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Report No. DS-69-6

FINAL REPORT

Project No. 560-004-03H

Contract No. FA67WA-1811

ANGLE OF ATTACK PRESENTATION IN PILOT TRAINING

AVAILABLE IN ELECTRONIC FORMAT

March 1969

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Aircraft Development Service
Washington, D. C.

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March 1969

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DEPARTMENT OF TRANSPORTATION
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ABSTRACT

The crucial relation of angle of attack to aircraft performance suggests than an angle of attack instrument would enhance the process of learning to pilot an airplane. Therefore, a project to determine the possible value of angle of attack presentation in addition to other required instruments for flight training in general aviation aircraft was conducted. The project entailed comparing the performance of two similar groups of Embry-Riddle Aeronautical Institute flight students enrolled in the private pilot course. Flight instruction of both groups proceeded concurrently utilizing the same aircraft except the experimental group was trained using an angle of attack instrument in addition to the airspeed indicator. A series of three scored tests was employed to measure the performance of each student on selected maneuvers during and upon completion of the course.

Scores of the experimental group and the control group were tested for significance of difference by the analysis of variance method. A comparison of the derived variance ratios with the corresponding values in the Table of F ratios at the 5% level signified in all instances that the null hypothesis should not be rejected. Consequently, statistical evidence indicated that there was no true difference in the quality of performance of students trained with and without the angle of attack indicator at the private pilot level.

The overall similarity of the performance of the two groups is attributed to the following two conditions. (1) Experimental group students were required to learn the use of the angle of attack indicator in addition to the airspeed indicator. The difficulty certain students experienced early in the program in developing skill in using this instrument tended to compensate for possible enhancing effect which might have been realized in the final stage. (2) At the present state of the development of flight instruction curricula, contact flight is the quintessence of the private pilot program. An instrument capable of producing a significant effect on pilot performance at this level, consequently, would be rare.

Findings of this project indicate that further research in the use of the angle of attack indicator is appropriate. Projects should be conducted to determine the value of angle of attack presentation: (1) when used in lieu of airspeed in private pilot training, and (2) in instrument flight training.

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INTRODUCTION

The relation of angle of incidence to aircraft performance was recognized as far back as Wilbur and Orville Wright. However, the importance of angle of attack instrumentation did not become manifest until the advent of the jet airplane, and it appears that renascence of the angle of attack indicator should be attributed to research and development conducted by the U. S. Navy[1].

During the period of transition from propeller driven aircraft to jets, the Navy determined that carrier landing touchdowns must be accomplished at the minimum allowable airspeed. The limitations of shipboard arresting gear and airframe structure were not in consonance with the increase in kinetic energy of jets at point of touchdown as compared to propeller aircraft. The weight of a Navy jet is ten times more than a corresponding piston airplane and the landing speed is as much as 75 knots greater. At the same time as the Navy determined the need for minimum airspeed at touchdown, they discovered that pilots were incapable of accomplishing the required precise control of airspeed in this realm of flight. This condition existed because of one of the inherent characteristics of a turbojet airplane. In the area of optimum approach airspeed, extremely small increments of throttle movement produce proportionally large changes in velocity.

In order to obviate human limitations in jet carrier landings the U. S. Navy Bureau of Aeronautics initiated development of an automatic throttle (Approach Power Compensator). The APC regulates engine power to maintain a constant angle of attack selected for the approach to provide proper speed on landing. Angle of attack is used as an input to the auto-throttle system rather than airspeed because the angle of attack for a prescribed performance parameter remains constant regardless of airplane weight changes, flap settings, angles of bank, "g" forces, or density altitude variations.

Whereas evidence seems to indicate that the problem of jet carrier landings precipitated the rebirth of angle of attack presentation, the Navy found that this instrument contributed substantially to the general enhancement of jet operations to include (1) virtual elimination of accidents caused by premature rotation on take-off, (2) stall warning at high altitude (above 40,000 feet) when executing maneuvers involving high "g" forces, and (3) flight at maximum range and endurance. Many of the advantages of using angle of attack as a primary reference for performance of Navy jets apply to commercial turbojet aircraft. Therefore, widespread use of angle of attack indicators in jetliners and corporate jets is anticipated[2].

While angle of attack presentation is essential in certain realms of jet flight and is advantageous in others, the need and specific purpose of this instrument in

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[1]C. H. Tuomela, "Angle of Attack as an Aid to Flying" (paper from U. S. Naval Missile Center read at the Society of Automotive Engineers National Aeronautical Meeting, Washington, D. C., 1965) p. 1.

[2]"Angle of Attack Device Seen Aid to Piloting", Aviation Week and Space Technology, (September 26, 1966).

propeller driven aircraft are obscure. Except for high altitude and supersonic flight conditions, every advantage of angle of attack presentation for jet aircraft is applicable to piston engine aircraft. However, it would appear that the margin of improvement in propeller aircraft operations attributable to an angle of attack instrument would be less than in jets. The extent of this margin, and whether or not flight training per se is included are unknown. In the interest of progress and safety in general aviation, investigations in these areas are warranted. The possible advantage of angle of attack presentation in the initial stage of pilot training is the basis for this project.

Statement of Problem.

The purpose of this project was to determine the value of angle of attack presentation during private pilot training in addition to other flight instrumentation presently required for general aviation aircraft.

Objectives of the Investigation.

Specific objectives of this inquiry were to determine:

(1) Whether or not the angle of attack indicator will improve the quality of performance at the private pilot level of persons trained in general aviation aircraft equipped with this device.

(2) What areas within the private pilot course does angle of attack presentation have the most effect.

History of Accomplishments in Pilot Training Research.

A recent review of research related to pilot training reveals that the majority of the projects in this field were completed during the past twenty years[3]. However, aviation human factors research conducted under the auspices of the Civil Aeronautics Administration dates back as far as the late 1930's. Since then, research of this nature has been accomplished primarily by the Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio, the United States Naval School of Aviation Medicine, Pensacola, Florida, and the Human Resources Research Office of the George Washington University. A bibliography of pilot training research containing over 200 references indicates that certain universities and private agencies also have contributed to this effort[4].

The gamut of pilot training research accomplished to date contains a variety of projects on the various aspects of learning to fly. Particular areas of pilot training research most closely related to the project being reported herein are studies of the effects of the sequence of flight training on student pilot acquisition of flying skills, and the measurement of pilot performance.

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[3]Alfred F. Smode, Eugene R. Hall, and Donald E. Mayer, An Assessment of Research Relevant to Pilot Training, (Wright-Patterson Air Force Base: Aerospace Medical Research Laboratories, U. S. Air Force Systems Command, 1966), p. 211-241.

[4]Ibid.

Projects concerned with the sequence of flight training on student pilot acquisition of flying skills include research in the integration of contact and instrument techniques, and the use of light aircraft during the initial stages of flight training. Smode, Hall, and Mayer's review of available research indicates that the effects of early integration of instrument and contact instruction are neither well defined nor adequately substantiated, and that after approximately 200 hours of flight experience differences between control and experimental groups disappear. A similar condition was found between control and experimental groups in the value of light plane flight training prior to training in heavier high performance aircraft. However, their assessment indicated that pilot training in light planes could be used profitably to predict specific proficiency criteria during the early stages of primary training.

The relationship of research in the measurement of pilot performance and the project reported herein is particularly significant in that pilot performance measurement provides the basis for possible findings of any nature concerning the value of angle of attack presentation in flight training. Smode, Hall, and Mayer assess the development of an adequate system for pilot performance measurement as one of the prime requirements in aviation human factors research. The principal reason for their viewpoint is the close association of training effectiveness to performance measurement effectiveness. This writer would add that new knowledge in the entire scope of aviation psychology, developed and verified by research is dependent on accurate, reliable and valid pilot psychometrics. While objective pilot performance measurement may be lagging, the field is not without a record of research. During the 1940's specific aspects of light plane performance were measured objectively by employing rudimentary flight recorders and photography of flight instrument readings. The equipment used in early pilot performance measurement experiments was bulky, costly, and required specially equipped aircraft. However, the availability of sophisticated, compact, lightweight recording equipment today paves the way for objective inflight scoring of various aspects of pilot performance. For example, recent experimentation indicates that discrimination among pilots of varying proficiency is possible by instrumenting applicable aircraft systems, obtaining systems output recorded on a 4-channel FM tape recorder, converting tape records to digital tape format, and final analysis using an IBM computer.

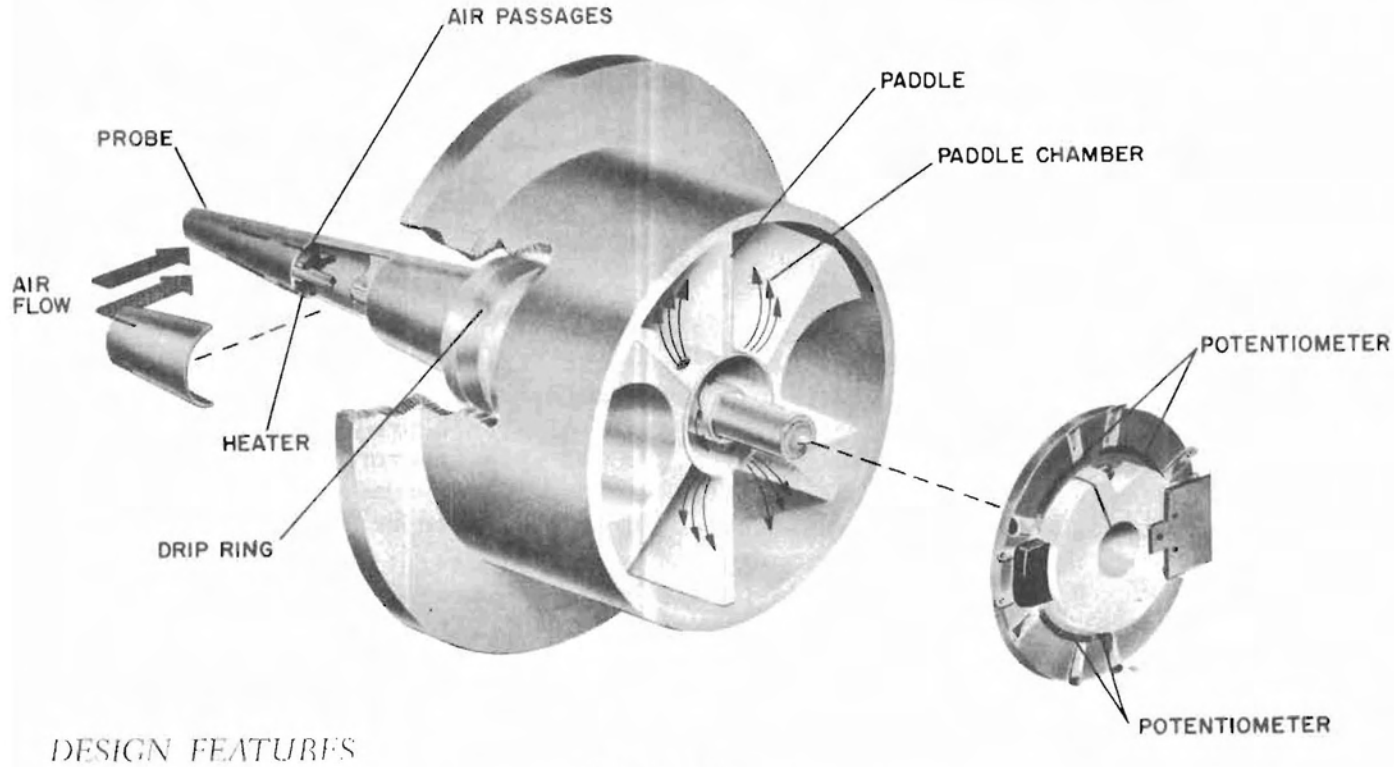
Narrative.

(1) In early May 1967, contract negotiation with the Federal Aviation Administration revealed the possibility that Embry-Riddle Aeronautical Institute would be one of two recipients of a contract for the angle of attack project, and that Automated Specialties Division of Teledyne, Inc., would ship government furnished equipment consisting of three angle of attack instrument systems. The preliminary plan for completing the project consisted of three phases to be accomplished as follows:

Phase No.	Description	Duration
I	Preparation: Installation and calibration of instruments in aircraft; organization for execution of the project; completion of performance measurement system; training of instructors.	May-August 1967

Phase No.	Description	Duration
II	Accumulation of data: Selection and assignment of students; flight training and performance measurement; scoring and collating performance measurement information.	Sept.-Dec. 1967
III	Analysis of data and preparation of report.	Jan.-Feb. 1968

(2) In response to Embry-Riddle's request, representatives of Automated Specialties visited Daytona Beach May 10-12, 1967, for the purpose of initial coordination, demonstration of the angle of attack instrument, and study of the aircraft to be used for the project. One of the first considerations requiring study was configuration of the installation of the angle of attack instrument system in a Cessna 150. The most critical element of the system effecting installation configuration was the angle of attack transmitter. This component contains a conical probe which senses changes in the aircraft's angle of attack. Normally the probe protrudes from the fuselage of an aircraft perpendicular to the flow of air. A paddle located inside the transmitter housing is attached to the probe (See Fig. 1.). Both the probe and paddle are free to rotate. Two sets of slots in the probe allow pressure variations, caused by changes in airstream direction, to be transmitted through separate air passages to opposite sides of a paddle chamber. When the pressure acting on one side of the paddle is greater than the other, the paddle and the probe rotate until the pressures are equal. The probe thus positions itself to determine the angle of attack of the aircraft. Position of the probe is registered on a dial located on the aircraft's instrument panel through an electrical system.



