using the performance equivalent visual system as a baseline. For example, in training the student to discriminate the visual cues for flare and landing, hypotheses regarding the optimum CRT resolution (number and pattern of lines displayed) for training may be tested. Instructional cues foreign to the real world scene also can be added to demonstrate the most relevant cues for the task (Payne, 1954).

Proposed Experimental Investigations

Four studies on content of the visual display are shown in Figure 5. They comprise. (1) establishment of ASUPT as criterion system, (2) determination of transfer from that system to the aircraft, and (3) evaluation of the performance equivalence approach, while obtaining information relevant to *two* different configurations of the visual display.

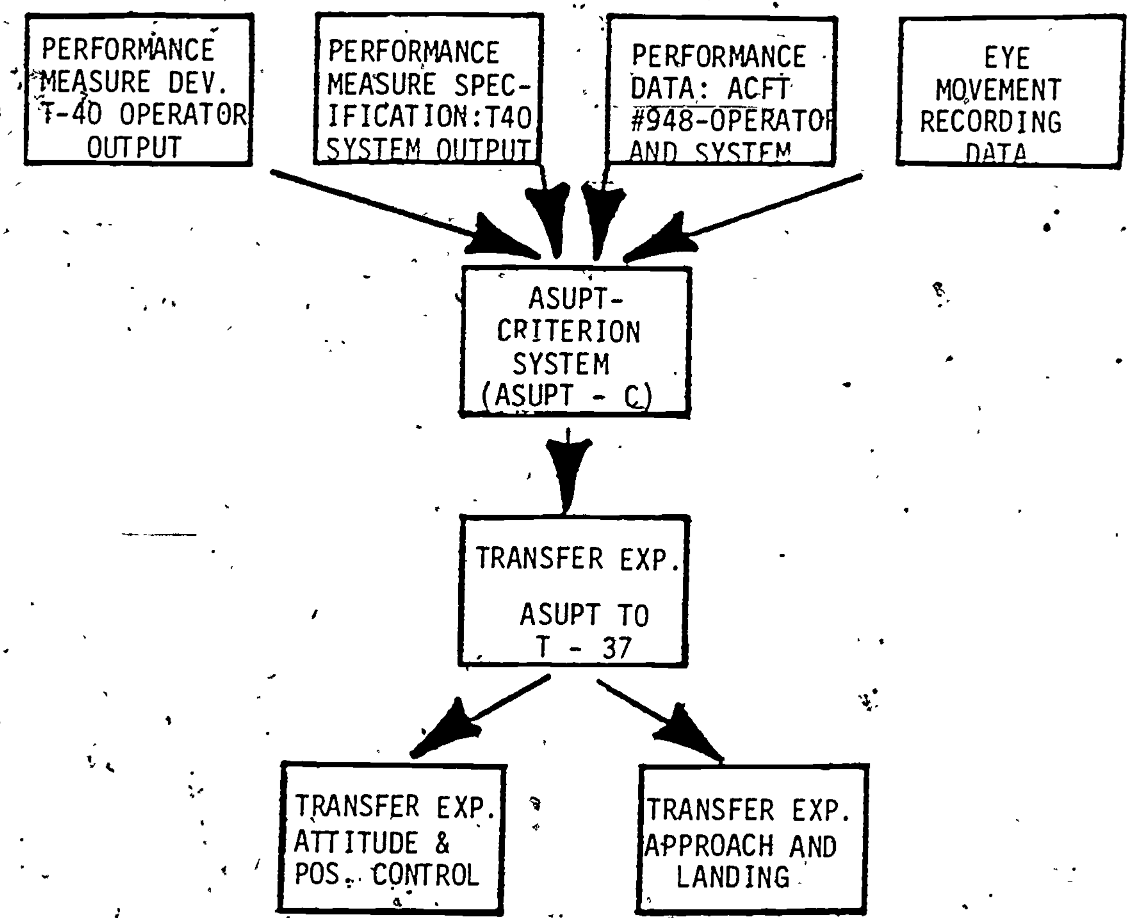

Figure 5. Proposed visual display studies and antecedent investigations.

