INVESTIGATIONS OF THE RELATIVE AMOUNT OF TIME SPENT ON THE GROUND AND IN THE AIR BY CIVILIAN PILOT TRAINING STUDENTS

Prepared

by

National Research Council
Committee on Selection and
Training of Aircraft Pilots

March 1945

CIVIL AERONAUTICS ADMINISTRATION
Division of Research
Report No. 43
Washington, D. C.

National Research Council

Committee on Selection and Training of Aircraft Pilots

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LETTER OF TRANSMITTAL

NATIONAL RESEARCH COUNCIL

2101 Constitution Avenue, Washington, D. C.
Division of Anthropology and Psychology
Committee on Selection and Training of Aircraft Pilots

March 1, 1945

Dr. Dean R. Brimhall
Director of Research
Civil Aeronautics Administration
Washington 25, D. C.

Dear Dr. Brimhall:

Attached is a report entitled Investigations of the Relative Amount of Time Spent on the Ground and in the Air by Civilian Pilot Training Students. This report was prepared and is submitted by the Committee on Selection and Training of Aircraft Pilots with the recommendation that it be included in the series of technical reports issued by the Division of Research, Civil Aeronautics Administration.

The report is largely the outgrowth of your interest in examining the variations among airports, among instructors, among student pilots, etc., with respect to the amount of time spent on the ground and in the air during flight training. There are presented quantitative findings which are pertinent in these connections gathered in two preliminary studies at the University of Maryland and at Tulane University, and in a major integrated study at a number of airports conducted under the immediate direction of the staff of the Committee on Selection and Training of Aircraft Pilots.

Findings of the report confirm the opinion held by many that differences in amount of time spent in the air and on the ground do exist. The investigations were not sufficiently large in scope or exacting in design to permit definitive explanation of the reasons for such variations or to lead to specific recommendations as to the extent to which they should and how they can be eliminated. Perhaps the most immediately important finding of this series of studies is that which shows that students undergoing instruction in relatively small private fields, used solely for civilian trainees, spent a significantly greater proportion of time during Stages C and D actually flying than did student pilots training at the larger commercial airports. In general, the findings suggest the desirability for making instructors and operators aware of the need for considering special local situations which may result in excessively extending the amount of time spent on the ground during flight training.

Cordially yours,

M S Viteles

Morris S. Viteles, Chairman
Committee on Selection and
Training of Aircraft Pilots
National Research Council

MSV:tp

EDITORIAL FOREWORD

Very soon after the initiation of the research program of the Committee on Selection and Training of Aircraft Pilots, Dr. Dean R. Brimhall, Director of Research, Civil Aeronautics Administration, drew attention to the amount of time spent on the ground and in the air during flight periods as a possible source of significant variance in the training of civilian aircraft pilots. As a result, in 1940, observations were made of the proportion of flight time spent on the ground and in the air as an incidental feature of larger investigations being conducted at the College Park Airport, Maryland, and at the New Orleans Airport.

In both of these earlier studies registrations on commercial graphic recorders (R-S Ride Recorder and Friez Cable Control Recorder) were used as a means of determining the distribution of "flight time" between ground and air. Subsequently, the Committee on Selection and Training of Aircraft Pilots secured a supply of Servis Recorders, especially adapted for registering air, ground, and taxi time, and initiated a major study, conducted at four widely separated airports, designed to provide more extensive data on differences in the amount of time spent on the ground and in the air and on the influence of such factors as type of airport, instructor, student attitudes, etc., upon such variability.

There are included in the present report the findings of the two earlier studies, reported by R. M. Bellows, University of Maryland, and by H. M. Johnson, Tulane University, and those of the major study conducted by the Committee on Selection and Training of Aircraft Pilots. The latter investigation was largely designed and supervised by J. W. Dunlap, as Director of Research for the Committee on Selection and Training of Aircraft Pilots. F. L. Kelly, Purdue University, made major contributions, both to the design of the study and in the adaptation of the Servis Recorder for use in the investigation. M. W. Lund, University of Utah; E. L. Kelly, Purdue University; and L. Mishach, University of Kansas City, served as Project Supervisors in this study.

E. S. Ewart, formerly of the Purdue University research staff, was responsible for the initial treatment and organization of data from the major study, under the direction of J. W. Dunlap. The report was prepered in final form by the Editorial Staff, including particularly, H. S. Odbert, E. S. Ewart, and R. C. Rogers, with the assistance of the staff of the Statistical Unit, University of Rochester.

The studies included in this report, particularly the major integrated study, have served to provide preliminary findings of interest in examining the variation among airports, among instructors, and among civilian pilot students with respect to the time spent on the ground and in the air during training. The investigations have also served to indicate the needs, if it seemed desirable to do further work in this area, in the way of more exacting design and of larger samplings of airports, instructors, and students required to answer with any degree of definitiveness the questions asked in initiating these studies on air-ground time.

Morris S. Viteles, Chairman
Committee on Selection and
Training of Aircraft Pilots

CONTENTS

SUMMARY

Parts I and II of this report describe exploratory investigations conducted at two airports to determine what percentage of "flying time" student pilots spend in the air and on the ground. An analysis of the data collected in a preliminary investigation at the College Park Airport, under the direction of R. M. Bellows, showed that in the early stages of primary flight training, the percentage of time spent on the ground was rather high, almost 24%. The data in Part II, collected at the New Orleans Airport under the direction of H. M. Johnson, indicated that between 15 and 30% of the allotted flying time was actually spent on the ground, the earlier stages of instruction showing higher percentages of time spent on the ground than did the advanced stages.

A more extensive study in 1942 at four airports, including two sucessive programs at three of these ports, discussed in Part III, showed that student pilots undergoing C.P.T. primary training at those airports which were relatively small private fields and used solely for C.P.T. trainees, spent a significantly greater part of their total lesson time during Stages C and D actually flying than did student pilots training at the larger commercial airports. The possibility that these differences may be due to the type of operation on relatively small private ports is indicated by the following facts:

1. The C.P.T. operation at Salt Lake City, carried out at the large Municipal Airport during the Spring program, was moved, at the beginning of the Summer program, to a field used solely for C.P.T. flying. Student pilots trained at this port during the Summer program spent a significantly greater portion of their total lesson time in the air than did (a) student pilots flying at the Purdue port (a semi-commercial field), or (b) student pilots flying at the Salt Lake City airport in the Spring program.

2. At both Purdue and Salt Lake City airports the student pilots spent a significantly greater proportion of time in the air during the Spring than during the Summer program in Stage A. For Stages B, C, and D it was found that (a) at Salt Lake City where the operation was transferred from the Municipal to a private airport at the end of the Spring program the student pilots spent a greater proportion of time in the air during the Summer program, (b) at Purdue and Kansas City (where the same airports were used in both Spring and Summer programs) there were no instances of significant differences between Spring and Summer programs with respect to the amount of total lesson time spent in the air, but the general trend of the data indicated that for Stages B, C, and D the students spent a greater amount of time in the air in the summer than in the Spring.

Data on the 35 students at the Purdue port in the Spring program for whom criterion scores for pilot proficiency were available indicated that for this small sample no relationship existed between total lesson time spent flying and pilot proficiency.

INVESTIGATIONS OF THE RELATIVE AMOUNT OF TIME SPENT ON THE GROUND AND IN THE AIR BY CIVILIAN PILOT TRAINING STUDENTS

INTRODUCTION

The primary course in the Civilian Pilot Training Program required that a student have a minimum of 35 hours of "flying time" before being eligible for examination for a private license. However, field observation suggested that the term "flying time" had extremely variable limits resulting in questions such as: "How much time do students actually spend in the air during these 35 hours of training?", "What differences are there among instructors with reference to the time they spend with the students in the air and on the ground during a standard instruction period?", "What is the extent of variation among students with respect to the time spent on the ground and in the air?", and "How is the time on the ground spent -- in instruction, in taxiing, in unavoidable delays due to traffic conditions of the airport, or in unnecessary loitering or perhaps even malingering on the part of the student?"[1] These questions and their answers have an important bearing upon the effectiveness and economy of training.

In order to arrive at a workable definition of "flying time," the total lesson time may be divided into two parts: (1) time actually spent in the air during a given lesson, and (2) time spent in the plane but on the ground, i.e., time during which the plane is being taxied or is motionless on the ground after the beginning of the flight lesson. Time spent on the ground may be influenced by any or all of the following:

1. Time devoted to instruction and discussion of maneuvers -- a function of the instructor (or adequacy of instruction) and of the student's success in ground operations.