DESIGN FEATURES

Figure 1.
Angle of Attack Indicator Transmitter

In order to function properly the probe must be located at a point free from influences not related to the aircraft's angle of attack. Automated Specialties Division previously had established general criteria for location of the transmitter. The point chosen should be ideally on the side of the fuselage at least two fuselage diameters rear of the nose and at least one wing root chord forward of the leading edge[5].

However, these rules apply to jets, and the aircraft to be used for this project were propeller driven. Location of the transmitter anywhere on the fuselage of a Cessna 150 would subject the probe to "prop wash". Therefore, it was decided to situate the probe on the wing tip, and to install spill plates to minimize the effect of wing tip vortex. Suitability of the wing tip position of the probe would be determined by a tuft test[6].

Upon conclusion of preliminary considerations of problems relative to preparation for the project, Automated Specialties Division and Embry-Riddle Aeronautical Institute agreed on the following sequence of events and responsibilities for completing Phase 1:

Task No.	Description	Responsibility of: Auto. Spec.	E-RAI
1	Furnish angle of attack system hardward	X	
2	Fabricate spill plates; modify one Cessna 150 accordingly; obtain FAA approval to change classification of this aircraft from utility to experimental category; provide modified airplane for test.		X
3	Install tufts; conduct in-flight photography.	X	
4	Provide pilots and second aircraft for photographer.		X
5	Analyze test data, determine exact transmitter location and possible modifications to spill plates.	X	

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[5] Installation and Calibration Instructions for Angle of Attack Transmitter, MR 235B, (Charlottesville; Automated Specialties, A Teledyne Co., 1967), p. 2.

[6] A tuft study for angle of attack transmitter location is conducted by photographing the tuft area from another aircraft flying in close formation using a long focal length lens. The aircraft under test is flown over the full range of airspeeds available for level flight. Airflow paths are determined by studying the photographs and noting the position of the wool tufts.

Task No.	Description	Responsibility of: Auto. Spec.	E-RAI
6	Install angle of attack instrument systems on all three aircraft; provide pilot and aircraft for final flight calibration.		X
7	Furnish technical representation for flight calibration.	X	
8	Obtain Supplemental Type Certificate for Cessna 150 modified with spill plates and angle of attack instrument and accessories installed.		X

(3) Contract FA 67WA-1811 was awarded July 3, 1967, and one Cessna 150 complete with angle of attack system and spill plates was ready for calibration and test on the 15th of July.

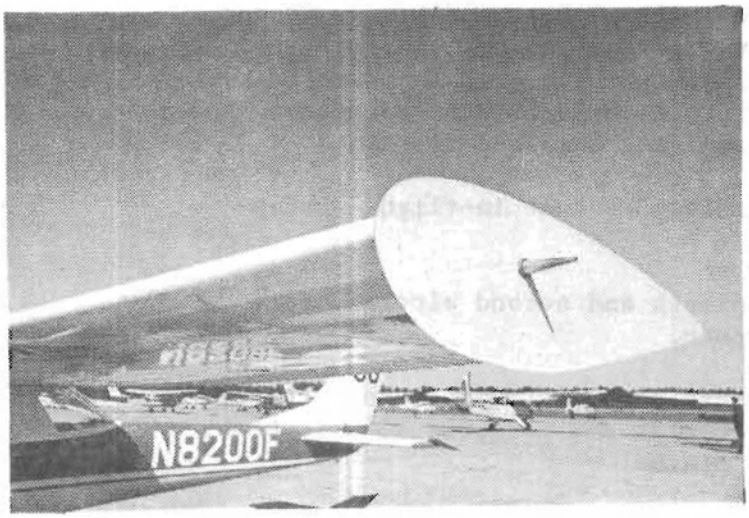

Figure 2.
Spill Plate and Angle of Attack Probe on Cessna 150

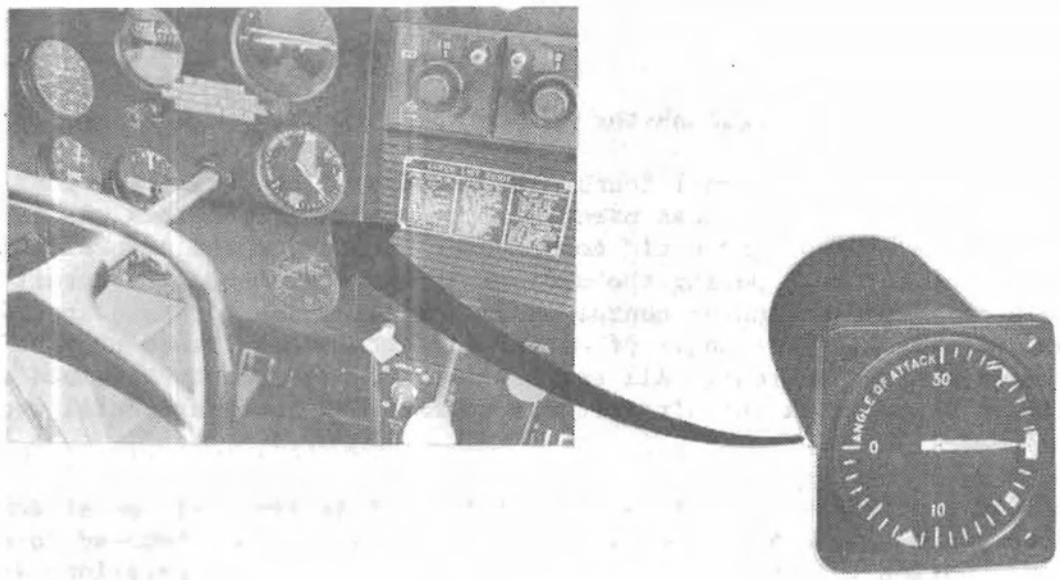

Figure 3.
Angle of Attack Indicator Dial

The particular system Automated Specialties Division furnished for this test contained a probe capable of measuring a maximum angle of 30 degrees. However, during the test it was found that the Cessna 150 flight characteristics required the measurement of angles up to 34 degrees. In order to remedy the situation, the system was removed from the airplane and returned to the factory. Automated Specialties Division modified the probes of all three systems accordingly, and returned them to Embry-Riddle. During the remainder of the summer Embry-Riddle completed the following preparatory actions:

(a) Designation of flight instructors and check pilots.

(b) Selection and procurement of intelligence test for mental screening of students.

(c) Submission of application for Supplemental Type Certificate to the FAA Engineering and Manufacturing District Office, Miami, Florida, for modification of a Cessna 150 with spill plates and angle of attack indicating system.

(4) Whereas initial plans for this project contemplated that flight training of all students would be conducted during the period September-December, 1967, the first group of students did not start until May 1968. The necessity for factory modification of the angle of attack instrument system, and difficulties in satisfying the requirements for a Supplemental Type Certificate for installation of the angle of attack instrument system to include wing tip spill plates in the Cessna 150 were reasons for the delay.

(5) In early December 1967 an Embry-Riddle representative visited Columbus, Ohio to observe activities relevant to the same type of experiment being conducted at Ohio State University. The most significant information obtained during this visit was the importance to the project of obtaining valid feed-back from the performance measurement system. Therefore, Embry-Riddle personnel reviewed the system intended for use in the project, and determined that the design and planned

utilization method would accomplish the desire purpose.

Ohio State University personnel found that a means of rendering the instrument inoperative by a locking device was needed. The purpose of the lock was to insure that members of the control group did not attempt to operate the aircraft by reference to angle of attack. During the project at Embry-Riddle all aircraft equipped with an angle of attack indicator contained a locking device for this instrument. Keys capable of unlocking the angle of attack indicator were issued only to students in the experimental group. All angle of attack instruments remained in the locked position except when the aircraft was operated by an experimental group student.

(6) The first group of students available for use in the angle of attack project after award of the Supplemental Type Certificate were scheduled to enroll in early May. During the period 15 March - 3 May 1968 final preparations were completed, namely, calibration of all angle of attack instruments by representatives from Automated Specialties Division, procurement of mental aptitude tests for selection of test subjects, orientation of flight instructors in the use of the angle of attack instrument, and completion of the pilot performance measurement system.

(7) The period early May--mid-November 1968 was devoted to the conduct of flight training for students selected as test subjects and collection of data. A schedule of students completing training under this project is shown in Appendix A. Data collation, analysis, and preparation of preliminary report occurred during the period mid-November--mid-December 1968.

TEXT

Experimental Design

Type of experiment:	Single-variable.
Independent variable:	Introduction of angle of attack indicator during flight training.
Dependent variable:	Pilot performance as determined by an objective flight test.
Number samples:	Two (experimental group and control group).
Sample size:	N=15
Basis for selection of sample members:	(1) Scores obtained on a mental aptitude test (California Test of Mental Maturity). (2) Zero time previous flight training.
Action taken to reduce the influence of factors other than the independent variable:	(1) Flight instructors were assigned an equal number of students in each group. (2) Instructor differences were minimized by pre-experiment standardization. (3) Check pilot standardization.
Indication that all test subjects were from the same population as measured by the CTMM:	See Appendix B.

Procedures.

Upon completion of the screening process and assignment to either the experimental or control group, student pilots participating in the project attended instruction in Phase I of the Embry-Riddle Professional Pilot Program. This phase consisted of aeronautical training at the private pilot level and included forty-five hours of flight instruction in Cessna 150's (Appendix C) and fifty hours of ground school. The training of each student was identical except flight instruction for the experimental group was conducted using an angle of attack indicator in addition to other instruments contained in the Cessna 150. Information on method of employing the angle of attack indicator in light aircraft flight training during this project is contained in Appendix D. The performance of each student was measured three times during the process of the private pilot course as follows:

(1) Pre-solo check, flight instruction period #11

(2) 20-hour check, period #22

(3) Final check, period #43

Activities relevant to this project were conducted concurrent with the normal flight instruction program of the institution. Ostensibly the only difference between students participating in the project and other Embry-Riddle flight students

was the aircraft used. However, certain other differences existed, viz the use of the angle of attack indicator for students in the experimental group, and the use of a special performance measurement device during check rides for all students participating in the project.

Pilot Performance Measurement.

The design of this project provided for determining the statistical significance of the effects on a dependent variable (pilot performance) by manipulating an independent variable (pilot training method). This determination required that information on performance be recorded and evaluated. A method of describing performance quantitatively, therefore, was necessary. In the interest of producing a valid experiment, these quantitative descriptions must be in consonance with the true ability of the performer. It was concluded that data which accurately describes the performance of the various student pilots for purposes of this experiment were attainable by an objective flight test. However, prepared tests of this nature are neither utilized at this institution, nor were they known to be available from pilot training publications suppliers. Consequently, the construction of an objective flight test was one of the sub-tasks of the angle of attack project. Preparation of this test involved initially an examination of the course of instruction. This study revealed that the objectives of the experiment could be attained by measuring performance during the execution of selected maneuvers contained in the private pilot course. Criteria used for selection of these maneuvers were: (1) requires demonstration of an essential skill of a private pilot except for navigational techniques, and (2) involves angle of attack change.

The following maneuvers were used.

1. Normal Take-off
2. Climbing Turns
3. Straight and Level Flight
4. Straight and Level Flight at Reduced Airspeed
5. 720° Steep Turns
6. Arrival Stalls
7. Departure Stall
8. Accelerated Stalls
9. Gliding Turns
10. Turns about a point
11. Normal Landing
12. Missed Approach
13. Cross-Wind Landing
14. Cross-Wind Take-off
15. Short Field Landing
16. Short Field Take-off
17. Soft Field Landing
18. Soft Field Take-off

A Performance Analysis Sheet for each maneuver was prepared. The basic elements of the maneuver were listed on the left hand column of the page. The right hand column contains aphorisms of the most common variations observed among student pilots in executing each maneuver element. An extract of the Performance Analysis Sheet for one of the maneuvers (Straight and Level Flight) used is shown below.