Two criteria can be used in establishing the ASUPT criterion visual system; first, equivalent performance by experienced pilots both in terms of system and operator output, and second, consensus of subjective opinion from experienced pilots that the visual scene in ASUPT is acceptable as an adequate cueing stimulus to the real world scene.

Major variables important to the investigation of the ASUPT visual display are. (1) number of objects in the display, (2) position of the objects in the display, and (3) "stylization" or amount of detail per object. The number and placement of objects tested will be defined after analysis of the eye-movement data, although early hypothesis formulation may result from the visual model previously discussed.

Visual Study 1. Using the NAC Eye Mark Recorder adapted to an HGU-26P flight helmet, a Singer portable camera, and a Singer portable video tape recorder, experienced pilots will fly contact and instrument maneuvers from the T-37 syllabus. This procedure will provide an accurate, objective record of the pilot's eye movements as he performs actual UPT flying tasks. This process will be duplicated in ASUPT using the same pilot subjects. If the recorded eye movements show essentially the same scan pattern, frequency and duration of focus in the T-37 and ASUPT, ASUPT will be supported as a criterion system.

Visual Study 2. This study will employ the classical transfer of training paradigm discussed by Gagne, Foster and Crowley (1948). A small number (approximately 8) of UPT students will be trained in the T-37 syllabus contact maneuvers using ASUPT as the criterion system. When these students reach proficiency, they will advance to the flight line for T-37 aircraft training. Their progress will be monitored and the average number of hours of flying instruction required to pass their contact check ride will be recorded. This will be compared to the average number of flying hours for control group students to determine the training transfer achieved through the use of the simulator.

Visual Studies 3 and 4. These experiments deal with the content of the visual display and are divided into two categories. (1) determination of content necessary for control of the attitude and position of the aircraft, and (2) definition of cues required for the identification and use of environmental features. Results will be generalizable to the specification of displays for both simple and complex aircraft simulators.

The third and fourth studies allow the determination of features of the environment which enable the pilot to change the aircraft's position in a purposeful way. The two major UPT tasks in this category are (1) traffic pattern, approach and landing, and (2) formation flying. The traffic pattern, including approach and landing, has been researched more extensively than formation flying, but recent work at AFHRL/FT using the formation flight training (FFT) has provided data directly applicable to the specification of formation trainers.

The variables and levels for studying visual cues essential for attitude and position control are given in Table 7.

Table 7. Visual Display Experimental Conditions–Attitude and Position Control

	Display Features		
Dimension of Control	Condition 1	Condition 2	Condition 3
Pitch	Criterion ASUPT ystem	Horizon line	To be determined through equivalence tests
Bank		Horizon line	
Heading		Vertical line sub tending 1° visual angle placed each 45° in azimuth on horizon line	
Longitudinal		Grid pattern ground plane	
Lateral		Grid pattern ground plane	
Vertical		Grid pattern ground plane	

NOTE: 1. Grid line spacing to be determined in pretest.

2. Figure-ground contrast to be determined through pretest to provide positive differentiation of figure from ground.

3. All encoding in Conditions 2 and 3 must be experimentally determined in equivalence pretesting to insure non-equivalence for Condition 2 and equivalence for Condition 3.

The ASUPT visual display capability allows the presentation of the relevant referents for the touchdown phase of landing. Satisfactory study of this flight phase has not been possible prior to ASUPT. The variables and encoding suggestions for the approach and landing study are given in Table 8.

Table 8. Visual Display Experimental Conditions—Approach and Landing

	Display Features		
Dimension of Control	**Condition 1**	**Condition 2**	**Condition 3**
Pitch	Criterion ASUPT system	Horizon line	To be determined through equivalence tests
Bank		Horizon line	
Heading		Vertical line subtending 1° visual angle placed each 45° in azimuth on horizon line	
Longitudinal		Grid pattern, runway outline cross stripes each 100 yards	
Lateral		Grid pattern, runway edges and runway centerline	
Vertical		Grid pattern, runway edges and cross stripes	

NOTE:
1. Cross stripe spacing may be modified after pretest.
2. Figure-ground contrast to be determined through pretest to provide positive differentiation of figure from ground.
3. Encoding in Condition 2 and 3 must be experimentally determined in equivalence pretesting to insure non-equivalence for Condition 2 and equivalence for Condition 3.