2. Time spent in taxiing and in practice in handling the plane on the ground -- also a function of the instructor, and of the student's success.

3. Traffic conditions and delay by the tower -- a function of the type of airport at which the instruction is given.

4. The student's motivation -- reluctance, malingering, or fear on the part of the student resulting in slow taxiing, unnecessary delays, etc.

5. Type of maneuver practiced, e.g., the student who has difficulty in learning to land will spend more time on this maneuver and thereby increase his ground time.

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[1]Such questions were originally raised by Dr. Dean R. Brimhall, Director of the Division of Research, Civil Aeronautics Administration.

An analysis of those influences suggests that a study of the relative amounts of time spent in the air and on the ground should provide information concerning the following questions:

1. Does the type of airport appreciably affect the amount of time spent on the ground by the students? In a busy airport with a control tower the amount of time spent on the ground because of traffic may conceivably be as high as 15 minutes per 30 minutes of logged "flying time." If such were found to be the case, the value of a 30-minute lesson may be questioned. Possibly such time spent on the ground only because of traffic should not be logged as "flying time." Also, the advisability of having C.P.T. instruction at commercial airports may be questioned. If it is found that students who train at airports with heavy traffic spend more time on the ground and that this factor is detrimental to their efficiency, the training operation should be moved to a smaller port.

2. Are there significant differences in the amount of time spent on the ground at a single port? If a ground-time difference is found among students who have the same instructor, port, operator, etc., it might prove to be an efficient predictor of future flight success. The student who spends a lot of time on the ground may be "stalling," overcautious, or actually lacking ability. Should a predictor of this sort be found, students might possibly be washed out at 15 hours instead of waiting until they had completed the full 35.

3. Do instructors differ in the amount of time they keep students on the ground for (a) instruction and discussion of maneuvers, and (b) taxiing and handling of the plane on the ground? If there are differences attributable to instructors, adjustment values for individual instructors might be established so that a more valid index of air time could be obtained. Further, if just as good flyers are graduated by those spending more time on the ground, money and equipment might be saved by converting other instructors to those techniques.

It should be recognized that these questions have clear meaning only within a specific context of regulations and practices. A large portion of the student's time is obviously spent in "instruction on the ground" if one includes ground school, instruction under the wing, etc. Strong arguments can be made for developing as much instruction as possible on the ground, so that flight time may be used to the best advantage. C.P.T. contracts with flight operators provide for a certain amount of time devoted to such instruction prior to the time "in the air." There is no implication in these studies, therefore, that all of the time spent in flight instruction should be time in the air. In view of the relatively high cost of <u>flight time</u>, however, it is important to know whether this time is being used to the best possible advantage or is being devoted to instruction which could be just as well administered out of the plane.

The following sections of the report describe three studies of the amount of "flying time" actually spent in the air. The first two studies, conducted in 1940, were each concerned with results at a single airport with a limited number of students. The more extended study described in the Part III analyses results by stages at four airports, and by successive programs at three of those ports.

PART I

ANALYSIS OF RECORDS OBTAINED AT COLLEGE PARK AIRPORT[2]

As part of a larger investigation conducted during 1940, a study was made of the percentage of total time spent on the ground during flight periods by ten students at the College Park Airport in Maryland. The study made use of records obtained from graphic recording instruments (Fries Flight Analyzers #643 and #644 and ink-writing polygraphs) designed to run at a constant speed. The records could be analyzed so as to provide measures of (1) the time in the air, and (2) the time spent on the ground taxiing and waiting for traffic.

Early in the investigation it was found that the instruments did not maintain constant speed at all times. For this reason not all records could be used in a time analysis. In spite of this, it was felt that enough records were usable to yield figures which would be representative of the whole flying course.[3] The data presented below on the time analysis of the records were taken only from records which did not appear to deviate significantly from the time logged by the student for that flight. The student's log time was taken from a slip on which he was punched out, with a regular time clock, at the beginning of the flight and punched in at the end of the flight by the field manager. Throughout this study, Model J-3, 50 h.p. Piper Cub Trainer planes were used.

During this investigation, a total of 583 flights were recorded for 10 students. All records were taken during the first 35 hours of their flying time.[4] Of these 583 records, only 318 proved to be usable in the analysis of the data. The percentage of time spent on the ground during these 318 flights was calculated for each student and for the total group. The 318 flights on which these percentages were based are considered a random sampling of the flights and there is no reason to suppose that percentages based

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[2]Adapted from R. M. Bellows, Graphic registration of flight performance. Progress Report to the Committee on Selection and Training of Aircraft Pilots, September 1940. (Copy in Committee files.)

[3]Usable records: Records taken when the instruments were running at a reasonably constant speed, i.e., when there were no mechanical failures, evident friction in the paper guides, or other obvious reasons for believing the instruments were not in good running order.

[4]See footnote 13

on all flights would have varied significantly from those indicated. The percentage of time spent on the ground by all 10 students during these 318 flights was 23.4%. Presented in Table 1 are the percentages of time spent on the ground by the individual students. It should be noted that although the mean percentage of time on the ground for all subjects is 23.4%, there is one subject who spends as much as 34.6% of flight time on the ground and another as little as 18.9%.

During the early stage of flight training the flights were separated for analysis into two categories: (1) "flights primarily for the practice of landings," and (2) "flights for air maneuvers." Flights primarily for the practice of landings were defined as flights lasting no less than 15 minutes and during which at least three landings were made. These records were all taken from Stage A, i.e., the training period up to the time when the student makes his first solo flight. During this period most of the time is spent practicing landings.

Table 2 shows the percentage of time spent on the ground by individual students for both types of flights. The average percentage of time spent on the ground during 61 such flights for all ten students was 35.2%; the average percentage of time on the ground during 38 flights for air maneuvers in the same stage was 16.5%. Such a grouping of the flights was not possible after Stage A was completed because the students were learning new maneuvers and practicing many different maneuvers in one flight. The data in the last column of Table 2 show that students 25 and 46, who took the smallest number of flights, appeared to have spent the largest percentage of time on the ground, while student No. 50, who took the largest number of flights, spent the smallest percentage of time on the ground.

As an incidental finding of this investigation on the graphic registration of flight performance it was discovered that the amount of time spent on the ground at the College Park airport was rather high, and it was questioned whether it was desirable for the students to spend approximately 23% of training time on the ground. It was observed that not all of the ground time was spent in taxiing, but that much of it was due to traffic conditions, e.g., waiting at the runway for other ships to land. These findings aided in suggesting further extensions of this problem which appeared to posit important practical implications for pilot training.

TABLE 1

PERCENTAGE OF TOTAL TIME SPENT ON THE GROUND DURING FLIGHT PERIODS

Student Number	Number of Periods	% of Time on Ground
12	31	22.9
25	30	34.6
27	33	24.2
45	31	22.1
46	25	23.2
47	33	23.0
48	34	21.4
49	34	22.7
50	34	18.9
51	33	24.2
All 10 students	318	23.4

TABLE 2

PERCENTAGE OF TIME SPENT ON THE GROUND DURING FLIGHT PERIODS FOR PRACTICE OF AIR MANEUVERS AND FOR PRACTICE OF LANDINGS (STAGE A)

	Flights for Air Maneuvers		Flights for Landings	
Student Number	Number of Flights	% of Time on Ground	Number of Flights	% of Time on Ground
12	3	17.1	7	33.4
25	4	18.9	4	41.7
27	3	16.9	8	36.0
45	6	16.4	5	34.6
46	5	14.8	4	42.7
47	4	16.1	6	34.8
48	3	16.3	6	33.4
49	4	16.3	5	32.2
50	3	12.2	9	30.6
51	3	25.6	7	37.6
Total	38	16.5	61	35.2

PART II

PROPORTIONS OF FLIGHT TIME SPENT IN THE AIR AND ON THE GROUND, C.P.T. NEW ORLEANS AIRPORT[5] (June-September, 1940)

In this investigation an R-S Ride Recorder and a Friez Cable Control Recorder were mounted in a Model 50-TL Aeronca Tandem trainer. Records from each of these instruments indicated, by means of characteristic traces, the moments of take-off and landing. It was thus possible to apportion the time spent in the air and the time spent on the ground for each recorded flight by carefully scaling either record.[6] Also, by means of either record, periods during which the plane was taxiing over rough ground, periods during which it was at rest, and periods during which it was moving along a smooth runway (as in the initial take-off run), could be differentiated. It was therefore possible to apportion the time spent on the ground among these activities. This investigation, however, was confined to a survey of the relation of the time spent on the ground to the time allotted to the instruction flight and took no account of the purposes of periods spent on the ground.