* * * * * * * * * * * * * * *

Element or Phase	Manner of Performance
Altitude Control	1. Held proper altitude
	2. Deviated not more than 100' above
	3. Deviated more than 100' above
	4. Deviated not more than 100' below
	5. Deviated more than 100' below
Power Control	1. Regulated power setting as required to maintain proper altitude and airspeed
	2. Inadequate power control
Heading Control	1. Heading held within $\pm 5^{o}$
	2. Heading held within $\pm 10^{o}$
	3. Allowed heading to deviate more than $\pm 10^{o}$

* * * * * * * * * * * * * * *

Performance analysis sheets were assembled into booklets which the examiners used during the three check rides previously described. The pre-solo check involved only maneuvers 1-4, 6, 9 and 11. However, all eighteen maneuvers were scored on the 20-hour and final flight check. A duplicate of the Performance Analysis Booklet Master Copy is annexed herewith as Appendix E.

Objectiveness of the performance measurement system used in the project is attributed to the following conditions:

(1) Performance recording and performance scoring were two separate and remote actions.

(2) Performance recording involved either noting directly the indications of certain aircraft instruments or subjective judgements of only small, well-defined aspects of performance.

Data Collection.

Performance analysis booklets were used to guide the sequence of events of a check ride and provide a means for the examiner to record student performance.

Performance recording was accomplished by placing an "X" over the number of the statement in the right hand column of the appropriate sheet which most accurately described the manner of performance of the particular maneuver element being considered. Only one option was "X-ed" for a given element, but all maneuver elements, as listed in the left hand column of each sheet, were considered for the selection of a performance option.

Upon completion of a specific check ride, the examiner forwarded the Performance Analysis Booklets to the Project Director's office for scoring. The scoring system provided for award of points depending on which items in the right hand column of the various Performance Analysis Sheets were "X-ed". Options warranting award of points, and the number of points allowed are shown in the Master Copy. The number of points per option depends on the relative importance of the particular facet of performance being considered. A zero was awarded for any option "X-ed" in a student's booklet which does not contain an "X" in Appendix E. If the examiner, for example, when considering manner of performance of directional control during take-off run, had determined that the student veered to the right excessively the examiner would place an "X" over option 1 (See Page E-1). The score for this element of the maneuver, therefore, would be zero. If the examiner "X-ed" option No. 2, the student would receive one point. Additional points for this and other maneuvers were determined by comparing each page of the booklet submitted with the corresponding page of Appendix E. The total score for each maneuver was obtained by adding up the points awarded for the entire maneuver. This score was placed at the lower right hand corner of the final page of the maneuver. Maneuver scores also were transcribed on a Summary Score Sheet, the format of which is contained in Appendix F. Student pilot records relating to this project, therefore, consisted of:

(1) Student's name

(2) CTMM score

(3) Performance Analysis Booklet for pre-solo, 20-hour, and final progress check

(4) Completed Summary Score Sheets

A tabulation of scores obtained by all students on the various maneuvers is given in Appendix G. Scores shown in Appendix G were extracted from the individual Summary Score Sheets.

Data Analysis

The significance of the differences between sample means was determined on twenty-two score sets by the analysis of variance method. Score sets used consist of t_1 through t_{18}, X, Y, Z and T, as shown in Table I below.

Table I

Score Sets

MANEUVER	SCORE			
	Pre-Solo	20-Hour	Final	Total
Normal Take-off				t_1
Climbing Turns				t_2
Straight and Level Flight (Normal Cruise)				t_3
Straight and Level Flight @ Reduced Airspeed				t_4
720 Steep Turns				t_5
Arrival Stalls				t_6
Departure Stalls				t_7
Accelerated Stalls				t_8
Gliding Turns				t_9
Turns About a Point				t_{10}
Normal Landing				t_{11}
Missed Approach				t_{12}
Cross Wind Take-off				t_{13}
Cross Wind Landing				t_{14}
Short Field Take-off				t_{15}
Short Field Landing				t_{16}
Soft Field Take-off				t_{17}
Soft Field Landing				t_{18}
Totals	X	Y	Z	T

Score set quantitative values taken from the Summary Score Sheet for each student are summarized in the following tables.

Table II(a)

Score Set Summary

Score Set	Experimental Group 101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	Mean
t1	15	14	10	14	13	11	13	13	8	12	12	14	13	9	15	12.40
t2	10	14	10	9	10	8	14	14	14	11	9	9	12	12	12	11.20
t3	18	14	8	11	11	15	13	16	8	11	15	14	17	12	14	13.13
t4	12	8	15	10	9	12	5	15	9	9	13	11	13	9	14	10.93
t5	9	13	5	10	8	10	9	14	10	11	12	13	6	9	9	9.86
t6	13	15	10	12	15	12	15	18	16	14	18	15	15	10	6	13.60
t7	9	10	4	10	9	12	12	12	10	12	10	12	12	9	7	10.00
t8	9	12	3	9	7	12	9	12	12	12	9	6	9	11	6	9.20
t9	11	14	7	12	10	11	11	12	12	10	12	8	10	12	13	11.00
t10	5	10	4	7	7	7	5	6	6	4	6	5	5	5	6	5.86
t11	30	27	16	26	15	21	22	26	22	26	23	29	28	17	26	23.60
t12	7	7	6	6	6	7	8	6	6	7	7	7	5	7	7	6.60
t13	10	9	6	10	7	9	7	9	6	10	8	9	10	7	7	8.26
t14	16	11	6	16	7	14	12	15	9	14	10	15	16	13	11	12.33
t15	8	7	7	10	7	8	8	9	6	6	8	7	10	8	9	7.86
t16	13	12	8	11	14	11	15	16	13	10	12	11	15	12	11	12.26
t17	10	7	4	7	6	10	9	7	6	9	8	6	9	8	8	7.60
t18	11	13	12	13	13	13	15	14	11	14	14	15	15	11	13	13.13
X	40	34	35	24	27	16	33	31	16	21	26	22	39	17	27	27.20
Y	79	85	49	92	60	90	77	97	103	89	89	92	87	65	82	82.40
Z	97	98	57	87	87	97	92	106	65	92	91	92	94	99	85	89.26
T	216	217	141	203	174	203	202	234	184	202	206	206	220	181	194	198.86

Table II(b)

Score Set Summary

Score Set	Control Group 201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	Mean
t1	14	7	13	14	12	14	15	14	13	9	10	13	12	8	13	12.06
t2	13	8	9	8	10	10	13	12	10	9	9	12	11	9	11	10.26
t3	14	8	13	13	15	16	10	16	13	10	13	17	14	15	18	13.66
t4	14	6	12	12	15	15	8	16	14	7	10	8	13	13	14	11.80
t5	9	7	12	11	13	13	7	13	9	9	10	10	13	11	11	10.53
t6	18	7	15	18	12	13	8	18	15	17	12	15	15	16	7	13.73
t7	12	6	12	12	12	10	5	12	12	10	12	9	12	12	10	10.53
t8	9	6	12	9	12	6	4	12	9	11	12	12	12	12	12	10.00
t9	12	7	14	10	11	13	11	13	9	12	11	14	10	10	12	11.26
t10	3	7	9	5	10	7	7	7	6	5	5	9	7	6	7	6.66
t11	20	19	27	30	17	28	21	29	24	16	18	20	24	23	24	22.66
t12	8	4	7	8	8	6	5	8	7	7	6	8	8	7	6	6.86
t13	10	5	6	4	10	10	5	9	9	8	9	10	9	8	10	8.13
t14	7	7	14	16	12	14	13	15	6	10	14	13	14	13	11	11.93
t15	7	3	7	6	10	10	6	9	9	8	8	9	10	7	9	7.86
t16	8	5	11	14	12	14	9	14	9	15	14	8	14	15	10	11.46
t17	9	4	5	7	10	8	5	9	8	6	10	5	9	8	4	7.13
t18	8	6	16	16	9	15	13	16	12	13	15	14	16	15	8	12.80
X	37	19	26	36	15	28	30	39	34	20	8	24	21	20	30	25.80
Y	86	9	101	95	90	101	84	101	75	82	93	86	102	93	94	86.13
Z	72	94	87	82	105	93	51	102	85	80	97	96	100	95	73	87.46
T	195	122	214	213	210	222	165	242	194	182	198	206	223	208	197	199.40

Table III

Summary of Null Hypothesis Tests*
N = 30 K = 2

Score Set	Source	Mean Sq. Variance	Derived F	F-ratio .05 df 1&28	Null Hypothesis Failed to Reject	Rejected
t_1	SSm	.83				
	SSw	11.11	.0749	4.2	x	
t_2	SSm	6.53				
	SSw	7.79	.8381	4.2	x	
t_3	SSm	2.13				
	SSw	17.62	.1210	4.2	x	
t_4	SSm	5.63				
	SSw	19.79	.2845	4.2	x	
t_5	SSm	3.33				
	SSw	11.34	.2938	4.2	x	
t_6	SSm	.13				
	SSw	26.96	.0049	4.2	x	
t_7	SSm	2.13				
	SSw	11.21	.1903	4.2	x	
t_8	SSm	4.79				
	SSw	16.18	.2965	4.2	x	
t_9	SSm	.53				
	SSw	7.45	.0715	4.2	x	
t_{10}	SSm	4.79				
	SSw	5.92	.8096	4.2	x	
t_{11}	SSm	6.53				
	SSw	45.14	.1447	4.2	x	
t_{12}	SSm	.53				
	SSw	2.25	.2363	4.2	x	
t_{13}	SSm	.13				
	SSw	7.12	.0187	4.2	x	
t_{14}	SSm	1.19				
	SSw	21.86	.0548	4.2	x	
t_{15}	SSm	0.00				
	SSw	5.65	.0000	4.2	x	

Table III (continued)

Score Set	Source	Mean Sq. Variance	Derived F	F-ratio .05 df 1&28	Null Hypothesis Failed to Reject	Null Hypothesis Rejected
t_{16}	SSm	4.79				
	SSw	15.43	.3109	4.2	x	
t_{17}	SSm	1.63				
	SSw	7.94	.2054	4.2	x	
t_{18}	SSm	.83				
	SSw	14.77	.0563	4.2	x	
X	SSm	14.70				
	SSw	151.90	.0967	4.2	x	
Y	SSm	104.53				
	SSw	785.79	.1330	4.2	x	
Z	SSm	24.29				
	SSw	393.58	.0617	4.2	x	
T	SSm	2.13				
	SSw	1387.17	.0015	4.2	x	

*Analysis of variance computations were accomplished by a FORTRAN IV program on an IBM 1130 computer. All numerical quantities are truncated to two places. A summary of the theory concerning analysis of data and use of null hypothesis used in this project is attached herewith as Appendix H.

Instructor Evaluation.

After final check rides for all students participating in the project were completed, the opinion of instructors and check pilots concerning the angle of attack instrument in pilot training was obtained. A total of 10 instructors and check pilots responded to the following questions in the manner indicated:

(1) Question

Your observations of student performance when using an angle of attack instrument in pilot training at the private pilot level indicates that, in general, this instrument:

( ) Aids the student.

( ) Neither helps nor hinders.

( ) Is a detriment.

Response

2 checked "Aids the student"

6 checked "Neither helps nor hinders"

2 checked "Is a detriment"

(2) Question

Would a different presentation of angle of attack information than the method provided during this project improve use of this information in pilot training at the private pilot level.

( ) Yes.

( ) No.

Response

6 checked "Yes"

3 checked "No"

1 undecided

Opinions on how to change the display varied between a circular display with clockwise rotation of the needle, and a vertical display.

(3) Question

According to your observation students developed skill in one or more specific maneuvers more readily when learning with the angle of attack indicator.

( ) Yes.

( ) No.

Response

6 checked "Yes"

4 checked "No"

The consensus of opinion among instructors responding affirmatively was that the angle of attack instrument materially assisted in maneuvers involving steep ascent and descent.

(4) Question

Would an acceptable angle of attack indicator facilitate learning during any other phase of pilot training that would warrant installation of this instrument and accessories in general aviation aircraft.

( ) Yes.

( ) No.

Response

Seven out of ten instructors were of the opinion that the angle of attack indicator would facilitate acquisition of pilot skills during the commercial and instrument phases of training to a degree that would warrant installation of this instrument in general aviation aircraft.

Rational Analysis.

Statistical analysis of the scores obtained during this project indicates unequivocally that the experimental group and the control group were two random samples from the same normally distributed population. On the other hand, the nature of the angle of attack indicator tends to challenge the certainty of this finding. This instrument provides direct reading of the relative wind with reference to the wing which is accurate throughout the speed range of the aircraft. Consequently, the angle of attack indicator reveals performance data directly which only can be approximated using the airspeed indicator. Possible insight relevant to causes for this unharmonious situation may be obtained by consideration of certain factors not evident from an examination of scores.

Information obtained from instructors participating in the project evinced that certain experimental students appeared at times to be confused by the angle of attack indicator. These students all received instruction in the concept of the angle of attack and use of the instrument. However, they were required to develop skill in the use of this instrument in addition to the airspeed indicator and other instruments. Whereas the basic premise of this experiment postulates that the angle of attack indicator will simplify learning to fly, this premise is valid only at such time as the student pilot has acquired a certain minimum ability to properly use the instrument.