The essential features listed under Conditions 2 and 3 in Tables 7 and 8 can be defined more accurately after the eye-movement records and the full visual capability of ASUPT have been analyzed.

Studies 3 and 4 will test the performance equivalence approach for simulator development. They will assess the training transfer to the aircraft of smaller FOV visual systems. The measures of number, position and stylization of objects will be varied so that. (1) a condition not equivalent to the criterion ASUPT is obtained, and (2) a condition equivalent to the criterion ASUPT system is obtained. Classical transfer of training experiments will be conducted to determine whether equivalent systems yield a greater amount of transfer than non-equivalent systems.

The design format for Studies 3 and 4 is shown in Table 9.

Table 9. Design Format for Visual Display

Condition 1	Condition 2	Condition 3
ASUPT criterion system	Non-equivalence to ASUPT criterion system established using experienced pilots.	Equivalence to ASUPT criterion system established using experienced pilots
Data from Study 2 Figure 5	Students trained to criterion in non-equivalent system and transferred to T-37 aircraft.	Students trained to criterion in equivalent system and transferred to T-37 aircraft

VII. MOTION CUE RESEARCH

Determining the necessary axes of cockpit motion for training simulators was listed sixth on the priority list of training issues. Experimental manipulation of motion, G-seat and gravity alignment cueing is particularly easy using ASUPT.

As pointed out by Smith (1972), it is not feasible to investigate all of the possible permutations of the six axes of motion, gravity alignment and G-seat configurations that could be used. Screening of these variables by pretest experimentation or "common sense" is necessary. The combinations of experimental conditions to be studied may use either classical transfer methods or be approached through the performance equivalence method. (In the discussion to follow, the performance equivalence method is assumed.)

The Effective Time Constant Model

The Effective Time Constant (t_e) Model (Matheny, 1969; Matheny & Norman, 1968) provides a basis for understanding the vision/motion interaction effects as well as to formulate hypotheses to be tested. In brief, the model assumes that the precision of closed-loop error-nulling behavior is a function of the immediacy of feedback to the controlling operator (e.g., the pilot). The time used for feedback to occur has been termed the Effective Time Constant of the man/machine system. The value of t_e depends upon the modalities through which the information is received and the threshold level of those modalities.

According to the model, information about the aircraft, particularly changes in attitude of the aircraft, is transmitted more rapidly as feedback to the operator through the motion senses than the visual senses. The model assumes that the motion senses are cued by rates of onset of acceleration which allow for the initiation of response much earlier than would be occured by the positional change of the visual stimulus. Increasing the gain on a given display will increase the immediacy of the feedback to the operator, thus increasing the precision of control. Likewise, visual displays which provide the operator with rate, acceleration or onset of acceleration information allow him to receive more immediate information about the system and to control it more precisely.

From the Effective Time Constant model, the prediction can be made that in systems such as the T-37 aircraft, performance of the precise attitude control task will be enhanced by addition of proper motion cues, while other tasks such as positional control in which the visual feedback is timely and adequate will not benefit greatly from the addition of motion cues It is further predicted that the visual display which incorporates the higher gain will result in a higher precision of control.

Experimental Studies of Motion

The overall question addressed by these experiments is: "under what method of introducing motion cues and across what conditions of flight are the control performances of experienced pilots equivalent"? The determination of how pilot performance varies as a function of motion-cue conditions across different maneuvers and different levels of external disturbances is the prime research issue in this study. Particular combinations of platform motion, G-seat and gravity alignment variables have been selected to obtain data about ten specific research issues. The experimental conditions are listed in Table 10 and matrixed with appropriate experimental issues in Table 11.