The R-S Ride-Recorder records were chosen for scaling since its chart was printed with a horizontal scale (graduated in feet, inches, and tenths of an inch) and with convenient horizontal reference lines, whereas the Friez Cable Control Recorder chart was plain. The record of each instru-

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[5]From a Progress Report submitted by H. M. Johnson to the Committee on Selection and Training of Aircraft Pilots, February 24, 1941. (Copy in Committee files.)

[6]These data were collected by Oscar Backstrom, Jr. and compiled by Lillian Galt Martin under the direction of Dr. H. M. Johnson, Professor of Psychology, Tulane University.

tion flight obtained was carefully scaled to the nearest .05 inch (corresponding to 0.01 minute at the employed paper speed of 1 1/2 inches per minute). Since the determination of the moment of take-off may be subject to an error of several seconds,[7] and since this order of precision was unnecessary for the problem in hand, only one place of decimals was retained in the averages.

Records were received for 10 C.P.T. students and a research assistant for Stages A and B of flight training; 9 C.P.T. students for Stage C; and 8 C.P.T. students for Stage D.[8] All students were trained by one instructor[9] at the Southern Aviation School at New Orleans.

The results are presented by stages of instruction in Table 3

TABLE 3

VARIABLES FOR FOUR STAGES OF INSTRUCTION

Column	A	B		C		D	E	
Stage	Number of Flights	Total Flight Time (Minutes)		Minutes of Flight Time on Ground		$\frac{C}{B}$ (100)	Per cent of Total Flight Time Spent on Ground	
		Mean	S.D.	Mean	S.D.		Mean	S.D.
A	134	35.1	6.7	7.4	3.0	21.1%	21.7	8.1
B	67	35.6	9.8	10.4	4.2	29.2%	30.5	10.7
C	92	50.5	13.6	8.4	3.4	16.8%	17.6	7.8
D	55	53.5	16.0	8.0	3.5	15.0%	16.0	[illegible].6
All Stages	198	44.0	14.9	8.[illegible]	3.5	19.1%	20.9	9.7

Column A of Table 3 shows the number of flights studied. The number of flights is largest for Stage A partly because two students were transferred to another instructor and no records were available for their performance during Stages B, C, and D. The results given as "All Stages" are based not on the total number of flights, but on a sample of about 50 per cent of the total number of flights, selected so that the number of flights for each stage is nearly proportional to the total time allotted to it.

Columns B and C give the averages and the standard deviations (S. D.) of the time scores; Column D shows the average flight time on the ground expressed as the per cent of the <u>average</u> total flight time; Column E shows the averages and standard deviations of the percentage scores for flying time spent on the ground, the score for each flight being expressed as

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[7] It is to be noted that all averages and standard deviations are those of a distribution of <u>flights</u> and not a distribution of pilots.

[8] See footnote 18.

[9] Edna Gardner Kidd.

per cent of the total time allotted for the same flight.[10] These values differ slightly from the corresponding values in Column D; the former expresses the per cent ratio of one average to another, while Column D shows the averages of the individual ratios. Two such determinations will not in general agree.

From Table 3, it is evident that between 15 per cent and 30 per cent of the time allotted to flying was actually spent on the ground, and that the proportions vary according to the several stages of instruction. (A large proportion of many flights of Stages A and B consisted of practicing landings. It would therefore be expected that a larger proportion of time would be spent on the ground in these stages than in the later stages C and D.) Table 4 shows the total ranges of these ratios by stages.

TABLE 4

RANGE OF VARIATION RATIOS BY STAGES

Stages	Range of Time Ratios on Ground to Total Time	First Quartile (Per Cent)	Median (Per Cent)	Third Quartile (Per Cent)
A	8 - 46 per cent	16	20	26
B	14 - 64 per cent	21	29	39
C	6 - 49 per cent	12	17	20
D	7 - 43 per cent	11	15	18
Total	7 - 64 per cent	13	19	26

If we use the symbol T to denote the total time allotted to a flight and the symbol G to denote the part of this time spent on the ground, the correlation between T and G/T is of the order of 0.32. There is thus a slight positive association between length of flight and proportion of time spent on the ground.

In the Maryland study the average percentage of time spent on the ground for all students during 318 flights was 23.4% (Table 1), while the analysis made at the New Orleans airport by stages showed that the mean percentage of total flight time spent on the ground varied from 30.5 for Stage B to 16.0 for Stage D (Table 3). The mean average flight time for all stages was almost 21%. On the basis of the suggestive nature of these data a more elaborate study was designed which is described in Part III.

[10]A comparison of the average per cent (20.9) of flight time on the ground for the four stages of instruction obtained in this investigation shows a close approximation to the average per cent (23.4) of flight time spent on the ground for the ten subjects in the University of Maryland Study.

PART III

A COMPARISON OF AMOUNTS OF TIME SPENT ON THE GROUND AND IN THE AIR AT FOUR AIRPORTS

THE PROBLEM

The primary purpose of the present study was to determine whether there are differences among students flying at different airports in the percentage of total flight lesson time which they spent in the air. The following factors were also studied: (1) differences among stages[11] in percentage of total lesson time spent in the air; (2) differences between programs in single airports; (3) differences between dual and solo flights; (4) the consistency of differences among students; and (5) the relationship between the proportion of time in the air and ratings of pilot competency.

THE STUDY

Studies were undertaken in 1942, using C.P.T. students of the Spring and Summer programs at four centers.[12]

Table 5 indicates the relative size (in terms of the number of instructors) of the C.P.T. programs at these ports. Two of the centers (those at Purdue and Kansas City) were used in both Spring and Summer programs. In Salt Lake City there was a change of airports between the Spring and Summer programs. In the Spring phase of the study the C.P.T. operation was studied at a large Municipal Airport. In the Summer program, because of the heavy traffic at the Municipal Airport, the operation was moved to two small fields, data on only one of which were available for this study.[13] In all cases the subjects in the Spring and Summer programs differed, i.e., a new group of students entered for the Summer program.

It was not possible to secure flight records for all students at all ports. Table 6 shows the number of records actually taken at each port. Table 6 is to be read as follows: In Stage A in the Spring group (Spr.) in the Salt Lake Municipal Port, the total number of avail-

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[11]See footnote 18.

[12]Originally it was planned to include two large commercial airports, one in the Northwest and the other in the Southeast; and two private airports, one in the North and the other in the South. Uncontrolled circumstances made this distribution impossible for the present study.

[13]The operator of the Salt Lake Municipal Airport was R. L. Peck; the project supervisor, M. W. Lund. Project supervisor at the small C.P.T. port in Salt Lake City was M. C. Barlow. Port operators at the Purdue University port were L. Aretz and G. Webster; the project supervisor was E. L. Kelly. In Kansas City the port operator was N. A. Ong; the project supervisor, L. Misbach.

TABLE 5

INSTRUCTORS AND STUDENTS (N) AT THE FOUR DIFFERENT PORTS DURING THE SPRING AND SUMMER PROGRAMS

Airport	Number of Instructors Spring	Number of Instructors Summer	Number of Students Spring	Number of Students Summer
1. Salt Lake Munic. Salt Lake City	3	Not Used	30	Not Used
2. C.P.T. Port. Salt Lake City	Not Used	4	Not Used	15
3. Purdue Univ. Port. Lafayette Ind.	6	7	40	20
4. Ong Aircraft Corp. Kansas City, Mo.	11	12	50	62

TABLE 6

TOTAL NUMBER OF STUDENTS ON WHOM TWO OR MORE RECORDS WERE AVAILABLE (N), MEDIAN NUMBER OF RECORDS PER STUDENT, AND THE NUMBER OF STUDENTS ON WHOM FEWER THAN FIVE RECORDS WERE TAKEN

		Salt Lake Municipal			Salt Lake C. P. T.			Purdue University			Kansas City (Ong)		
Stage	Program	N	Mdn.	2-4 Rec.	N	Mdn.	2-4 Rec.	N	Mdn.	2-4 Rec.	N	Mdn.	2-4 Rec.
A	Spr.	20	3.5	12	--	---	---	40	14	0	--	---	---
	Sum.	--	---	--	15	4	9	15	4	14	56	13	6
B	Spr.	28	7	2	--	---	---	39	7	1	--	---	---
	Sum.	--	---	--	15	7	0	20	7	2	49	6	16
C	Spr.	28	11	1	--	---	---	38	13	0	19	8	8
	Sum.	--	---	--	15	12	0	20	12	0	55	6	14
D	Spr.	28	9.5	0	--	---	---	37	12	0	36	8	8
	Sum.	--	---	--	15	13	0	20	19	0	49	6	17

able records is twenty, with a median number of records per student of 3.5. On twelve of the students more than one and less than five records were taken, i.e., they had either two, three, or four records.[14]

[14] Students on whom only one record was taken are not included in Table 6.