An examination of the mean scores tends to verify the initial deleterious effect of having to learn to use the angle of attack indicator in addition to other instruments. The greatest difference in mean scores of score sets X, Y and Z occurred at

the 20-hour check (score Y). The experimental group mean score was 82.4, but the control group attained a mean of 86.13. However, on the final check, the experimental group was superior. They obtained an 8.32% increase in performance on the final check over the 20-hour check. The control group increase in performance was only 1.54%.

This evidence seems to support the assumption that learning to use the angle of attack instrument in addition to other instruments might have impeded the experimental students during the initial moiety of the private pilot program. A method of obviating this possible condition in determining the value of the angle of attack presentation in flight training at the private pilot level appears feasible by substituting angle of attack indicator for the airspeed indicator.

A second consideration which explains the irrational statistical findings is the fact that the private pilot course predominately involves "contact flight techniques", i.e., perception of the attitude of an airplane by visual reference to the horizon. Reference to instruments is required to a slight degree during all phases of private pilot training, and approximately three hours are devoted to piloting "on instruments", but, the total effect of the use of instruments in developing pilot skills at the private pilot level is meager. A significant difference in performance among private pilots attributed to the angle of attack indicator or any other instrument, therefore, would be unusual.

Instrument flight training, conversely, is conducted exclusively by reference to instruments. Upon reaching this stage of training, student pilots are in a better position to appreciate the significance of angle of attack than at the private pilot stage, and learning to use the instrument would be comparatively simple. These facts substantiate the opinion of several of the flight instructors and examiners who participated in this project that the full potential of the angle of attack indicator in flight training could be realized at the instrument pilot level.

CONCLUSIONS AND RECOMMENDATIONS

It is concluded that:

(1) There is no significant difference between students trained in general aviation aircraft at the private pilot level with an angle of attack indicator in addition to other required instruments and students trained in identical aircraft without the angle of attack indicator.

(2) There are no specific exercises requiring maneuvering skills at the private pilot level that students trained with angle of attack indicator in addition to other required instrumentation could perform better significantly than students trained without this instrument.

(3) The use of an angle of attack indicator in lieu of the airspeed indicator is a potential method of determining the true value of angle of attack presentation in pilot training at the private pilot level.

(4) A project to determine the value of angle of attack presentation in instrument flight training would provide a setting for the advantages of this instrument to be realized.

It is recommended that:

(1) No further consideration be given to using an angle of attack indicator in addition to airspeed for the purpose of improving flight training at the private pilot level.

(2) Research in the use of angle of attack presentation in flight training be continued.

(3) Projects be conducted to: (a) determine the value of the angle of attack indicator in place of the airspeed indicator in private pilot training, and (b) determine the value of the angle of attack indicator in instrument flight training.

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STUDENT COMPLETION SCHEDULE

CONTROL GROUP					EXPERIMENTAL GROUP				
NO.	IDENT*	CTMM SCORE	STARTED	COMPLETED**	NO.	IDENT*	CTMM SCORE	STARTED	COMPLETED**
1	206	147	6 May 68	10 July 68	1	115	191	6 May 68	12 July 68
2	205	141	6 May 68	10 July 68	2	113	184	15 July 68	20 Sept. 68
3	215	195	6 May 68	27 June 68	3	106	149	5 Aug. 68	1 Nov. 68
4	209	156	5 Aug. 68	21 Nov. 68	4	102	122	5 Aug. 68	31 Oct. 68
5	213	189	5 Aug. 68	11 Oct. 68	5	105	147	5 Aug. 68	16 Nov. 68
6	212	176	5 Aug. 68	7 Oct. 68	6	107	152	5 Aug. 68	18 Nov. 68
7	201	109	5 Aug. 68	12 Sept. 68	7	101	112	5 Aug. 68	19 Sept. 68
8	211	169	5 Aug. 68	19 Sept. 68	8	110	154	5 Aug. 68	30 Oct. 68
9	204	135	5 Aug. 68	21 Nov. 68	9	104	133	5 Aug. 68	31 Oct. 68
10	208	154	5 Aug. 68	21 Nov. 68	10	108	153	9 Sept. 68	19 Nov. 68
11	207	153	9 Sept. 68	6 Nov. 68	11	109	153	9 Sept. 68	11 Nov. 68
12	202	123	9 Sept. 68	21 Nov. 68	12	114	190	9 Sept. 68	15 Oct. 68
13	214	193	9 Sept. 68	28 Oct. 68	13	111	160	9 Sept. 68	15 Oct. 68
14	203	134	9 Sept. 68	5 Nov. 68	14	112	163	9 Sept. 68	16 Nov. 68
15	210	158	9 Sept. 68	15 Nov. 68	15	103	133	9 Sept. 68	20 Nov. 68

*Computer identification number...based on relative standing on CTMM
**Date of final check ride

NOTE: A total of 38 students participated in the project, but eight were dropped because of disenrollment or unusually long interruptions in attendance.

TEST OF SIGNIFICANCE OF DIFFERENCE BETWEEN THE MEANS OF EXPERIMENTAL AND CONTROL GROUP CTMM SCORES

Experimental		Control	
X	X^2	Y	Y^2
112	12,544	109	11,881
122	14,884	123	15,129
133	17,689	134	17,956
133	17,689	135	18,225
147	21,609	141	19,881
149	22,201	147	21,609
152	23,104	153	23,409
153	23,409	154	23,716
153	23,409	156	24,336
154	23,716	158	24,964
160	25,600	169	28,561
163	26,569	176	30,976
184	33,856	189	35,721
190	36,100	193	37,249
191	36,481	195	38,025
Sum of X= 2,296	Sum of X^2=358,860	Sum of Y= 2,332	Sum of Y^2=371,638
N= 15		N= 15	
Mx= 153.06		My= 155.47	
Mx^2=23,427.36		My^2=24,170.92	
Sx= 22.28		Sy= 24.59	
Smx= 5.96		Smy= 6.57	

S_{diff}=8.87
CR= .2717
Not Significant at the 5% Level
Table of t ratios: df=14

APPENDIX C

EMBRY-RIDDLE AERONAUTICAL INSTITUTE

PRIVATE PILOT COURSE

(Angle of Attack Project)

EMBRY-RIDDLE AERONAUTICAL INSTITUTE

DAYTONA BEACH, FLORIDA

PROFESSIONAL PILOT FLIGHT TRAINING SYLLABUS
PRIMARY & BASIC FLIGHT

PURPOSE: To qualify the student in fundamental maneuvers and techniques required for solo flight; basic maneuvers, techniques and flight knowledge required for control of the aircraft by visual and instrument reference; flight planning and air navigation techniques necessary for the conduct of safe cross-country flight during daylight hours; elementary night operation; and the procedures necessary for the award of a private pilot's certificate.

NOTE: This syllabus standardizes the primary & basic flight course within limitations. The syllabus should not be considered a rigid blueprint to be strictly adhered to under all circumstances. The instructor recognizing the individual differences do exist among students, should feel free to make adjustments to take these differences into account. However, satisfactory completion of all materials contained in the syllabus is prerequisite to the advanced flight course and must therefore be accomplished by the student within the prescribed time.

LESSON NO. 1 ORAL
A discussion of the forces acting on the aircraft in flight, axes, function of the controls (including trim-tabs and flaps), instruments and their elementary functions. Demonstration and instruction of complete preflight procedures in detail; explanation of check list and its use.

READING ASSIGNMENT: Chapters 1 thru 7, Student Pilot Flight Manual

THIS PERIOD: Dual Solo S.I.* Oral
TOTAL

LESSON NO. 2 DUAL
REVIEW:
(1) Preflight procedures; visual inspection of aircraft
(2) Use of checklist
DEMONSTRATE: (Orientation Flight)
(1) Engine starting and stopping
(2) Taxiing
(3) Pre-take-off procedures
(4) Radio procedures
(5) Effect and use of controls
(6) Pitch and Bank reference to straight and level flight VR, IR
(7) Medium banked turns
(8) Orientation to practice area (point out landmarks and physical features he can use for orientation)

*S.I.--Simulated Instruments

STRESS:
(1) Importance of being orientated
(2) Being relaxed
(3) Looking around
(4) Flying safety

READING ASSIGNMENT: Chapters 8 & 9 (pages 39-53) Student Pilot Flight Manual.

THIS PERIOD: Dual 1.0 Solo S.I. Oral
TOTAL (1.0)

LESSON NO. 3 DUAL
REVIEW:
(1) Visual inspection; use of Checklist
(2) Starting and stopping engine
(3) Taxiing technique and use of brakes
(4) Pre-take-off procedures
(5) Use of controls
DEMONSTRATE:
(1) Take-off
(2) Climbs and climbing turns; correction torque, "P" factor, etc.
(3) Level off procedure
(4) Straight and level flight
(5) Gentle and medium turns
(6) Use of trim
(7) Altitude and directional control by visual reference
(8) Altitude and directional control by instrument reference
(9) Glides and gliding turns
PRACTICE:
(1) Altitude and directional control
(2) Climbs and climbing turns
(3) Glides and gliding turns
(4) Level off from climbs
(5) Level off from glides
(6) Level turns
(7) Division of attention; looking around
(8) Use of trim
(9) Use of section lines for turns
STRESS:
(1) Looking around
(2) Staying relaxed
(3) Remaining oriented

READING ASSIGNMENT: Chapter 12, Student Pilot Flight Manual.

THIS PERIOD: Dual 1.0 Solo S.I. .2 Oral
TOTAL (2.) (.2)

LESSON NO. 4 DUAL
REVIEW:
(1) Visual check
(2) Material given in Lessons 2 and 3
(3) Visual reference and instrument reference for four fundamentals of flight

DEMONSTRATE:
(1) Slow flight without flaps VR, IR
(2) Use of flaps
(3) Confidence maneuvers
(4) Coordination exercises

PRACTICE:

(1) Climbs and glides; climbing turns and gliding turns
(2) Level flight and turns
(3) Use of trim tabs
(4) Coordination of pitch and power
(5) Level offs from climbs and glides; directional control

STRESS:
(1) Alertness and division of attention - looking around
(2) Use of control pressure and not movement in the air
(3) Proper torque correction
(4) Use of Checklist

READING ASSIGNMENT: Review Chapters 9, 10 and 12 Student Pilot Flight Manual.

THIS PERIOD:	Dual	1.0	Solo	S.I.	.2	Oral
TOTAL		(3.0)			(.4)	

LESSON NO. 5 DUAL

REVIEW:
(1) Coordination Exercises
(2) Four fundamentals of flight

DEMONSTRATE:
(1) Power off stalls
(2) Power on stalls
(3) Stall demonstration as instructor feels necessary
(4) Simple F.L. and emergency procedures

PRACTICE:
(1) Climbs and glides; climbing and gliding turns
(2) Straight and level flight at various airspeeds
(3) Power off and power on stalls
(4) Coordination exercises

STRESS:
(1) Division of attention - head out of cockpit
(2) Staying relaxed and ways to accomplish this
(3) Use of pressure on controls
(4) Altitude, directional and bank control by visual reference
(5) Good safe flying habits

READING ASSIGNMENT: Chapter 11, Student Pilot Flight Manual and FAR's 61 and 91
Complete pilot's questionnaire - Primary Trainer

THIS PERIOD:	Dual	1.0	Solo	S.I.		Oral
TOTAL		(4.0)			(.4)	

LESSON NO. 6 ORAL

Discussion of local ground and air traffic patterns and rules; engine out and radio failure emergencies; communications procedures and light signals. Review pertinent sections of FAR's 61 and 91.