Table 11 shows the experimental conditions required for providing information on ten specific research issues dealing with motion. Three data collection sessions will provide information relevant to the ten research issues. The issues have been selected sequentially so that successive data collection sessions build upon earlier results. Combinations of conditions are examined to determine the relative contribution of levels of the variable under study to pilot performance. Effects under one set of conditions guide the selection of experimental conditions in the next session. The incremental design outlined by Demaree in "A Recommended Design for Experimental Studies Using ASUPT" will be followed (AFHRL-TR-75-26(II), Appendix H).

The first research issue listed in Table 11 requires data collected under experimental Conditions 1, 10, 11, 15, 16, and 17. Performance under these conditions will show if the major simulation conditions of: (1) no motion, (2) six degrees of freedom platform, (3) six degree of freedom platform with gravity alignment, (4) six degree of freedom platform with full G-seat, (5) six degree of freedom platform with full G-seat and gravity alignment, and (6) G-seat only, differentially affect performance.

Table 10. Experimental Conditions for Motion and G-Seat Studies

Experimental Condition	Condition Description*
1	No Motion
2	P, R (Platform)
3	P, R, Y (Platform)
4	P, R, Y, H (Platform)
5	P, R, H (Platform)
6.	P, R, H, L (Platform)
7	P, R, H, F, & A (Platform)
8	P, R, H, L, F, & A (Platform)
9	P, R, Y, H, L (Platform)
10	6 Degree of Freedom Platform
11	6 Degree of Freedom Platform with Gravity Alignment
12	P, R (Platform) with Gravity Alignment
13	P, R, H (Platform) with Gravity Alignment
14	P, R, Y, H, L (Platform) with Gravity Alignment
15	6 Degree of Freedom Platform with Full G-seat
16	6 Degree of Freedom Platform with Full G-seat and Gravity Alignment
17	Full G-seat only
18	P, R (G-seat), H (Platform)
19	P, R (Platform), H (G-seat)
20	P, R (G-seat)
21	P, R, F, & A (Platform)
22	H only

*Legend:
P - Pitch
R - Roll
Y - Yaw
H - Heave
L - Lateral
F&A - Fore-and-aft

If experimental Conditions 1 and 10 differentially affect performance, the second session will be performed using experimental Conditions 2, 3, 4, 5, 6, 7, 8, 9, 21, and 22 to determine the combination of axes of motion that are equivalent.

As a test of the performance equivalence approach, it is proposed that Conditions 1 (no motion), 10 (full motion) and conditions found to be equivalent to full motion be used in the paradigm shown in Table 12. In this paradigm, equivalence and non-equivalence are established by the methods outlined on pages 14 through 16. (It is assumed that a condition of less than the full criterion ASUPT system may be established.)

In the final session, experimental Conditions 12, 13, 14, 18, 19, and 20 are investigated. Comparison of Conditions 13 and 5 will answer the question of the contribution of gravity alignment to a two degree of freedom platform (i.e., one with pitch, roll and heave). Analysis of the second research issue may redefine a nominal platform and, therefore, change this assumption.

The comparison of Conditions 15 and 16 is designed to investigate the contribution of gravity alignment when maximum platform is used with the G-seat.

The comparison between Conditions 2 and 12 gives information about the contribution of gravity alignment with minimum motion platform (i.e., one which provides only pitch and roll stimuli).

Condition 14 will be compared with Conditions 9 and 10 to analyze the longitudinal acceleration cue contribution when maximum motion platform is used, i.e., whether the gravity alignment or fore-and-aft translation effects performance.

Table 11. Experimental Conditions for Specific Motion Issues

RESEARCH ISSUE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1. Major areas of simulation	X									X	X				X	X	X					
2. Minimum degrees of freedom		X	X	X	X	X	X	X	X	X											X	X
3. Gravity alignment contribution - maximum platform										X	X											
4. Gravity alignment contribution - nominal platform					X								X									
5. Gravity alignment contribution - maximum platform plus G-seat															X	X						
6. Gravity alignment contribution - minimum platform		X										X										
7. Longitudinal acceleration cue contribution - maximum platform - gravity alignment or fore and aft									X	X				X								
8. Substitute gravity alignment for fore and aft - maximum platform										X				X								
9. Substitute gravity alignment for fore and aft - minimum platform												X									X	
10. G-seat substitution for platform		X				X												X	X	X		