Unavoidable irregularities in the records have limited the types of treatment which are possible. For example, at all of the ports certain instructors were replaced during the course of a single program. There was an interchange of students among the instructors at two of the three ports. As a consequence of these irregularities the number of subjects whose records were uniform for the complete course and whose training had been under one instructor throughout, was too small to warrant limiting the treatment to this group.

APPARATUS

Time records were taken by means of modified Servis Recorders[15] (Fig. 1) mounted in Piper Cub J-3, 60 h.p., tandem training planes. The recorder was mounted in the left-hand side of the baggage compartment of the plane close to the fabric of the fuselage.[16]

Air, ground, and taxi time were read from tracings made by two styli on a wax disc record. This disc, calibrated in minutes, was clamped on a spring clock mechanism which rotated at a constant speed. Vibration of the plane while taxiing or in flight activated a weighted pendulum inside the recorder, causing a broad trace to be made on the wax disc by Stylus 1 (see Fig. 1).

A special modification of the Servis Recorder made it possible to record "air time" by means of the second stylus. The time that the plane was actually in flight could thus be differentiated from the time the plane was taxiing or standing motionless on the ground. This stylus (Stylus 2) was connected mechanically with an 11-inch air-time arm hinged on the back of the recorder and extending 5 inches out into the "slip stream" of the plane through a hole cut in the fabric of the fuselage. Attached to the end of this arm was a metal disc 1 inch in diameter[17] The spring tension of the air-time arm was so adjusted that the stylus would contact the wax disc when the plane attained a flying speed of approximately 38 miles per hour. Thus, when the plane attained flying speed (38 or more miles per hour), the slip stream blew on the metal disc at the end of the air-time arm and activated the second stylus causing a second trace indicating air time to appear on the record directly below the trace indicating taxi time and ground time. (Bursts of the throttle during taxiing occasionally activated this second stylus. However, the duration and character of the tracing under these conditions were easily distinguished from the solid line resulting from sustained flight.)

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[15]This equipment is manufactured by the Service Recorder Co., Cleveland, Ohio.

[16]The method of mounting the Servis Recorder in the plane is described in Appendix A.

[17]This disc is not shown in Figure 1.

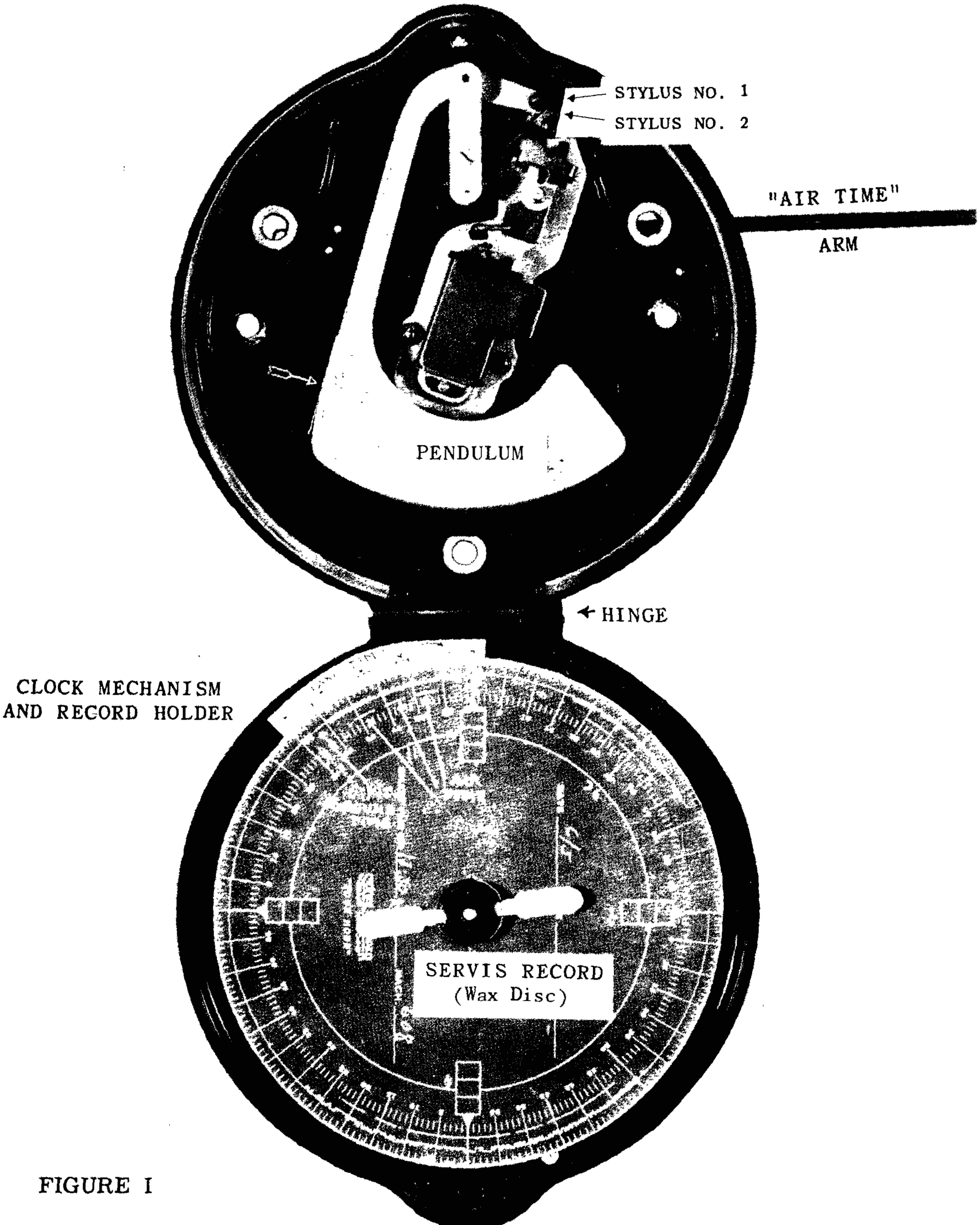

FIGURE I

SERVIS RECORDER
(Open)

PROCEDURE

One individual (the operator) at each port was in charge of compiling data sheets and interpreting the Servis records. The following basic information was recorded by the operator for each student at the time of each flight which was studied:

1. Plane number (coded to correspond to the registration numbers of the planes).

2. Servis record number (records were to be numbered consecutively).

3. Student number (code).

4. Dual or solo flight.

5. Stage of training in which flight was made (A, B, C, or D).[18]

6. Number of hours logged by student previous to given flight.

7. Time at which plane left line.

8. Time at which plane returned to line.

9. Total lesson time (elapsed time, from 7 to 8 above).

10. Wind direction at time flight was made.[19]

11. Wind velocity at time flight was made.

12. "Ceiling" at time of flight.

13. Visibility at time of flight.

14. Traffic conditions at time of flight, coded as follows:

    (a) No traffic -- no planes circling airport or taxiing on field.

    (b) Light traffic -- 1-3 planes circling airport or taxiing on field.

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[18] At the time this investigation was carried out the controlled C.P.T. flight course was divided into four stages; A, B, C, and D. Stage A ended when the student soloed, usually between the eighth and tenth hours. Stage B covered five additional hours, through the thirteenth hour. Stage C ended at approximately 25 hours, and Stage D at 35 hours. Provision was made for additional hours in each stage in cases where the student needed further practice on certain maneuvers.