READING ASSIGNMENT: Chapters 13 and 14, Student Pilot Flight Manual

THIS PERIOD:	Dual	Solo	S.I.	Oral
TOTAL	(4.0)		(.4)	

LESSON NO. 7 DUAL

REVIEW:
(1) Basic flying techniques - four fundamentals
(2) Power on and off stalls

DEMONSTRATE:
(1) Wind drift correction
(2) S Turns
(3) Rectangular courses
(4) Spacing by reference to aircraft on rectangular course at 800'
(5) Engine failure on take-off
(6) Steep turns

PRACTICE:
(1) As necessary to begin to understand wind drift, "S" turns, rectangular course
(2) Forced landings; emergency procedures
(3) Forced landings on take-off

STRESS:
(1) Proper drift correction
(2) Any maneuver or procedure that needs emphasis
(3) Staying oriented; looking around

READING ASSIGNMENT: Review chapters 12 and 13, Student Pilot Flight Manual

THIS PERIOD:	Dual	1.0	Solo	S.I.	Oral
TOTAL		(5.)		(.4)	

LESSON NO. 8 DUAL

REVIEW:
(1) Wind drift correction, "S" turns, rectangular course
(2) Climbing and gliding turns
(3) Power on and off stalls
(4) Slow flight

DEMONSTRATE:
(1) Take-off
(2) Slips, forward and side
(3) Accelerated stalls
(4) High altitude emergencies
(5) Power approach and landing

PRACTICE:
(1) Power off stalls
(2) Rectangular course
(3) Forward and side slips

STRESS:
(1) Wind drift correction as related to rectangular course (traffic pattern)
(2) Visualizing flight path over the ground

READING ASSIGNMENT: None

THIS PERIOD:	Dual	1.0	Solo	S.I.	.2	Oral
TOTAL		(6.0)			(.6)	

LESSON NO. 9 DUAL

REVIEW:

(1) All basic maneuvers - instructor will work with student in any area necessary to improve basic flying technique

DEMONSTRATE:

(1) Aborted take-off
(2) Overshooting and undershooting procedures
(3) Go-around procedures
(4) Slip method of drift correction on final approach
(5) Full stall landings

PRACTICE:

(1) All previous lessons as necessary
(2) Take-offs and landings
(3) Traffic pattern and traffic pattern entry
(4) (If cross wind) - Slip method of drift correction on final approach

STRESS:

(1) Torque corrections as necessary for proper coordination
(2) Alertness on ground and in the air
(3) Keeping area cleared
(4) Altitude and airspeed control in traffic
(5) Proper drift correction in traffic pattern (crab)
(6) Proper spacing
(7) Proper radio procedure

READING ASSIGNMENT: None

THIS PERIOD:	Dual	1.0	Solo	S.I.		Oral
TOTAL		(7.0)			(.6)	

LESSON NO. 10 DUAL

REVIEW:

(1) Traffic patterns
(2) Proper spacing in traffic
(3) Any weak points student may have
(4) Take-off and landing

DEMONSTRATE:

(1) Elevator trim tab stall - demonstration at instructor's discretion
(2) Cross-control stalls; departure stalls; arrival stalls
(3) Turns about a point
(4) Slow flight with flaps
(5) Stalls with flaps

PRACTICE:

(1) Slow flight
(2) Power on and power off stalls
(3) Traffic pattern and landings
(4) Go-arounds

STRESS:

(1) Traffic entry
(2) Spacing in traffic
(3) Flying traffic pattern in a rectangular pattern
(4) Courtesy and common sense
(5) Necessity of being alert

READING ASSIGNMENT: Review Part 91, FAR, in preparation for solo flight

THIS PERIOD: Dual 1.0 Solo S.I. Oral
TOTAL (8.0) (.6)

NOTE: Before Lesson No. 11 can be given, student must have passed the E-R pre-solo written on FAR, aircraft operation, local rules and regulations and must have passed a blindfold cockpit check given by his instructor. (It is suggested that the instructor let the student sit in the aircraft for a few minutes to familiarize himself with the particular aircraft in which the cockpit check will be given.)

LESSON NO. 11 PRE-SOLO PROGRESS CHECK

PURPOSE:

(1) To see if the student will be able to solo and to continue in the program. A grade of no less than "C" is necessary for the student to continue. Less than a "C" will require that the student be given a minimum of two hours additional training before he can continue with regular program.

MANEUVERS:

(1) Student will demonstrate his ability to perform any of the maneuvers that have been covered to this point.

READING ASSIGNMENT: None

THIS PERIOD: Dual .7 Solo S.I. Oral
TOTAL (8.7) (.6)

LESSON NO. 12 DUAL AND SOLO (OR DUAL)

REVIEW:

(1) As necessary to prepare student for first supervised solo flight

PRACTICE:

(1) Basic maneuvers in which student is weak

STRESS:

(1) Good basic flying and correct techniques. Student should be able to correct bad landings, abort take-off that is not correct, go around instead of landing
(2) His responsibility in traffic, clearing runway, etc.

NOTE: If the student is ready for solo, the instructor should have previously taken care of all tests and paper work. If student does not solo during this lesson he must be soloed on extra training slips. Lessons No. 13 and 14 will be the 2nd and 3rd supervised solo.

READING ASSIGNMENT: Chapter 18, Page 115, Flap Operation, Student Pilot Flight Manual

THIS PERIOD: Dual .6 Solo .7 S.I. Oral
TOTAL (9.3) (.7) (.6)

LESSON NO. 13 SOLO (SUPERVISED)

READING ASSIGNMENT: None

THIS PERIOD: Dual .5 Solo .7 S.I. Oral
(9.8) (1.4) (.6)

LESSON NO. 14 SOLO (SUPERVISED)

READING ASSIGNMENT: None

THIS PERIOD: Dual .5 Solo .6 S.I. Oral
TOTAL (10.3) (2.0) (.6)

LESSON NO. 15 SOLO
This is the student's first completely solo flight. Instructor will supervise pre-flight activity and determine satisfactorily weather conditions and that student will remain in the traffic pattern during this period and practice landings and take-offs. At least five landings and take-offs should be accomplished.

READING ASSIGNMENT: None

THIS PERIOD: Dual Solo 1.0 S.I. Oral
TOTAL (10.3) (3.0) (.6)

LESSON NO. 16 SOLO
Student will remain in the traffic pattern and practice take-offs and landings. At least five take-offs and landings will be completed.

READING ASSIGNMENT: None

THIS PERIOD: Dual Solo 1.0 S.I. Oral
TOTAL (10.3) (4.0) (.6)

LESSON NO. 17 DUAL (AREA CHECKOUT)
REVIEW:
(1) Power on and off stalls
(2) Steep turns
(3) Slow flight
(4) Boundaries of practice area
DEMONSTRATE:
(1) VOR basic orientation, tracking to the station
(2) IR - turns by magnetic compass
(3) Use of map by student in practice area
STRESS:
(1) Traffic pattern entry
(2) Correct spacing in pattern
(3) Remaining alert at all times

READING ASSIGNMENT: Review chapters 9, 12 (pages 63-71), 13 and 14, Student Pilot Flight Manual

THIS PERIOD: Dual 1.0 Solo S.I. .3 Oral
TOTAL (11.3) (4.0) (.9)

LESSON NO. 18 SOLO
REVIEW AND PRACTICE:
(1) Climbs and climbing turns
(2) Clearing turns (Prior to flow flight and stalls minimum altitude for recovery from stalls is 1500' AGL)
(3) Slow flight - 090° 180° turns with and without flaps
(4) Accelerated stalls, power on and off stalls
(5) As directed by instructor

READING ASSIGNMENT: None

THIS PERIOD: Dual Solo 1.0 S.I. Oral
TOTAL (11.3) (5.0) (.9)

LESSON NO. 19 SOLO
REVIEW:
(1) As directed by instructor

READING ASSIGNMENT: None

THIS PERIOD: Dual Solo 1.0 S.I. Oral
TOTAL (11.3) (6.0) (.9)

LESSON NO. 20 DUAL
REVIEW:
(1) Turns about a point
(2) All stalls, arrival, accelerated, departure stall entry
(3) Slow flight with and without flaps
(4) Forward and side slips
(5) Steep turns of 360° - to be increased to 720° when student is ready
DEMONSTRATE:
(1) Around pylon 8's
(2) More complicated forced landings than those given previously
(3) Short field take-offs and landings, soft field take-offs and landings
PRACTICE:
(1) As necessary for above named flight maneuvers
STRESS:
(1) Student's weak points
(2) Precision flying
(3) Alertness and division of attention

READING ASSIGNMENT: Review chapters 12, 14 and 15, Student Pilot Flight Manual

THIS PERIOD: Dual 1.0 Solo S.I. .2 Oral
TOTAL (12.3) (6.0) (1.1)

LESSON NO. 21 SOLO
PRACTICE:
(1) As directed by instructor

READING ASSIGNMENT: Chapters 9 (pages 51-53), 11, 13 and 18 (pages 113-114) Student Pilot Flight Manual

THIS PERIOD: Dual Solo 1.0 S.I. Oral
TOTAL (12.3) (7.0) (1.1)

LESSON NO. 22 PROGRESS CHECK
During this period the student shall demonstrate to the check pilot his knowledge of all techniques and procedures learned in the preceding periods of dual instruction. The student will be evaluated on the basis of judgment, planning, knowledge of procedures, coordination and smoothness. The student must achieve an overall grade of average on this progress check prior to continuation of the program. In the event of

an unsatisfactory grade the individual instructor will give the student at least two hours of additional dual instruction followed by a re-check. This progress check must be successfully completed prior to the start of Lesson No. 23.

READING ASSIGNMENT: None

THIS PERIOD:	Dual	.7	Solo		S.I.		Oral
TOTAL		(13.0)		(7.0)		(1.1)	

LESSON NO. 23 SOLO
PRACTICE:
(1) As directed by instructor

READING ASSIGNMENT: None

THIS PERIOD:	Dual		Solo	1.0	S.I.		Oral
TOTAL		(13.0)		(8.0)		(1.1)	

LESSON NO. 24 SOLO
PRACTICE:
(1) Student will practice particular maneuvers as specified by the instructor using techniques for correcting errors he suggests

READING ASSIGNMENT: None

THIS PERIOD:	Dual		Solo	1.0	S.I.		Oral
TOTAL		(13.0)		(9.0)		(1.1)	

LESSON NO. 25 ORAL
Discussion shall include map preparation, checking weather prior to departure, use of computor, Airman's Information Manual and other publications necessary for cross-country planning and preparation, flight log preparation, completion of flight plan form, methods of filing flight plan and a review of cross-country procedures as outlined in the school student operations manual. The instructor should emphasize to the student the importance of observing changes in the weather from forecast conditions while enroute and of avoiding flying over cloud formations. Procedures to follow when lost or when inadvertently entering instrument flight conditions should be reviewed in detail. Use of radio aids to navigation with emphasis on VOR should be included.

READING ASSIGNMENT: Chapter 21 (pages 129-131 VOR), Student Pilot Flight Manual

THIS PERIOD:	Dual		Solo		S.I.		Oral
TOTAL		(13.0)		(9.0)		(1.1)	

LESSON NO. 26 DUAL (CROSS-COUNTRY)
Pre-flight disucssion shall include pre-flight planning, plotting of the course, preparing flight log, weather briefing, filing flight plan (FVFR and explanation of DVFR), procedures to follow when lost. During the flight, the instructor will supervise and instruct the student in dead reckoning navigation, pilotage, communications procedures to include position reporting, obtaining weather information, making changes of flight plan enroute and the use of radio navigation aids. At least one landing will be made at a strange field during the course of the flight. In instances

where the home base or point of departure is not equipped with a control tower, the flight will be planned so that the required strange field landing is made at an airport served by a control tower and requiring the use of functioning two-way radio communications. Planned duration of this flight is three hours.

READING ASSIGNMENT: Review thoroughly Part 4 (pages 119-156), Student Pilot Flight Manual

THIS PERIOD:	Dual	3.0	Solo		S.I.	.3	Oral
TOTAL		(16.0)		(9.0)		(1.4)	

LESSON NO. 27 SOLO

PRACTICE:

(1) Climbs and climbing turns to altitude
(2) Slow flight with full flaps
(3) Climb at slow flight
(4) Descents at slow flight
(5) Short field take-offs and landings as directed by instructor
(6) Soft field take-offs and landings as directed by instructor

READING ASSIGNMENT: FAA Flight Training Handbook (as directed by instructor)

THIS PERIOD:	Dual		Solo	1.0	S.I.		Oral
TOTAL		(16.0)		(10.0)		(1.4)	

LESSON NO. 28 SOLO

PRACTICE:

(1) Climb and climbing turns to altitude
(2) Departure stalls, arrival stalls, accelerated stalls
(3) Spiral - Right and left to 1500'
(4) Around pylon 8's
(5) As directed by instructor

READING ASSIGNMENT: FAA Flight Training Handbook (as directed by instructor)

THIS PERIOD:	Dual		Solo	1.0	S.I.		Oral
TOTAL		(16.0)		(11.0)		(1.4)	

LESSON NO. 29 DUAL

Review:

(1) Basic instrument flying techniques - straight and level, standard rate turns, constant airspeed climbs and descents and turns, magnetic compass
(2) VOR turning and tracking
(3) High and low level emergency
(4) Around pylon 8's rectangular course, "S" turns, 720'/pt
(5) All stalls
(6) Slow flight - full flaps
(7) Stalls with flaps
(8) 360° Overhead

DEMONSTRATE:

(1) Spirals, 1080° overhead
(2) Short field take-offs and landings with cross-wind
(3) Soft field take-offs and landings with cross-wind

(4) Accuracy landings
(5) 180° side approach

PRACTICE:
(1) As demonstrated by instructor
(2) As needed by particular student

STRESS:
(1) Looking around
(2) Planning and judgment
(3) Positive aircraft control

READING ASSIGNMENT: FAA Flight Training Handbook and E-RAI Basic Instrument Handbook (as directed by instructor)

THIS PERIOD:	Dual	1.0	Solo	S.I.	.2	Oral
TOTAL		(17.0)	(11.0)		(1.6)	

LESSON NO. 30 SOLO

PRACTICE:
(1) As directed by instructor

READING ASSIGNMENT: FAA Flight Training Handbook and E-RAI Basic Instrument Handbook (as directed by instructor)

THIS PERIOD:	Dual		Solo	1.0	S.I.	Oral
TOTAL		(17.0)	(12.0)		(1.6)	

LESSON NO. 31 SOLO

PRACTICE:
(1) As directed by instructor

READING ASSIGNMENT: FAA Flight Training Handbook and E-RAI Basic Instrument Handbook (as directed by instructor)

THIS PERIOD:	Dual		Solo	1.0	S.I.	Oral
TOTAL		(17.0)	(13.0)		(1.6)	

LESSON NO. 32 ORAL

The instructor will discuss with the student the essential differences between day and night vision, the preservation of night vision, proper cockpit lighting, the importance of having within reach a serviceable flashlight, navigation lights and interpretation and the use of landings lights. Prior to night flight, the student should be able to accomplish satisfactorily a blindfold cockpit check in the aircraft to be utilized. Discussion should be terminated with a review of airport and obstruction lighting systems.