Table 12. Paradigm for Test of Performance Equivalence Method for Motion Requirements

Condition 1	Condition 2	Condition 3
No-motion-non-equivalence to ASUPT criterion system established using experienced pilots	Equivalence to ASUPT criterion system established using experienced pilots	ASUPT criterion system
Students trained to criterion on this system and transferred to aircraft	Students trained to criterion on this system and transferred to aircraft	Students trained to criterion on this system and transferred to aircraft

For all three sessions, the experimental conditions will be applied to instrument flight using the maneuvers of straight and level flight, 30° bank turns and unusual attitudes. Three levels of disturbance (e.g., none, medium, high) will be imposed upon the basic flight tasks to determine the equivalence of physical systems across representative tasks and disturbances. Disturbance level for conditions will be determined through pre-testing of the turbulence generation system of ASUPT.

Motion-Visual Interaction Study

Results from the visual and motion studies will guide an experiment on the interactive effects of these two variables The experiment will be conducted using visual cues that the pilot uses to control aircraft attitude and position. The experiment is designed to determine if different platform motion conditions produce differential interactive effects (Table 13).

Table 13. Experimental Conditions for Initial Motion–Visual Interaction Studies

Tasks	Approach to landing Straight and level
Variables	Motion–no motion and full 6 degree Turbulence–high and low Precision of control–high and low
Subjects	Experienced pilots

It is hypothesized that the motion-vision interactive effect is influenced primarily by the level of precision and control required and the nature of the external forcing functions (typically, turbulence) imposed upon the system. The first interaction experiment will examine close precision attitude control in which the interaction effect is likely to be greatest, as predicted by the effective time constant model.

The performance equivalence paradigm will be used for this experiment. Experienced pilots will fly each of the conditions and tasks to determine whether their control behavior differs under the various conditions when aircraft performance remains constant. In possible follow-on studies, performance of groups of students trained under each condition and subsequently transferred to the aircraft will be compared as a further test of the validity of the performance equivalence approach to developing ASUPT as a criterion device.

VIII. TRAINING METHODS RESEARCH

This report does not address training methods research in depth inasmuch as the long term use of ASUPT in this regard is the basic mission of AFHRL/FT and is continuously documented in Project 1123 and the AFHRL Research Program. Consequently, the following discussion is intended only to highlight key areas of interest.

Training method research has high potential for producing results which will increase UPT program effectiveness. The basis for the proposed research is the establishment of ASUPT as a criterion system for investigating training methods. This is particularly critical for research in two areas: cognitive pre-training and feedback.

Cognitive Pretraining

Cognitive pre-training refers to practice on the intellectual elements and understanding of action requirements in a task prior to its being formally trained. For the perceptual and cognitive aspects of flying tasks, (e.g., learning to scan, read and interpret the instruments or learning procedural sequences) multi-media instructional aids provide highly effective and inexpensive training. Mental practice may be excellent training for continuous control tasks through use of simple devices or even no equipment at all (Prather, 1972).

Flexman et. al., (1950, 1954) support inclusion of cognitive pre-training directly into the training program. These techniques require the student to become proficient at verbalizing pertinent cues and responses necessary to meet the requirements of the task. The instructor determines whether the student is merely "parroting" the words or whether he understands the concepts and responses required for accomplishing the task. Investigation of the time savings through the use of cognitive pre-training methods is highly recommended.

AFHRL/FT has an audiovisual instrument training device (AVIT) programmable for cognitive pre-training in scanning, reading and interpreting the instruments for basic instrument flight. The capability of AVIT to reduce simulator training time in teaching basic flight maneuvers will be investigated. A functional description of the device is given in AFHRL-TR-75-26(II), Appendix G. Using time to reach criterion proficiency in the simulator as a dependent variable, an experimental group will be trained to criterion proficiency in AVIT and compared with a control group trained only in the simulator. Both groups will be taught all maneuvers in the basic instrument UPT flight curriculum to determine the degree of generalization from the three maneuvers trained in AVIT to other maneuvers trained in the simulator.