[19] Variables 10 through 16 were not analyzed in this study due to the apparent unreliability in the recording of these measures.

(c) Medium traffic -- 4-7 planes circling airport or taxiing.

(d) Heavy traffic -- 8 or more planes taxiing or circling airport.

15. "Field conditions" coded as follows: G-Good, F-Fair, P-Poor.

16. "Comments" -- including any unusual incidents such as sudden squalls, breaking of landing gear, etc.

The following four time measurements were recorded for each student on the basis of the interpretation of the Servis records:

1. Total lesson time: The total time elapsing between the plane's leaving and returning to the line.

2. Air time: The amount of time actually spent in the air.

3. Taxi time: Time on the ground spent in taxiing.

4. Ground time: Time spent "motionless" on the ground after the plane left the line and before returning to it.

Three facts complicated the interpretation of the records: (1) certain stall maneuvers, when the plane lost flying speed, caused a brief cessation of the air-time trace. (2) if a plane landed on a smooth runway, and continued to roll with the engine idling, a trace similar to the ground-time trace was evident, (3) in landing practice, when the plane touched the ground and took off immediately, determination of taxi time was difficult. In view of these factors, the following standards for interpretation were issued to the project directors and operators at each port:

1. Ground time. When the plane was motionless on the ground (ground time) Stylus 1 made a narrow trace on the wax disc (see Fig. 1). The ground-time trace was not considered unless it was continued for 1 minute or longer, except when the operator could definitely state (from observation of the plane) that a trace of less duration represented ground time. No trace from Stylus 2 was evident in this portion of the record.

2. Taxi time. Because of the vibration of the plane during the time the plane was taxiing, Stylus 1 made a wide line on the wax disc. No trace was considered as taxi time unless continued for 1 minute or longer or unless the operator could corroborate the shorter trace. No trace from Stylus 2 was evident.

3. Air time. When the plane gained air speed (approximately 38 miles per hour or more) a trace became evident from Stylus 2, i.e., the air pressure on the disc at the end of the air-time arm extending out into the slip stream caused Stylus 2 to contact the wax record directly below the trace made by Stylus 1. Due to the fact that the

plane vibrated and rocked while in flight, Stylus 1 also made a broad trace at this time. The taxi-time trace from Stylus 1 was broader and heavier when the motor was running at cruising speed than when the plane was gliding. Short breaks in the air-time trace were disregarded unless it was evident from the taxi-time trace of Stylus 1 that a glide preceded the break in the air-time trace and that the motor was "gunned" for a take-off, indicating a landing and immediate take-off.

4. <u>Total time</u>. Total time was computed by determining the time which elapsed between the beginning of the first taxi-time trace and the end of the last taxi-time trace for a given lesson. A check on the beginning and end of each lesson was provided by the operator's observation and recording of the time each plane left and returned to the line.

<u>Training of Operators</u>. In an effort to insure that readings made by the three operators would be comparable, ten "test records" were made at the Purdue airport and sent in a sealed envelope together with the readings to the Salt Lake City operator. This operator then made his own interpretations of the records, compared those with the readings made at Purdue, and sent the records plus the Salt Lake and Purdue readings to the Kansas City port. The operator at Kansas City repeated this procedure and returned the records and readings to Purdue. Discrepancies between readings were discussed by mail.

As a further aid in the interpretation of the records, each project director was instructed to make a 30-minute flight while the Servis Recorder was in operation. During this period he was to jot down careful observations, using a stop-watch, as to when the plane was on the ground motionless, when it taxied, took off, landed, stood with engine running, and stood with engine dead. It was then possible for him to compare the traces on the Servis record with the notes made regarding the behavior of the plane at specific times and to instruct his operator in reading the records in accordance with his observations.

<u>Checking of Data Sheets and Records</u>. The data sheets and records were sent to Purdue University for analysis. The records from each of the ports were "spot checked," i.e., sample records were re-read, and the readings compared with the entries on the data sheets made by the operators. Where consistent errors had been made by the operator at any given port, all the records from that port were re-read, and the entries on the data sheets changed. The data from each port were punched into Hollerith cards, each card containing the data from a single flight for one subject.

RESULTS

<u>Reliability of Readings of Servis Records</u>. A representative sample of 63 records from each port was randomly selected[20] and read by a single observer. Pearsonian correlations between these readings and the readings

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[20]The number of data sheets from each port was divided by 63 and 2 every (N/63)th record was selected for reading.

entered on the corresponding data sheets were then determined as a measure of the reliability of the entries.

Table 7 presents these correlations separately for each time measure, each program, and each airport. It should be noted that the individual who made the readings was the same individual who had corrected many of the data sheets as a result of the spot check described above. It might be expected that the correlations would be somewhat higher than would be obtained between two independent observers. Actually, the correlations for the Summer program at the Salt Lake City C.P.T. port and the Purdue port show no marked difference from the remaining correlations even though the data for these correlations were not corrected by the individual making the second reading. At the ports for which all records were re-read, correction proved to be necessary for only a part of the measurements. While the correlations do not represent the reliability of the operator's readings, they appear to be a fair estimate of the reliability of the measurements actually used in the present analyses.

Examination of Table 7 indicates that correlations are extremely high between the data sheet entries and the independent measurements of total-time and air time. Measurements on taxi time and ground time are somewhat less reliable, the least reliable being those of the ground time variable.

TABLE 7

CORRELATION BETWEEN OPERATOR'S AND OBSERVER'S READINGS OF SAMPLE OF SERVIS RECORDS FROM THE THREE AIRPORTS

	PURDUE		KANSAS CITY		SALT LAKE CITY	
	Spring	Summer	Spring	Summer	(Municipal) Spring	(Private) Summer
Total Time	.996	.990	.996	.991	.994	.984
Air Time	.979	.990	.996	.993	.996	.990
Taxi Time	.905	.971	.959	.941	.898	.958
Ground Time	.546	.590	.935	.791	.643	.350

<u>Evaluation of the Variables</u>. It was originally intended to study the mean of the measurements for a given student on each of the following variables: total time, air time, ground time, and taxi time. Analysis of the data indicated that the inclusion of ground time as a separate variable was inadvisable for the following reasons:

1. Readings of ground time tended to be unreliable.

2. The contribution of the ground time variable to the total time spent on the ground was slight. As shown in Table 8 the mean ground time was only approximately 1/25th of the taxi time plus ground time. The relatively large standard deviations for ground time and the fact that over 50% of the ground time entries were zero indicates that the ground time distributions were positively skewed.

TABLE 8

COMPARISON OF "TAXI TIME PLUS GROUND TIME" WITH "GROUND TIME"*(IN MINUTES)

	GROUND TIME		TAXI TIME PLUS GROUND TIME	
	Spring	Summer	Spring	Summer
Mean	.37	.23	8.60	6.75
S.D.	.30	.39	2.42	2.75

3. Experience in the field indicated that the distinction between ground time and taxi time would not aid in a study of causative factors. Traffic delay, for example, may result in slow taxiing, or in a complete stop. Loitering may be manifested by the same two types of performance.

For the above reasons ground time was eliminated as a separate variable for further study. Only three variables, then, are used in the present analysis: total length of lesson, time spent in the air, and time spent on the ground (whether taxiing or motionless). The readings of total time and air time, taken from the Servis records, have been demonstrated to be reliable, and represent the only Servis record readings necessary for this analysis. Time spent on the ground in a given flight is merely the difference between total time and air time.

Statistical Analysis of Total Time and Air Time. The present investigation was not concerned primarily with the absolute total or the mean amounts of time spent in the air or on the ground at the various airports, but was rather concerned with the proportion of total lesson time spent in the air, i.e., the relative amounts of time spent in the air and on the ground per total lesson, by each student at each of the airports. Therefore, the ratio between mean air time and mean total time for each student was computed as the best estimate of the relative amount of total lesson time actually spent in the air. These means were computed from the total number of records available for each student. This ratio will hereafter be referred to as A/T.

Previous studies had indicated that significant differences in A/T ratios might be expected among stages of training. It also seemed possible that significant differences might appear between Spring and Summer programs, in view of differences in weather conditions, standards of training, caliber of students, etc. For this reason data have been treated separately for airports, stages of training, and programs. Distributions of the A/T ratios appear in Appendix B. Table 9 shows for each subgroup the number of students for whom A/T ratios were obtained, along with the mean and sigma of those ratios.