READING ASSIGNMENT: None

THIS PERIOD:	Dual		Solo		S.I.	Oral
TOTAL		(17.0)	(13.0)		(1.6)	

LESSON NO. 33 DUAL (NIGHT)

Introduce and discuss and practice runway alignment and take-offs techniques, controlled "sink-rate" approaches, and night landing techniques, with and without the

use of landing light. Practice take-offs and landings until the student is safe for solo night flight.

READING ASSIGNMENT: Chapters 23, 24 and 25 Student Pilot Flight Manual

THIS PERIOD:	Dual	1.0	Solo	S.I.	.2 Oral
TOTAL		(18.0)	(13.0)		(1.8)

LESSON NO. 34 PROGRESS CHECK
The student shall demonstrate his knowledge of pre-flight planning and the actual application of cross-country flying techniques and procedures to the check pilot. He must complete this progress check with an overall grade of average or above before he can continue with his solo cross-country requirements.

READING ASSIGNMENT: None

THIS PERIOD:	Dual	1.0	Solo	S.I.	Oral
TOTAL		(19.0)	(13.0)		(1.8)

LESSON NO. 35 SOLO (CROSS-COUNTRY)
This will be the student's first solo cross country flight. All pre-flight planning, etc. will be personally and strictly supervised by the instructor. The flight shall be over a triangular course and of two hours total duration. The course shall be selected so as to provide maximum utilization of dead reckoning and pilotage techniques and at least one leg utilizing radio aids shall be included.

READING ASSIGNMENT: None

THIS PERIOD:	Dual		Solo	2.5 S.I.	Oral
TOTAL		(19.0)	(15.5)		(1.8)

LESSON NO. 36 DUAL (OR PROGRESS CHECK - See Lesson No. 43 if Progress Check)
REVIEW:
(1) All private pilot maneuvers including ground reference maneuvers

READING ASSIGNMENT: None

THIS PERIOD:	Dual	1.0	Solo	S.I.	.2 Oral
TOTAL		(20.0)	(15.5)		(2.0)

LESSON NO. 37 SOLO
PRACTICE:
(1) As directed by instructor

READING ASSIGNMENT: None

THIS PERIOD:	Dual		Solo	1.0 S.I.	Oral
TOTAL		(20.0)	(16.5)		(2.0)

LESSON NO. 38 SOLO (CROSS-COUNTRY)
This is the student's second solo cross-country flight. The flight shall be conducted over a course of at least three legs, one of which is to be a destination located at a distance equal to 1.5 hours of flight at cruising speed, no wind, in the aircraft used from the point of departure. Dead reckoning combined with pilotage

and radio aids shall be the means of navigation. The flight should be of 3.5 hours duration.

READING ASSIGNMENT: None

THIS PERIOD: Dual Solo 3.5 S.I. Oral
TOTAL (20.0) (20.0) (2.0)

LESSON NO. 39 DUAL
REVIEW:
(1) All maneuvers VR, IR as given in this program

READING ASSIGNMENT: None

THIS PERIOD: Dual 1.0 Solo S.I. .3 Oral
TOTAL (21.0) (20.0) (2.3)

LESSON NO. 40 SOLO
PRACTICE:
(1) As directed by instructor

READING ASSIGNMENT: None

THIS PERIOD: Dual Solo 1.0 S.I. Oral
TOTAL (21.0) (21.0) (2.3)

LESSON NO. 41 DUAL
REVIEW AS NEEDED:
(1) All stalls including stalls with flaps
(2) 720° steep turns
(3) Slow flight at minimum controllable airspeed
(4) Coordination exercises
(5) Spirals, 1080 overhead, forced landings
(6) Around pylon 8's, 720/pt
(7) Short and soft field take-off's and landings, slips
(8) Power approaches, accuracy landings

READING ASSIGNMENT: Private Pilot's Test Guide, Private Pilot's Manual, Student Pilot Flight Manual, E-RAI Basic Instrument Handbook, FAA Flight Training Handbook and FAA 61-21

THIS PERIOD: Dual 1.0 Solo S.I. .2 Oral
TOTAL (22.0) (21.0) (2.5)

LESSON NO. 42 SOLO
PRACTICE:
(1) As directed by instructor

READING ASSIGNMENT: None

TOTAL PERIOD: Dual Solo 1.0 S.I. Oral
TOTAL (22.0) (22.0) (2.5)

LESSON NO. 43 PROGRESS CHECK

The primary and basic flight program is now complete and during this period the student should demonstrate to the check pilot his knowledge of flight, with the proficiency of a private pilot. This check shall be conducted in accordance with the procedures outlined in Federal Aviation Agency Advisory Circular 61-3. The check pilot shall indicate in his final report any and all areas in which the student is below average. The student must receive a final overall grade of average or "C" in order to successfully complete the program. Should the student fail to satisfactorily accomplish any phase of this final check, the individual instructor may give two hours of additional dual instruction to correct the student's weaknesses. A re-examination in these phases will then be required. Upon unsatisfactory completion of this final check the instructor will complete the student's files including the FAA Form 355 and cumulative flight record. The student will then be recommended for the private pilot's flight test with the appropriate FAA representative.

READING ASSIGNMENT: None

THIS PERIOD:	Dual	1.0	Solo		S.I.	.3	Oral
TOTAL		(23.0)		(22.0)		(2.8)	

USE OF THE ANGLE OF ATTACK INDICATOR

The following extracts were taken from a Memorandum to flight instructors and students of the experimental group on use of the angle of attack indicator:

* * * * * * * * * * * * * *

The dial of the instrument is graduated in thirty units. These units are not degrees of angle of attack, but are purely arbitrary reference units. Use of the instrument requires knowledge of which reference unit pertains to the particular maneuver contemplated. The first reference indicates zero lift and is located at the 5 unit index. Since this index corresponds to the angle of attack for zero lift, flight at this reading would be impossible. The second index is at the 15 unit mark. This is called the approach roger. This index is the optimum approach angle and is based on an airspeed of 1.3 VSO. The 15 unit mark also is the angle of attack for the best rate of climb. The next index on the dial (18½ units) indicates the angle of attack for the best glide. This reading also is the same for the angle of attack for maximum range. The last marked index on the dial is the stall index at 25 units. When the pointer reaches the 25 mark the stall warning horn is actuated automatically.

4. USE OF THE ANGLE OF ATTACK INDICATOR (AAI)

During the conduct of this project there must be no deviation from the prescribed syllabus, either with Control students or Experimental. This tends to eliminate all differences between the two groups except for the AAI. Members of the Experimental Group will be instructed in use of the AAI as described in the following maneuvers:

a. Straight and Level Flight--A power setting of 2450 rpm will be used as standard which will give an average indicated airspeed of 97 mph at 2,000 feet. The angle of attack reading is 12 units. It should be pointed out that the difference between zero lift (5 units) and 12 units is the angle of attack needed to support the aircraft in flight at one "G". Any change in weight or thrust would require a corresponding change in the angle of attack which would be reflected by the AAI.

b. Straight and Level at Reduced Airspeed--This will be accomplished at 60 mph, approximately 2,100 rpm, AAI 21 units.

c. Turns--Turns will be practiced with varying degrees of bank--up to 45 in level flight. It should be pointed out that during a turn centrifugal force increases the load factor. Therefore additional lift is required which may be obtained by increasing the angle of attack. Banks and turns for purposes of this project will be executed as shown below:

(1) Gliding Turns (30° bank) 70 mph, AAI 15 units

(2) Climbing Turns (20° bank) 75 mph, AAI 15 units

(3) 720° Steep Turns (45° bank) 80 mph, AAI 16.4 units

d. Stalls—Standard procedures for entry and recovery from all stalls will be employed to include power on and power off stalls with all flap configurations. The comparative reliability of the angle of attack indicator to the airspeed indicator when operating in the stall range should be noted.

e. Climbs—Normal climbs will be accomplished at 75 mph, AAI 14 units. Best rate of climb will be at the speed of 72 mph, AAI 15 units. Best angle of climb will be at 52 mph, AAI 20 units. Power settings for all climbs will be full throttle.

f. Approaches—Normal approaches will be made with 20° of flaps, 65 mph airspeed, and AAI 15 units. Short field approaches will be made with 40° of flaps, 58 mph, AAI at 15 units as in the Approach Roger. Here emphasis should be placed on holding the AAI pointer on the approach index which also will provide proper airspeed. Power must be adjusted and coordinated to control descent.

When an angle of attack indicator is installed and calibrated for a given airplane design the instrument should give the same readings for specific maneuvers for all airplanes of the same type. However, slight differences in the rigging of airplanes of the same model produce inequities which are reflected in the AAI. Also, the angle of attack instrument is sensitive to rough air. There is a dampening mechanism incorporated in the system, but rough air still causes the pointer to fluctuate. Therefore, use average indications. Instructors are cautioned to be alert for the student who has a tendency to concentrate his attention on the AAI rather than cross checking with other instruments and flying the airplane with reference to the horizon.

APPENDIX E

EMBRY-RIDDLE AERONAUTICAL INSTITUTE

PERFORMANCE ANALYSIS BOOKLET

(Master Copy)

NAME OF STUDENT: _____

DATE: _____

PROGRESS CHECK: Pre-Solo, 20-Hr., Final

PERFORMANCE ANALYSIS SHEET

Maneuver: Take-off (Normal, Cross-wind, Short Field, Soft Field)

Element or Phase	Manner of Performance
Directional Control during take-off run	1. Veered to right or left excessively
	/ X. Maintained straight path
Lift-off as requred by type of take-off being executed	1. Too soon or too late
	/ X. At proper time
Attitude immediately after lift-off considering type of take-off	1. Nose too high
	2. Nose too low
	/ X. Correct attitude
Climb-out flight path	1. Drifted to right
	2. Drifted to left
	/ X. Maintained proper ground track (extension of runway)
Attitude during climb-out	1. Nose too high
	2. Nose too low
	3. Nose oscillated
	/ X. Held correct attitude for maximum rate of climb or angle of climb as specified.