The capability fof AVIT to teach perceptual cues required in contact maneuvers will be investigated. If the major portion of the learning task of the UPT student is composed of perceptual and cognitive factors as contrasted to motor responses, it is hypothesized that once the student has learned the desired stimulus relationships, recognizes departures from these desired relationships, and knows in which direction he should initiate control movements to correct them, his training time will be significantly reduced.

Feedback

Feedback (i.e., knowledge of results) facilitates training (Smode, 1958). Cautions, however, should be observed when applying this principle to particular tasks. For example, Briggs (1962) points to the interactive effect of augmented feedback (positive or negative), complexity of the feedback criteria and level of training. He also draws attention to the importance of the feedback withdrawal schedule. Ward and Sanders (1966) suggest that adding feedback to the task has a workload associated with it and may interfere with carrying out the primary task.

Feurzeig (1971) provided instructional monitoring as a method of feedback. The trainee was given computer generated diagnostic information, instructional suggestions and a two-dimensional dynamic display of his progress through a holding pattern. This technique should prove quite beneficial in UPT, but interference effects and feedback withdrawal schedule must be investigated.

Sequencing of Training Tasks

Sequencing of training tasks was listed as a top priority issue by the training issues panel. Sequencing problems are more properly solved using the instructional system development (ISD) task analysis approach suggested in AFM 50-2 Separate tasks also may be approached through research in training methodology (e.g., cognitive pre-training and feedback). The comparison of two sequences may be tested using ASUPT as the criterion device, within which all training is given and final training is tested. This comparative experiment should be undertaken after thorough analyses of the tasks and should include a synthesis of the tasks of the total curriculum based upon the task analysis suggested by Meyer et al., (1974).

Contextual Training

The arguments for investigation of contextual training are identical to those just presented for sequencing of the training tasks. The context within which certain tasks are to be trained should be established and synthesized by task analysis prior to experimental investigation. Comparative studies of the issues for "contextual" training should then be investigated in ASUPT using it as both the training and the criterion device.

Individualized Instruction

A data base will be developed for guiding management decisions about individualized instructional programs Adaptive instructional strategies and incentives could guide the trainee's progress as a function of his rate of skill attainment, biographical background and other individual characteristics. Two major research thrusts are foreseen for AFHRL/FT in the area of individualized instruction. First, techniques for effectively and efficiently individualizing instruction into flying training programs will be developed and evaluated Secondly, the managerial aspects of implementing individualized instructional programs into the operational environment will be considered.

IX. CONCLUDING STATEMENT

This volume presented a precis of a much larger and more detailed document. If the reader desires further clarifying information at this point, he should refer to AFHRL-TR-75-26(II). Also, as concerns the programming of AFHRL/FT facilities illustrated in Appendix A, it must be remembered that all plans and research activities are dynamic in nature. They are subject to change as additional information is acquired.

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APPENDIX A: AFHRL/FT CALENDAR YEAR 1975 RESEARCH PROGRAMS

Hardware Configuration
1 Motion G-Seat-Visual Interactions
2 Visual Display Brightness and Motion Interaction
3 The Contributions of Motion to Training - I
4 The Contributions of Motion to Training - II

Software Configurations
1 The Development of ASUPT as the Criterion System
2 Pilot Discrimination of Motion Simulation Conditions
3 Visual Cue Utilization During Flight

Training Methods
1 Automated Performance Measurement
2 Orientation Ride Pretraining
3 Task Load Measurement
4 Simplified Instruction of Normal Landing
5 Evaluation of Prereviewed Demonstrations
6 Fatigue Effects During Acquisition of Flying Skill
7 F-15 Emergency Training

Operational Effectiveness
1 Studies of Operational Utility: I

Systems Engineering
1 Formal Helicopter Demonstration
2 A-10 Demonstration
3 Ideal Airport Data Base
4 Cross-Country Airport
5 Data-Base Refinement
6 Motion Actuator Velocity Distribution
7 Control Landing/Ground Requisition
8 Non-Linear Device for G-Seat
9 Buffet Philosophy
10 ASUPT Wing Implementation
11 Flight Module Redesign
12 CIG Software Redesign
13 Dual RTM Updates
14 BPS Dual Disc
15 PR Completion
16 Configuration Baseline
17 System Expansion