TABLE 9

MEAN A/T BY PORTS AND STAGES

	PURDUE		SALT LAKE CITY		KANSAS CITY	
	Spring	Summer	(Municipal) Spring	(Private) Summer	Spring	Summer
Stage A						
N	40	15	17	15	NO	56
M	.788	.741	.784	.689	DATA	.784
σ	.047	.076	.045	.064		.064
Stage B						
N	39	20	29	15	NO	47
M	.779	.797	.764	.800	DATA	.786
σ	.069	.045	.074	.043		.074
Stage C						
N	38	20	28	15	19	55
M	.827	.899	.808	.910	.867	.876
σ	.041	.033	.049	.019	.039	.037
Stage D						
N	37	20	21	15	34	50
M	.792	.810	.823	.894	.888	.893
σ	.044	.036	.040	.022	.040	.032

<u>Differences Among Airports</u>. Are there significant differences among airports with regard to the proportion of time spent in the air during a given stage of flight training? Two tests of significance were applied to different parts of the data in an effort to answer this question:

1. Epsilon squared.
2. The "t" tests.

(a) Epsilon squared[21] was used as a preliminary test to determine significance and extent of differences among ports. The size of this coefficient is a function of the relationship between the standard deviation of the scores in each port and the standard deviation of scores in the entire distribution. The statistic offers a convenient test, and in addition gives an indication of the strength of relationship between "airport" and "A/T."

The test was applied for each stage of the Summer data, and for Stages C and D of the Spring data. (Data were available from only two ports for Stages A and B of the Spring program. Differences between these two ports were therefore studied only by the t test discussed below.) The results of the test appear in Table 10. All of the coefficients of relationship, except that in Stage B of the Summer program, are seen to be significant. The strongest relationships appear to occur in Stage D.

TABLE 10

SUMMARY OF APPLICATION OF "EPSILON SQUARED" TO DATA

	E^2 Summer		Level of Sig. E^2	
	Spring	Summer	Spring	Summer
Stage A	---	.22	---	$<$ .01
Stage B	---	.00	---	Not significant
Stage C	.20	.30	$<$ .01	$<$ .01
Stage D	.49	.56	$<$ .01	$<$ .01

(b) Application of the "t" test indicates more specifically which of the differences between any two ports would be least likely to occur by chance. Table 11 indicates that eleven of the twenty differences are significant at better than the 1% level. The Spring program (Stage A) and the Summer program (Stage B) of the Salt Lake City and the Purdue ports, as well as the Summer program (Stage D) of the Salt Lake City and Kansas City ports, show the least significant differences.

(c) Ratios such as those considered here will usually not distribute themselves normally, and when they do not do so (within students, within stages, and within airports), the use of the above tests of significance may be rendered suspect. However, an examination of the distributions presented in Appendix B indicates no very strong reason for rejecting the hypothesis of normality of distribution in the case of the population or populations from which these data were drawn.

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[21] The statistic "Epsilon," developed by T. L. Kelley, is an unbiased expression of the correlation ratio which is not subject to distortion resulting from size of the sample, as is the conventional "Eta." See: Peters, C. C. and Van Voorhis, W. R. Statistical procedures and their mathematical bases. New York: McGraw Hill, 1940 (pp. 319-330, 494-497).

TABLE 11

DIFFERENCE IN MEAN A/T BETWEEN PORTS

	Stage A		Stage B		Stage C		Stage D	
	Spring	Summer	Spring	Summer	Spring	Summer	Spring	Summer
Salt Lake vs. Purdue								
Diff. $(M_{sl}-M_p)$	-.004	-.052	-.015	.003	-.019	.071	.031	.084
t	.296	2.02	.862	.200	1.71	7.51	2.68	7.85
P-value	.76	.05	.38	.85	.08	$<.01$	$<.01$	$<.01$
Kansas City vs. Purdue								
Diff. $(M_{kc}-M_p)$	---	.043	---	-.011	.040	.037	.096	.083
t	---	2.22	---	.619	3.43	3.92	9.54	9.37
P-value	---	.03	---	.53	$<.01$	$<.01$	$<.01$	$<.01$
Salt Lake City vs. Kansas City								
Diff. $(M_{sl}-M_{kc})$	---	-.095	---	.014	-.059	.034	-.065	.001
t	---	5.08	---	.697	4.39	3.40	5.79	.112
P-value	---	$<.01$	---	.50	$<.01$	$<.01$	$<.01$	.90

Differences Among Stages. The differences between stages in mean A/T ratio at the various ports are tabulated in Table 12. Each difference is tested for significance in terms of the "t" test. Inspection of the table shows that twenty of the thirty-one P-values fall at or below the 1% level of significance. Differences between mean A/T ratios of Stages C and D are not significant except at the Purdue port where the mean A/T ratio for Stage C is significantly higher in both Spring and Summer programs.

Differences Between Spring and Summer Programs. In Table 13 are tabulated the mean A/T ratios at the various airports of Spring and Summer programs and the differences between the two mean ratios for each port. Each difference is tested for significance by means of the "t" test. At the private Salt Lake City port in the Summer program, the mean A/T ratio is higher than at the Municipal port during the Spring program in Stages B, C, and D. The differences in Stages C and D are significant at the 1% level. In Stage A, however, the mean A/T ratio is significantly lower for the Summer program using the private port.

At the other airports the only P-value which is significant at the 1% level is that between Spring and Summer programs during Stage A at Purdue University. Taking the results of Table 13 as a whole, however, the data indicate a tendency for the Summer programs of Stages B, C, and D, to yield a higher proportion of time in the air, since all eight of the obtained differences are in a negative direction. There is only 1 chance in 256 that in a group of eight differences all eight would occur in the same direction.

TABLE 12

DIFFERENCES IN MEAN A/T BETWEEN STAGES

	PURDUE		SALT LAKE CITY		KANSAS CITY	
	Spring	Summer	(Municipal) Spring	(Private) Summer	Spring	Summer
Diff. (B-A)	-.009	.056	-.020	.111	---	.002
t	.68	2.73	1.01	5.57	---	.14
P-value	.50	<.01	.31	<.01	---	.87
Diff. (C-A)	.039	.098	.024	.221	---	.092
t	3.87	5.17	1.64	12.77	---	9.22
P-value	<.01	<.01	.10	<.01	---	<.01
Diff. (D-A)	.004	.069	.039	.205	---	.109
t	.38	3.55	2.81	11.64	---	10.90
P-value	.70	<.01	<.01	<.01	---	<.01
Diff. (C-B)	.048	.042	.044	.110	---	.090
t	3.69	3.39	2.64	9.16	---	7.94
P-value	<.01	<.01	<.01	<.01	---	<.01
Diff. (D-B)	.013	.013	.059	.094	---	.107
t	.98	1.01	3.32	7.58	---	9.38
P-value	.32	.32	<.01	<.01	---	<.01
Diff. (D-C)	-.035	-.029	.015	-.016	.021	.017
t	3.58	2.66	1.15	2.11	1.82	2.49
P-value	<.01	<.01	.25	.04	.06	1.7

TABLE 13

DIFFERENCE IN MEAN A/T BETWEEN SPRING AND SUMMER PROGRAM

	PURDUE			SALT LAKE CITY*			KANSAS CITY		
Stage A	M		σ	M		σ	M		σ
Spring	.788		.047	.784		.045	---		---
Summer	.741		.076	.689		.064	.784		.064
Diff. (M_1 - M_2)		.047			.095				
t		2.75			4.87				
P-value		<.01			<.01				
Stage B									
Spring	.779		.059	.764		.074	---		---
Summer	.797		.045	.800		.043	.786		.074
Diff. (M_1 - M_2)		-.018			-.036				
t		1.06			1.74				
P-value		.30			.08				
Stage C									
Spring	.827		.041	.808		.049	.867		.039
Summer	.839		.033	.910		.019	.876		.037
Diff. (M_1 - M_2)		-.012			-.102			-.009	
t		1.13			7.73			.891	
P-value		.25			<.01			.36	
Stage D									
Spring	.792		.044	.823		.040	.888		.040
Summer	.810		.036	.894		.022	.893		.032
Diff. (M_1 - M_2)		-.018			-.071			-.005	
t		1.57			6.21			.626	
P-value		.12			<.01			.53	

*Differences between Spring and Summer programs for Salt Lake represent differences between a municipal port and a private port combined with whatever difference there may be between Spring and Summer.