SCORE _____

PERFORMANCE ANALYSIS SHEET

Maneuver: Climbing Turns--Gliding Turns

Element or Phase	Manner of Performance	
Angle of Bank	/ X. Held constant	
	2. Varied excessively	
Number of degrees of angle of bank	1. 5°	6. 30°
	2. 10°	7. 35°
	3. 15°	8. 40°
	/ X. 20°	
	5. 25°	
Airspeed	/ X. Held constant	
	2. Varied excessively	
Average Indicated Airspeed	1. 50	/ X. 75
	2. 55	7. 80
	3. 60	8. 85
	4. 65	9. 90
	5. 70	

Climbing Turns--Gliding Turns

Element or Phase	Manner of Performance
Coordination	2 X.
	1 X.
	This or This
	3.
	This or This

SCORE _____

PERFORMANCE ANALYSIS SHEET

Maneuver: Straight and Level Flight (Normal Cruise)

Element or Phase	Manner of Performance
Pitch Attitude Control	/ X. Held constantly correct
	2. Nose high tendency
	3. Nose low tendency
	4. Nose position oscillated excessively
Altitude Control	2 X. Held proper altitude
	/ X. Deviated not more than 100' above
	3. Deviated more than 100' above
	/ X. Deviated not more than 100' below
	5. Deviated more than 100' below
Power Control	/ X. Regulated power setting as required to maintain proper altitude and airspeed
	2. Inadequate power control
Heading Control	2 X. Held heading within $\pm 5^{\circ}$
	/ X. Held heading within $\pm 10^{\circ}$
	3. Allowed heading to deviate more than $\pm 10^{\circ}$

SCORE _____

PERFORMANCE ANALYSIS SHEET

Maneuver: Straight and Level Flight at Reduced Airspeed

Element or Phase	Manner of Performance
Pitch Attitude Control	1 X. Proper nose position for specified airspeed
	2. Nose tended to be too high
	3. Nose tended to be too low
	4. Nose position oscillated excessively
Altitude Control	2 X. Held proper altitude
	1 X. Deviated not more than 100' above
	3. Deviated more than 100' above
	1 X. Deviated not more than 100' below
	5. Deviated more than 100' below
Power Control	1 X. Regulated power setting as required to maintain proper altitude and airspeed
	2. Inadequate power control
Heading Control	2 X. Held heading within $\pm 5^{\circ}$
	1 X. Held heading within $\pm 10^{\circ}$
	3. Allowed heading to deviate more than $\pm 10^{\circ}$

SCORE_____

PERFORMANCE ANALYSIS SHEET

Maneuver: Stalls (Arrival, Departure and Accelerated)

Element or Phase	Manner of Performance
Pre-Stall Procedure	3 X. Proper sequence
	2. Inadequate
Recognition of Stall	1 X. Recognized at proper time
	2. Excessive time to recognize
	3. Did not recognize
Recovery Technique	2 X. Proper sequence and timing
	2. Inadequate timing and sequence

SCORE _____

PERFORMANCE ANALYSIS SHEET

Maneuver: Stalls (Arrival, Departure and Accelerated)

Element or Phase	Manner of Performance
Pre-Stall Procedure	3 ~~1~~. Proper sequence
	2. Inadequate
Recognition of Stall	1 ~~1~~. Recognized at proper time
	2. Excessive time to recognize
	3. Did not recognize
Recovery Technique	2 ~~1~~. Proper sequence and timing
	2. Inadequate timing and sequence

SCORE _____

PERFORMANCE ANALYSIS SHEET

Maneuver: Stalls (Arrival, Departure and Accelerated)

Element or Phase	Manner of Performance
Pre-Stall Procedure	3 ~~1~~. Proper sequence
	2. Inadequate
Recognition of Stall	1 ~~1~~. Recognized at proper time
	2. Excessive time to recognize
	3. Did not recognize
Recovery Technique	2 ~~1~~. Proper sequence and timing
	2. Inadequate timing and sequence

SCORE _____

PERFORMANCE ANALYSIS SHEET

Maneuver: 720° Steep Turn

Element or Phase	Manner of Performance
Establishment of Turn	1. Failed to coordinate elevators with ailerons and rudder while establishing bank
	/ X. Established proper angle of bank and turn smoothly and timely with proper power control
	3. Insufficient angle of bank or excessive time in establishing bank
	4. Failed to add power
Altitude Control During Turn	/ X. Held proper altitude within ±100'
	2. Deviated more than 100' above
	3. Deviated more than 100' below
Coordination	2 X.
*At any time during turn	/ X.
	This or This*
	3.
	This or This*
Angle of Bank During Turn	/ X. Proper steepness and constant angle
	2. Varied excessively

720° Steep Turn

Element or Phase		Manner of Performance
Recovery Heading	2 ~~1~~.	At proper point
	1 ~~2~~.	Within ±10° of proper point
	3.	More than 10° to right or left of proper point
Execution of Roll-Out	1 ~~1~~.	Properly coordinated and terminated with nose in proper position with respect to the horizon, and proper power control
	2.	Properly coordinated, but terminated with nose too high or too low
	3.	Poor coordination and improper pitch attitude at termination of maneuver (nose too high or too low), and improper power control

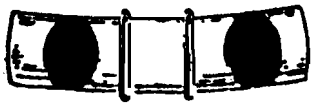
SCORE _____

PERFORMANCE ANALYSIS SHEET

Maneuver: Climbing Turns--Gliding Turns

Element or Phase	Manner of Performance	
Angle of Bank	/ X. Held constant	
	2. Varied excessively	
Number of degrees of angle of bank	1. 5°	/ X. 30°
	2. 10°	7. 35°
	3. 15°	8. 40°
	4. 20°	
	5. 25°	
Airspeed	/ X. Held constant	
	2. Varied excessively	
Average Indicated Airspeed	1. 50	6. 75
	2. 55	7. 80
	3. 60	8. 85
	4. 65	9. 90
	/ X. 70	

Climbing Turns--Gliding Turns

Element or Phase	Manner of Performance
Coordination	2
	1 This or This
	3.  This or This

SCORE _____

PERFORMANCE ANALYSIS SHEET

Maneuver: Turns About a Point

Element or Phase	Manner of Performance
Altitude Control	2 ✗. Altitude varied not more than ±50'
	1 ✗. Altitude varied not more than ±100'
	3. Altitude varied more than ±100'
Coordination	2 ✗.
	1 ✗.
	This or This
	3.
	This or This
Ground Track	2 ✗. Perfectly symmetrical, circular and at constant distance from given point
	1 ✗. Moderately symmetrical, circular and at constant distance from given point
	3. Fairly symmetrical, circular, but inadequate correction for wind drift (center point not same distance from all points on circle)
	4. Ground track unsymmetrical or not a circle

SCORE_____

PERFORMANCE ANALYSIS SHEET

Maneuver: Landing (Normal, Cross-Wind, Short Field, Soft Field)

Element or Phase	Manner of Performance
Traffic Pattern Entry	/ X. At proper angle of intersection with downwind leg, at proper altitude, and proper distance from runway
	2. Poor entry
Downwind Leg	/ X. In proper direction and parallel to runway
	2. Not in proper direction
	3. Not parallel to runway
Base Leg (considering other traffic)	/ X. Proper position with proper correction for wind drift
	2. Too close
	3. Too far out
Turn Onto Final	/ X. At sufficient safe altitude
	2. Excessively low
	3. Excessively high
Alignment with Runway Centerline Upon Completion of Turn Onto Final	/ X. Properly Aligned
	2. Too far to right
	3. Too far to left
Glide Path	/ X. With proper directional control and proper descent to touchdown at designated point
	2. Erratic glide path
	3. Landed when missed approach should have been executed, i.e., landed beyond first 1/3 of runway
	4. Had to drag it in

Landing (Normal, Cross-wind, Short Field, Soft Field)

Element or Phase		Manner of Performance
Round-out and touchdown	/	X. Smooth and accurate
		2. Excessive speed and bounce
		3. Stall and drop-in
Ground Run	/	X. Straight with proper use of brakes
		2. Veered to right or left
Airspeed Control during entire approach and landing	/	X. Constant and correct amount for type of landing
		2. Varied excessively
Power Control during entire approach and landing	/	X. Properly applied or reduced power to adjust rate of descent as required
		2. Failed to use power properly

SCORE _____

PERFORMANCE ANALYSIS SHEET

Maneuver: Missed Approach

Element or Phase		Manner of Performance
Initial Sequence of Actions	/	1. Proper sequence
		2. Improper sequence
Transition from Descent to Climb	/	1. Smooth and positive
		2. Erratic
		3. Excessive delay in establishing climb
Heading Control on Climb-Out	2	1. Held heading within $\pm 5^{\circ}$
	/	2. Held heading within $\pm 10^{\circ}$
		3. Allowed heading to deviate more than $\pm 10^{\circ}$

SCORE_____

PERFORMANCE ANALYSIS SHEET

Maneuver: Landing (Normal, Cross-Wind, Short Field, Soft Field)

Element or Phase		Manner of Performance
Base Leg (considering other traffic)	/	X. Proper position with proper correction for wind drift
		2. Too Close
		3. Too far out
Turn Onto Final	/	X. At sufficient safe altitude
		2. Excessively low
		3. Excessively high
Alignment with Runway Centerline Upon Completion of Turn Onto Final	/	X. Properly aligned
		2. Too far to right
		3. Too far to left
Glide Path	/	X. With proper directional control and proper descent to touchdown at designated point
		2. Erratic glide path
		3. Landed when missed approach should have been executed, i.e., landed beyond first 1/3 of runway
		4. Had to drag it in
Round-out and touchdown	/	X. Smooth and accurate
		2. Excessive speed and bounce
		3. Stall and drop-in
Ground Run	/	X. Straight with proper use of brakes
		2. Veered to right or left

Landing (Normal, Cross-wind, Short Field, Soft Field)

Element or Phase	Manner of Performance
Airspeed Control during entire approach and landing	/ X. Constant and correct amount for type of landing 2. Varied excessively
Power Control during entire approach and landing	/ X. Properly applied or reduced power to adjust rate of descent as required 2. Failed to use power properly

SCORE _____

PERFORMANCE ANALYSIS SHEET

Maneuver: Take-off (Normal, Cross-wind, Short Field, Soft Field)

Element or Phase		Manner of Performance
Directional Control during take-off run		Veered to right or left excessively
	/ X.	Maintained straight path
Lift-off as required by type of take-off being executed	1.	Too soon or too late
	/ X.	At proper time
Attitude immediately after lift-off considering type of take-off	1.	Nose too high
	2.	Nose too low
	/ X.	Correct attitude
Climb-out flight path	1.	Drifted to right
	2.	Drifted to left
	/ X.	Maintained proper ground track (extension of runway)
Attitude during climb-out	1.	Nose too high
	2.	Nose too low
	3.	Nose oscillated
	/ X.	Held correct attitude for maximum rate of climb or angle of climb as specified.

SCORE_____

PERFORMANCE ANALYSIS SHEET

Maneuver: Landing (Normal, Cross-Wind, Short Field, Soft Field)

Element or Phase		Manner of Performance
Base Leg (considering other traffic)	/ X.	Proper position with proper correction for wind drift
	2.	Too Close
	3.	Too far out
Turn Onto Final	/ X.	At sufficient safe altitude
	2.	Excessively low
	3.	Excessively high
Alignment with Runway Centerline Upon Completion of Turn Onto Final	/ X.	Properly aligned
	2.	Too far to right
	3.	Too far to left
Glide Path	/ X.	With proper directional control and proper descent to touchdown at designated point
	2.	Erratic glide path
	3.	Landed when missed approach should have been executed, i.e., landed beyond first 1/3 of runway
	4.	Had to drag it in
Round-out and touchdown	/ X.	Smooth and accurate
	2.	Excessive speed and bounce
	3.	Stall and drop-in
Ground Run	/ X.	Straight with proper use of brakes
	2.	Veered to right or left

Landing (Normal, Cross-wind, Short Field, Soft Field)

Element or Phase	Manner of Performance
Airspeed Control during entire approach and landing	/ X. Constant and correct amount for type of landing 2. Varied excessively
Power Control during entire approach and landing	/ X. Properly applied or reduced power to adjust rate of descent as required 2. Failed to use power properly

SCORE _____

PERFORMANCE ANALYSIS SHEET

Maneuver: Take-off (Normal, Cross-wind, Short Field, Soft Field)

Element or Phase	Manner of Performance
Directional Control during take-off run	1. Veered to right or left excessively
	/ X. Maintained straight path
Lift-off as required by type of take-off being executed	1. Too soon or too late
	/ X. At proper time
Attitude immediately after lift-off considering type of take-off	1. Nose too high
	2. Nose too low
	/ X. Correct attitude
Climb-out flight path	1. Drifted to right
	2. Drifted to left
	/ X. Maintained proper ground track (extension of runway)
Attitude during climb-out	1. Nose too high
	2. Nose too low
	3. Nose oscillated
	/ X. Held correct attitude for maximum rate of climb or angle of climb as specified.

SCORE _____

PERFORMANCE ANALYSIS SHEET

Maneuver: Landing (Normal, Cross-Wind, Short Field, Soft Field)

Element or Phase		Manner of Performance
Base Leg (considering other traffic)	/	1. Proper position with proper correction for wind drift
		2. Too Close
		3. Too far out
Turn Onto Final	/	1. At sufficient safe altitude
		2. Excessively low
		3. Excessively high
Alignment with Runway Centerline Upon Completion of Turn Onto Final	/	1. Properly aligned
		2. Too far to right
		3. Too far to left
Glide Path	/	1. With proper directional control and proper descent to touchdown at designated point
		2. Erratic glide path
		3. Landed when missed approach should have been executed, i.e., landed beyond first 1/3 of runway
		4. Had to drag it in
Round-out and touchdown	/	1. Smooth and accurate
		2. Excessive speed and bounce
		3. Stall and drop-in
Ground Run	/	1. Straight with proper use of brakes
		2. Veered to right or left

Landing (Normal, Cross-wind, Short Field, Soft Field)

Element or Phase	Manner of Performance
Airspeed Control during entire approach and landing	/ ✗. Constant and correct amount for type of landing 2. Varied excessively
Power Control during entire approach and landing	/ ✗. Properly applied or reduced power to adjust rate of descent as required 2. Failed to use power properly

SCORE_____

PERFORMANCE ANALYSIS SHEET

Maneuver: Take-off (Normal, Cross-wind, Short Field, Soft Field)

Element or Phase	Manner of Performance
Directional Control during take-off run	1. Veered to right or left excessively
	/ 2. Maintained straight path
Lift-off as required by type of take-off being executed	1. Too soon or too late
	/ 2. At proper time
Attitude immediately after lift-off considering type of take-off	1. Nose too high
	2. Nose too low
	/ 3. Correct attitude
Climb-out flight path	1. Drifted to right
	2. Drifted to left
	/ 3. Maintained proper ground track (extension of runway)
Attitude during climb-out	1. Nose too high
	2. Nose too low
	3. Nose oscillated
	/ 4. Held correct attitude for maximum rate of climb or angle of climb as specified.