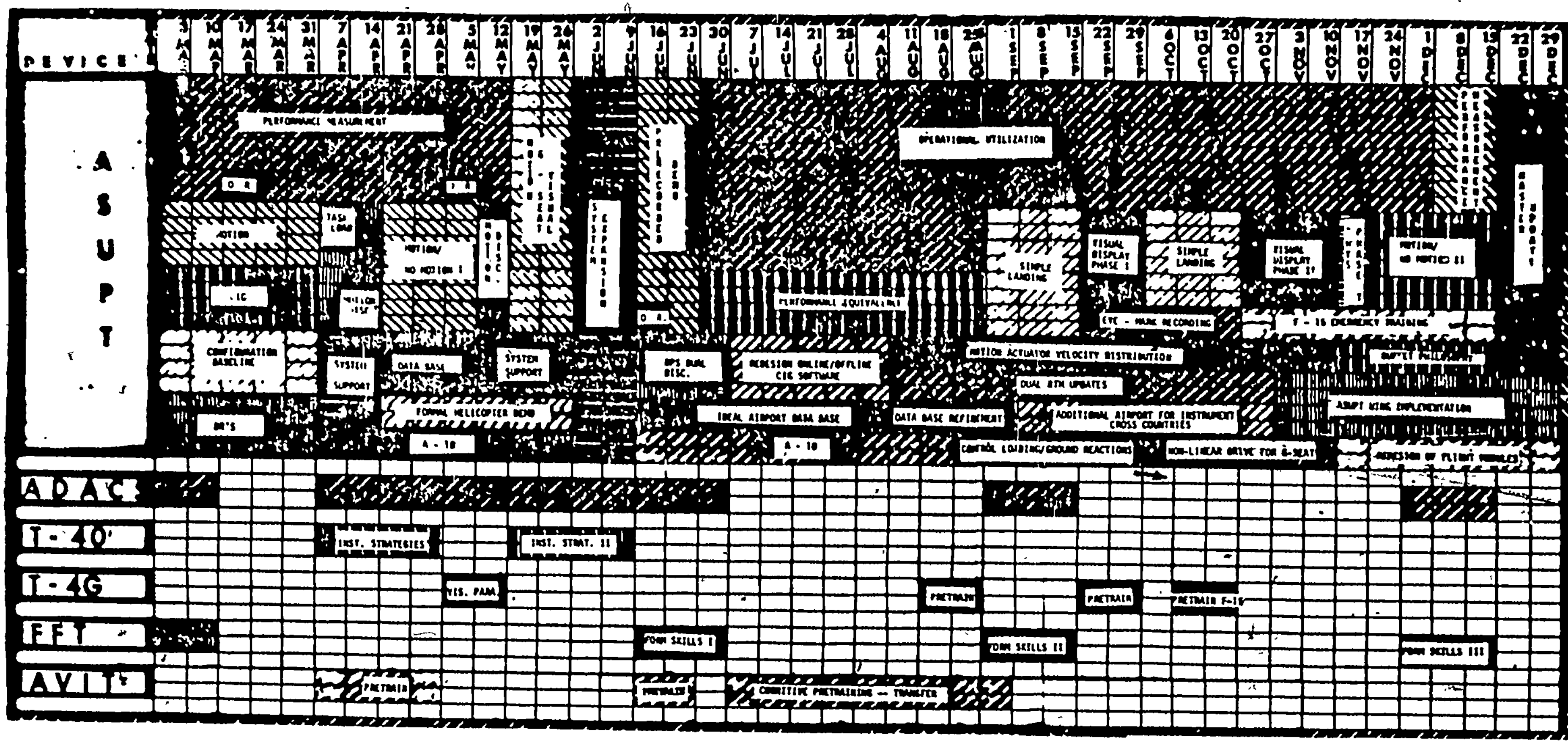

Figure A1. AFHRL/FT hardware utilization: Programmed CY 1975.

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