Differences Between Dual and Solo Flights. Earlier studies had revealed differences in A/T ratios in Stage A according to the type of maneuver being emphasized. The question arose concerning a possible difference between dual and solo flights in the relative amount of time spent in the air. Obviously, no such comparisons could be made for Stage A since all flights are dual. In Stages B, C, and D too few records were available for dual and solo flights respectively for individual ports to warrant the computation of mean total time and mean air time by students. The comparison is therefore based on combined data from Stages C and D. It seems justifiable to combine these two stages since they are similar in the type of maneuvers practiced, and since, with the exception of the Purdue port, mean A/T ratios on all flights in Stages C and D did not differ significantly in either the Spring or the Summer program.

The t values between dual and solo for the same students were determined by the t test for matched groups, and of the six comparisons, in Table 14, five were in the direction of greater A/T ratios for dual flights. Three of these were significant. The one difference in the opposite direction was significant.

TABLE 14

COMPARISON OF MEAN A/T BETWEEN DUAL AND SOLO FLIGHTS - DATA FROM STAGES C AND D COMBINED

	PURDUE		SALT LAKE CITY		KANSAS CITY	
			(Municipal)	(Private)		
	Spring Dual-Solo	Summer Dual-Solo	Spring Dual-Solo	Summer Dual-Solo	Spring Dual-Solo	Summer Dual-Solo
N	37	20	27	15	26	43
Mean Diff.	.011	.060	.005	.029	-.039	.016
t	1.15	7.47	.57	4.61	4.03	2.56
P-value	.25	< .01	.60	< .01	< .01	< .01

Differences Among Students. The ranges of A/T ratios for the students in the various ports are indicated in Tables B-1 and B-2 in Appendix B. For many reasons it is interesting to know whether individual students tend to maintain a consistent A/T ratio. A rough indication of the degree of consistency can be obtained by getting rank order correlations for the ratios between stages. The coefficients are in Table 15. The Summer program data from Kansas City and the Spring program data from Salt Lake City yielded rho's which were relatively high and positive. The coefficients between stages at the Purdue airport for the Spring program showed wide variations and were not consistent with those for the Spring program at Salt Lake City. Since it is not known to what extent these correlations are spurious (since the air time and total time are probably correlated) no definitive statement can be made relative to the significance of these correlations.

TABLE 15

RANK ORDER CORRELATIONS OF MEAN A/T VALUES, BETWEEN STAGES

	KANSAS CITY		SALT LAKE CITY		PURDUE	
Spring	ρ	N	ρ	N	ρ	N
AB	---		.56	(17)	.30	(35)
AC	---		.60	(17)	-.08	(35)
AD	---		.47	(17)	-.56	(35)
BC	---		.82	(28)	.03	(35)
BD	---		.56	(21)	.01	(35)
CD	.29	(17)	.62	(21)	-.02	(35)
Summer						
AB	.61	(27)	.46	(15)	.44	(15)
AC	.62	(27)	.61	(15)	.40	(15)
AD	.47	(27)	.29	(15)	.41	(15)
BC	.66	(27)	.32	(15)	.45	(20)
BD	.51	(27)	.17	(15)	.34	(20)
CD	.61	(27)	.68	(15)	.34	(20)

TABLE 16

RELATIONSHIP BETWEEN A/T RATIO AND MEASURES OF PILOT COMPETENCY
(Purdue, Spring)

A. ρ Between A/T Ratio and Check Pilot's Rating, Purdue Scale, Item 14
(N = 35)

Stage A	.11
Stage B	.02
Stage C	-.10
Stage D	-.07
All Stages	-.16

B. ρ Between A/T Ratio on Solo Flights and Criterion Measures

	Check Pilot's Rating (N=35)	Instructor's Final Rating (N=37)
Stage C	-.13	.07
Stage D	-.10	-.19
Stage C and D Combined	-.14	-.12

Relationship Between Proportion of Time in the Air and Ratings of Pilot Competency. Two measures of pilot competency were available for students flying at the Purdue port in the Spring program: (a) the over-all rating given the student at the end of the course by a check pilot (not the C.A.A. inspector), and (b) the over-all rating given the student at the end of the course by his instructor. The ratings were made on item 14 of the Purdue Scale for Rating Pilot Competency.[22]

The coefficients appear in Table 16. None of the coefficients is significant, whether solo flights or dual and solo flights together are considered. This lack of correlation may be related to low reliability of the A/T ratios or of the measures of pilot competency, or it may indicate that the mere ratio of time in the air to total time is not related to pilot competency.

DISCUSSION AND INTERPRETATIONS

Type of Airport. Analysis of data from the Spring program indicated that in Stages C and D, student pilots flying at the Kansas City port spent a significantly larger part of their total lesson times actually flying than did student pilots flying at the Municipal Salt Lake City or Purdue University airports. A possible explanation of this difference lay in the fact that the Kansas City port was small and was used solely for C.P.T. training.[23] Before the beginning of the Summer program, a change in airports furnished evidence bearing on the suggested hypothesis that "pilots training at small airports, used solely for C.P.T. flying, spend a greater part of their total lesson time in the air than do pilots training at other types of ports." This change was the removal of the operation at Salt Lake City from the large municipal airport to two small fields, some distance from the city. Data from students at one of these fields were available for the present analysis.

If this hypothesis were true, it would be expected that:

1. The mean A/T ratios at the Salt Lake City C.P.T. port would be significantly greater than the mean A/T ratios at the Purdue port, and they would not differ markedly from the mean A/T ratios at the Kansas City port.

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[22] Kelly, E. Lowell. The development of a scale for rating pilot proficiency. Washington, D. C.: C.A.A. Division of Research, Report No. 18, July 1943.

[23] Although as shown in Table 5, the number of students trained at the Kansas City private port was relatively large, the small size of the port did not result in greater traffic congestion than at the Purdue port which was physically larger. According to Dr. Lorenz Misbach, Project Supervisor at the Kansas City port, "Pilots and students observe vaguely but apparently with sufficient clarity, imaginary runway boundaries. It follows that width of runways is great and elastic. There are no boundary obstructions nor hazards in the field itself. Hence, many planes can be taxiing on the port simultaneously....I have often timed a plane from the line to the beginning of the runway and found it less than one minute."

2. The mean A/T ratios at the Salt Lake City port for the Summer program would be significantly higher than the mean A/T ratios for the Spring program.

3. The mean A/T ratios at the Purdue and Kansas City ports for the Spring and Summer programs would not differ significantly.

Examination of Table 13 indicates that when data from Stages C and D are considered, the conditions outlined above are met. The data from Stage B are in line with the hypothesis although the evidence is not so conclusive since, while the mean A/T at the private Salt Lake port for the Summer program is higher than the mean A/T for the Spring program (municipal port), the difference is significant at only the 8% level. The data from Stage A are wholly out of line with the hypothesis, since at the Salt Lake City port, the mean A/T was significantly higher for the Spring than for the Summer program, and a significant difference between Spring and Summer programs was evident at Purdue University. The inference might be that either (a) the type of operation does not affect the amount of total lesson time spent flying in Stage A, or (b) some other factors were operative in Stage A, which disturbed this relationship. (It has already been mentioned that field installations were being completed during Stage A at the Salt Lake City C.P.T. port.)

The specific factors in the type of operation at the Kansas City port during the Spring program, and at the Kansas City and private Salt Lake City ports during the Summer program, which caused the student pilots training at these ports to spend a significantly greater part of their total lesson time in the air, are unknown. Traffic conditions might perhaps account for the difference. Reliable estimates of the amount of traffic during each flight are, unfortunately, not available. However, the fact that the Kansas City port trained approximately 60 students during the Summer program, and 50 during the Spring program, yet showed no significant differences in mean A/T, would seem to discount traffic conditions as an influencing factor.

The Kansas City port and the private Salt Lake City port during the Summer program had certain characteristics in common: Both were relatively small ports bounded by no obstructions, and pilots flying at these ports were not confined to landing on well-defined runways. Thus not only was there less traffic congestion on the runways, but perhaps more important, due to the relative smallness of the ports, pilots were forced to land closer to the take-off point on the down-wind side of the field, and thus had a shorter distance to taxi after landing, before making another take-off.