SCORE _____

SUMMARY SCORE SHEET

NAME_____ CTMM RAW SCORE_____

GROUP - Experimental or Control

MANEUVER	SCORE			
	Pre-Solo	20 Hour	Final	Total
Normal Take-off				
Climbing Turns				
Straight and Level Flight (Normal Cruise)				
Straight and Level Flight @ Reduced Airspeed				
720 Steep Turns				
Arrival Stalls				
Departure Stalls				
Accelerated Stalls				
Gliding Turns				
Turns About a Point				
Normal Landing				
Missed Approach				
Cross-wind Take-off				
Cross-wind Landing				
Short Field Take-off				
Short Field Landing				
Soft Field Take-off				
Soft Field Landing				
Totals				

APPENDIX G

DETAILED SCORES
PRE-SOLO FLIGHT CHECK

Maneuver	Max. Score	Experimental Group															Control Group														
		101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215
Normal T-O	5	5	5	5	4	5	2	5	4	1	4	3	4	5	2	5	5	2	3	5	2	4	5	5	5	2	0	3	3	4	4
Climbing Turn	6	4	3	4	4	3	2	6	4	4	3	3	0	4	3	2	4	2	3	3	1	3	5	4	3	2	0	3	2	2	1
S&L Flt.(Nor. Cr.)	6	6	5	5	3	5	3	4	4	0	2	4	3	6	3	3	5	2	3	5	4	5	2	6	5	2	3	5	4	4	6
S&L Flt.(Reduced A/S)	6	5	1	6	0	2	4	3	3	0	1	3	2	5	2	3	5	1	2	4	5	5	2	5	6	2	1	3	2	1	3
720° Steep Turns																															
Arrival Stalls	6	6	6	6	3	6	0	6	6	4	2	6	3	6	1	1	6	1	4	6	0	1	3	6	6	5	0	3	3	4	3
Departure Stalls																															
Accelerated Stalls																															
Gliding Turns	6	4	6	3	4	3	2	5	4	4	2	3	0	4	2	4	4	2	4	3	2	2	4	4	3	4	4	4	2	1	4
Turns About a Pt.																															
Normal Landing	10	10	8	6	6	3	3	4	6	3	7	4	10	9	4	9	8	9	7	10	1	8	9	9	6	3	0	3	5	4	9
Missed Approach																															
Cross-Wind T-O																															
Cross-Wind Ldg.																															
Short Field T-O																															
Short Field Ldg.																															
Soft Field T-O																															
Soft Field Ldg.																															

DETAILED SCORES
20-HOUR FLIGHT CHECK

Maneuver	Max. Score	Experimental Group															Control Group														
		101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215
Normal T-O	5	5	4	2	5	3	4	3	4	5	4	5	5	4	4	5	4	0	5	4	5	5	5	4	4	3	5	5	5	1	5
Climbing Turn	6	3	5	3	3	4	2	4	5	6	4	3	4	5	4	5	5	2	3	3	4	3	3	4	5	4	6	4	3	3	5
S&L Flt.(Nor. Cr.)	6	6	5	3	6	2	6	3	6	6	5	5	6	5	3	5	4	0	4	6	5	6	3	5	5	5	6	6	5	5	6
S&L Flt.(Reduced A/S)	6	1	5	4	6	5	5	2	6	5	3	4	6	3	3	6	5	1	4	5	5	5	3	5	3	4	5	1	6	6	6
720° Steep Turns	8	3	6	3	6	3	6	3	7	7	5	6	7	3	3	4	4	1	7	6	6	6	5	7	3	7	4	3	6	7	6
Arrival Stalls	6	6	3	1	3	3	6	3	6	6	6	6	6	3	3	1	6	0	5	6	6	6	4	6	3	6	6	6	6	6	3
Departure Stalls	6	3	4	1	4	3	6	6	6	6	6	6	6	6	3	4	6	0	6	6	6	4	4	6	6	6	6	3	6	6	6
Accelerated Stalls	6	3	6	0	6	1	6	3	6	6	6	3	3	3	5	0	6	0	6	3	6	6	4	6	3	6	6	6	6	6	6
Gliding Turns	6	3	4	3	5	4	4	4	3	5	4	4	4	4	5	5	5	2	5	5	5	5	3	6	2	3	4	5	4	4	4
Turns About a Pt.	6	2	5	2	3	4	3	4	3	5	3	3	3	2	2	4	2	2	6	2	4	3	4	4	3	3	3	5	3	3	4
Normal Landing	10	10	9	5	10	2	9	9	10	9	9	10	10	10	4	9	7	1	10	10	6	10	10	10	8	5	8	9	9	10	10
Missed Approach	4	3	3	2	3	2	3	4	4	3	3	3	4	1	3	4	4	0	4	4	4	3	4	4	3	4	3	4	4	4	3
Cross-Wind T-O	5	5	4	3	5	4	4	2	4	5	5	4	5	5	4	3	5	0	5	4	5	5	4	4	4	4	4	5	5	3	5
Cross-Wind Ldg.	8	8	4	4	8	2	7	4	7	7	7	4	8	8	5	6	5	0	8	8	5	8	6	7	3	3	6	7	8	6	6
Short Field T-O	5	3	4	2	5	4	3	3	4	4	4	4	2	5	3	4	2	0	4	4	5	5	4	4	5	4	3	5	5	3	5
Short Field Ldg.	8	7	6	3	6	7	5	7	8	7	4	8	5	8	5	5	6	0	8	7	5	8	7	6	6	8	6	3	8	7	6
Soft Field T-O	5	5	2	2	2	1	5	5	2	4	4	4	1	4	3	4	4	0	3	4	5	5	4	5	4	2	5	3	5	5	2
Soft Field Ldg.	8	3	6	6	6	6	6	8	6	7	7	7	7	8	3	8	6	0	8	8	3	8	7	8	5	5	7	6	8	8	6

DETAILED SCORES
FINAL FLIGHT CHECK

Maneuver	Max. Score	Experimental Group															Control Group														
		101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215
Normal T-O	5	5	5	3	5	5	5	5	5	2	4	4	5	4	3	5	5	5	5	5	5	5	5	5	4	4	5	5	4	3	4
Climbing Turn	6	3	6	3	2	3	4	4	5	4	4	3	5	3	5	5	4	4	3	2	5	4	5	4	2	3	3	5	6	4	5
S&L Flt.(Nor. Cr.)	6	6	4	0	2	4	6	6	6	2	4	6	5	6	6	6	5	6	6	2	6	5	5	5	3	3	4	6	5	6	6
S&L Flt.(Reduced A/S)	6	6	2	5	4	2	3	0	6	4	5	6	3	5	4	5	4	4	6	3	5	5	3	6	5	1	4	4	5	6	5
720° Steep Turns	8	6	7	2	4	5	4	6	7	3	6	6	6	3	6	5	5	6	5	5	7	7	2	6	6	2	6	7	7	4	5
Arrival Stalls	6	1	6	3	6	6	6	6	6	6	6	6	6	6	6	4	6	6	6	6	6	6	1	6	6	6	6	6	6	6	1
Departure Stalls	6	6	6	3	6	6	6	6	6	4	6	4	6	6	6	3	6	6	6	6	6	6	1	6	6	4	6	6	6	6	4
Accelerated Stalls	6	6	6	3	3	6	6	6	6	6	6	6	3	6	6	6	3	6	6	6	6	0	0	6	6	5	6	6	6	6	6
Gliding Turns	6	4	4	1	3	3	5	2	5	3	4	5	4	2	5	4	3	3	5	2	4	6	4	3	4	5	3	5	4	5	4
Turns About a Pt.	6	3	5	2	4	3	4	1	3	1	1	3	2	3	3	2	1	5	3	3	6	4	3	3	3	2	2	4	4	3	3
Normal Landing	10	10	10	5	10	10	9	9	10	10	10	9	9	9	9	8	5	9	10	10	10	10	2	10	10	8	10	8	10	9	5
Missed Approach	4	4	4	4	3	4	4	4	2	3	4	4	3	4	4	3	4	4	3	4	4	3	1	4	4	3	3	4	4	3	3
Cross-Wind T-O	5	5	5	3	5	3	5	5	5	1	5	4	4	5	3	4	5	5	1	0	5	5	1	5	5	4	5	5	4	5	5
Cross-Wind Ldg.	8	8	7	2	8	5	7	8	8	2	7	6	7	8	8	5	2	7	6	8	7	6	7	8	3	7	8	6	6	7	5
Short Field T-O	5	5	3	5	5	3	5	5	5	2	2	4	5	5	5	5	5	3	3	2	5	5	2	5	4	4	5	4	5	4	4
Short Field Ldg.	8	6	6	5	5	7	6	8	8	6	6	4	6	7	7	6	2	5	3	7	7	6	2	8	3	7	8	5	6	8	4
Soft Field T-O	5	5	5	2	5	5	5	4	5	2	5	4	5	5	5	4	5	4	2	3	5	3	1	4	4	4	5	2	4	3	2
Soft Field Ldg.	8	8	7	6	7	7	7	7	8	4	7	7	8	7	8	5	2	6	8	8	6	7	6	8	7	8	8	8	8	7	2

DATA ANALYSIS THEORY

Introduction

In order to promote an understanding of the method of data analysis used in this project, a review of the basic problem and procedures is suggested. The fundamental problem was to determine the value of the angle of attack indicator in flight training at the private pilot level in general aviation aircraft. The approach to the problem provided for training two samples of student pilots under identical conditions in the same course of instruction except one group (experimental) acquired pilot skills using the angle of attack instrument in addition to the aircraft instruments common to both groups. The performance of all students was observed and recorded during and at the termination of the course of instruction. Performance recordings then were converted into numerical scores for the purpose of comparing the two groups of students. However, direct comparison of scores will not produce valid information of differences between the two groups because errors of measurement and chance variations are inevitable. Insight as to the difference between these two groups, on the other hand, may be obtained by statistical inference. This process entails the utilization and application of certain tools and principles described in the following paragraphs.

Mean (M)

The arithmetic mean is the sum of the scores divided by the number of scores. The mean of the experimental or control group on any score set, therefore, is the sum of the scores comprising the set divided by 15, i.e., the number of scores or sample size.

Significance of the Difference of the Means

The difference of the means of the experimental group and control group scores on any score set is significant when the difference is presumed to denote a true difference between the groups. This occurs when the difference is assumed not to be attributed to chance factors. An experimentor should never completely eliminate the possibility that a difference in mean scores may be imputed to chance, but if he determines that the probability of chance is 1:20 or less, he may ascribe the difference to other causes. There are various techniques of making this determination, and in this report the analysis of variance method was used.

Null Hypothesis

The null hypothesis is one of the tools used in psychological research. It asserts that the difference between the means of two samples of the same population are accidental differences caused by errors of measurement and other chance variations. Repeated performance by the two samples on the same test could result in better scores by sample no. 1 in the first instance, and in the second instance sample no. 2 could excel. In this project, the null hypothesis was assumed, i.e., any differences in the performance of the experimental group and the control group on any score set was imputed to the factor of chance. The purpose of data analysis involving the use of inferential statistics, therefore, was to determine if the premise of the null hypothesis should be retained or rejected.

The approach to this determination was to calculate the probability that differences in the scores was due to chance. If it were found that the probability was 1:20 or less that the differences could be attributed to accident, then the null hypothesis would have been rejected. Recantation of the null hypothesis would have implied--as far as this test is concerned--that differences in the scores of the

experimental group and the control group were caused by factors other than chance, and that the two groups were from different student pilot populations. However, by design both groups initially were samples of the same populations. It would have been assumed, therefore, that the only reason for the change in homogeneity of the samples was the effect of training with the angle of attack indicator. Statistical calculations accomplished in connection with this project, on the other hand, revealed in all instances that the difference of the means of the two groups in successive measurements would have been caused by chance factors more than once in every twenty measurements. The null hypothesis, consequently, was not rejected.

Embry-Riddle Aeronautical Institute, Daytona Beach, Florida.

ANGLE OF ATTACK PRESENTATION IN PILOT TRAINING.

F. G. Forrest, Final Report, March 1969, 77 pp., incl. 3 illus., 7 refs., 3 tables, 8 app. (Contract No. FA67WA-1811, Project No. 560-004-03H, Report No. DS-69-6). Unclassified Report.

The possible value of angle of attack presentation in addition to other required instruments for flight training in general aviation aircraft was determined. Two groups of inexperienced flight students from the same population as measured by a mental aptitude test (CTMM) participated in identi-

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IV. Report No. DS-69-6

Descriptors

Angle of Attack
Attitude Indicators
Flight Instruments
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