Variance Among Students or Among Instructors. Since the variance for instructors and students was not determined, no statistical evidence is available to prove that any obtained differences between ports are not due to variance among students, or among instructors, or an interaction of the two. In opposition, however, to the hypotheses that the differences in mean A/T between Spring and Summer programs are a function of peculiarities in type of student and type of instructor, are the facts that (a) student samples changed in Spring and Summer programs at all ports, (b) in general, instructor samples changed in the Spring and Summer programs at all ports,[24] (c) at all ports, there was considerable interchange of students among instructors, either between instructors in service at a given time, or as a result of turnover in the staff of instructors at a given port during the course of the Spring and Summer programs, respectively. The student and instructor factors may be, in part, cancelled out.

<u>Comparison with Earlier Studies</u>. Data from the University of Maryland study indicate that when all flights are considered, 23.4% of the total lesson time was spent on the ground; or, conversely, 76.6% of the total lesson time was spent in the air. At the Salt Lake City Municipal Airport, the range of mean time spent in the air during the four stages was from 76% to 82%. The difference in time spent in the air between the College Park Airport and the Salt Lake City Municipal Airport is small and might be explained by differences in type of operation or by differences in instrumentation in the two investigations.

The amount of total lesson time spent flying by student pilots at the New Orleans Airport (reported by H. M. Johnson in Part II) is not markedly different, except in regard to Stage B, from the values presented for the three airports in Part III.

<u>Future Studies</u>. The studies here reported are concerned chiefly with a gross study of time "on the ground" and "in the air." They also consider briefly the variations in time ratios for dual and solo flying, different stages of training, and flights concerned primarily with the training in landing. A full answer to the general problems outlined above would demand a large-scale experiment of exacting design, in view of the many sources of variance involved. For example, the studies would have to be undertaken at several airports of different types having an instructor personnel sufficiently large and sufficiently stable to permit a study of differences among instructors in the same port and among ports. Each airport would have to be large enough to supply samples of adequate size. A large and preferably uniform number of records of individual flights would have to be taken on each student. New methods of recording would have to be developed to supply information on types of activity during ground time.

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[24] The instructors at the Salt Lake City ports were not the same for the Spring and Summer programs, and only one instructor at the Purdue port and two at the Kansas City port instructed in both programs.

APPENDIX A

INSTRUCTIONS FOR INSTALLING THE SERVIS RECORDER

APPENDIX A

INSTRUCTIONS FOR INSTALLING THE SERVIS RECORDER[25]

The recorder is hung from a strip of 1/8 inch angle iron mounted on the bracing at the back of the baggage compartment. The recorder is mounted on the left side of the ship, as close as possible to the fabric on the left hand side of the fuselage. The arm of the recorder extends out into the slip stream of the plane, through a hole cut in the fabric of the fuselage. The detailed procedure for mounting the equipment is as follows:

1. Cut a length of angle iron sufficiently long so that it will ride on the bracing behind the baggage compartment, and extend from one side of the plane to the other.

2. Place this length of angle iron in position. Determine the position in which the recorder should be placed, and cut the hole in the fabric of the fuselage through which the arm of the recorder extends. Be certain that this hole is large enough to permit full excursion of the arm.

3. Hold the recorder in place, as far over toward the left side of the fuselage as possible, and mark on the angle iron the position of the two holes which must be bored in order to bolt the recorder to the angle iron. The holes to be used on the recorder are those two holes, 4 1/8 inches apart, which have been bored below the arm of the recorder.

4. Now remove the angle iron from the plane, and bore the holes to mount the recorder. Then bore two or three more holes on the other flange of the angle iron, to be used in fastening the angle iron to the bracing at the back of the baggage compartment.

5. Bolt the recorder to the angle iron before installing in the plane. Then, with the recorder bolted to the angle iron, fasten the angle iron to the cross-bracing in back of the baggage compartment of the plane with self-tapping screws. The screws holding the disc at the end of the arm of the recorder are soldered. Therefore, the disc cannot be removed, and care must be taken when pushing this arm through the hole in the side of the fuselage.

6. The spring tension on the arm is adjusted so that the force of the slip stream when the plane is in flight will force the arm back, and the stylus will record. Some adjustments in this tension may be necessary. The spring tension should be such that the stylus will record when the plane is in flight, but should not be activated by the propellor blast during taxiing.

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[25]Instructions for mounting the Servis Recorder are taken from Supplement I of a progress report prepared by R. M. Bellows. *Op cit*.

APPENDIX B

DISTRIBUTIONS OF A/T RATIOS BY PORTS FOR THE SPRING AND SUMMER PROGRAMS

APPENDIX B-1

A/T DISTRIBUTION BY PORTS FOR THE SPRING PROGRAM

	Stage A			Stage B			Stage C			Stage D		
A/T	P	S.L.	K.C.	P	S.L.	K.C.	P	S.L.	K.C.	P	S.L.	K.C.
.95			(No			(No						2
.94			data)			data)						1
.93				1					1			4
.92				-					2			3
.91				-					-			3
.90	1			-	1		1		2			4
.89	-			-	-		1		2		1	-
.88	1			-	-		2	2	1		-	6
.87	1			1	1		2	-	3	1	1	3
.86	-	1		1	-		3	2	2	-	3	2
.85	3	1		4	3		5	3	-	4	1	1
.84	2	1		3	2		4	1	1	4	4	1
.83	1	1		1	-		3	2	2	1	1	1
.82	-	-		3	3		4	2	1	2	4	1
.81	5	1		-	1		2	4	1	4	1	1
.80	2	3		5	-		4	3	-	4	-	-
.79	3	-		-	1		3	3	1	-	1	-
.78	1	2		4	1		-	1		1	-	1
.77	8	1		2	2		2	1		6	2	
.76	2	1		1	1		-	2		2	-	
.75	4	-		2	1		-	-		2	1	
.74	1	1		1	1		1	-		3	1	
.73	2	3		-	1		-	-		-		
.72	2	1		1	-		-	1		2		
.71	-			1	2		-	-		-		
.70	-			3	-		1	-		1		
.69	1			1	-			-				
.68				-	4			-				
.67				1	1			-				
.66				1	3			-				
.65				1				1				
.64				1								
.63												
.62												
.61												
.60												
N	40	17		39	29		38	28	19	37	21	34
Mean	.788	.784		.779	.764		.827	.808	.867	.792	.823	.888
σ	.047	.045		.069	.074		.041	.049	.039	.044	.040	.040

APPENDIX B-2

A/T DISTRIBUTION BY PORTS FOR THE SUMMER PROGRAM

	Stage A			Stage B			Stage C			Stage D		
A/T	P	S.L.	K.C.	P	S.L.	K.C.	P	S.L.	K.C.	P	S.L.	K.C.
.95												
.94									1		1	3
.93								5	1		-	2
.92						1		1	4		-	4
.91						2		4	8		4	14
.90						-		1	6		3	6
.89			1		1	-	1	3	8		2	4
.88			4		-	1	-	-	5		3	4
.87			1	1	-	-	4	1	4		-	3
.86			2	3	1	2	4		2	4	1	3
.85	1		5	-	1	2	1		1	-	1	0
.84	-		2	-	-	3	-		7	1		2
.83	2		5	1	1	4	5		4	2		2
.82	-		2	1	-	4	-		1	2		-
.81	1	1	-	1	3	3	1		-	2		2
.80	-	-	2	3	-	4	-		1	3		
.79	2	-	4	4	2	1	3		1	-		
.78	-	-	4	2	-	2	1		-	1		
.77	1	1	1	-	1	1			1	3		
.76	-	1	3	-	4	1				1		
.75	1	-	4	-	1	4				-		
.74	1	1	1	1		2				1		
.73	-	1	3	2		1						
.72	-	1	2	1		3						
.71	-	-	1			1						
.70	-	-	5			-						
.69	-	-	1			-						
.68	3	2	-			-						
.67	1	1	2			-						
.66	-	2	1			1						
.65	-	-				1						
.64	-	1				-						
.63	1	-				1						
.62	1	-				1						
.61		1				1						
.60		2										
N	15	15	56	20	15	47	20	15	55	20	15	50
Mean	.741	.689	.784	.797	.800	.786	.839	.910	.876	.810	.894	.893
σ	.076	.064	.064	.045	.043	.074	.033	.019	.037	.036	.022	.032