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EFFECTIVENESS OF A PILOT GROUND TRAINER AS A PART-TASK INSTRUMENT FLIGHT RULES FLIGHT-CHECKING DEVICE STAGE II

Robert J. Ontiveros

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FINAL REPORT

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16. Abstract

The second stage of a two-stage experiment was conducted at the National Aviation Facilities Experimental Center (NAFEC) to determine if a pilot ground trainer (PGT) could be used to flight check instrument-pilot applicants on instrument approaches in lieu of performing these tasks in an aircraft on their initial instrument flight check. Stage I defined the capabilities and equipment of PGT's considered essential for training pilots to perform instrument approaches and related instrument procedures. Based on the comparative PGT and aircraft performance scores of a control and experimental group, the results of Stage II indicate that an appropriately equipped PGT may be used to flight check instrument-pilot applicants on the automatic direction finder (ADF) very high frequency omni-directional radio range (VOR), and instrument landing system (ILS) approaches. The report lists the equipment and capabilities required for the ground trainer to be effective as a part-task flight-checking device for accomplishing these tasks. Significant differences between PGT and aircraft performance scores are discussed. Factors contributing to the performance differences are identified.

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INTRODUCTION

PURPOSE.

The purpose of this activity is to provide information on pilot ground trainers (PGT) in order to develop standards for determining their acceptance as part-task instrument flight-testing devices. The results of the first stage of this study (reference report FAA-RD-75-36) defined the capabilities and equipment considered essential for a PGT to be effective for training instrument pilot applicants in instrument flight approaches and related procedures. The second stage of study, which is the concern of this report, is an effort to determine if a PGT may be used effectively to flight check instrument-pilot applicants on instrument approaches in lieu of performing these tasks in an aircraft on their initial instrument flight check.

BACKGROUND.

The variety and use of pilot ground trainers continues to expand rapidly. Synonymously called simulators, flight trainers, flight duplicators, and procedural trainers, pilot ground trainers differ from the full-fledged certificated simulator in that they simulate fewer aircraft characteristics or simulate them to a lesser degree of fidelity. They are used to provide practice in flight maneuvers and procedures that are common to a broad spectrum of general aviation aircraft. Because of their wide usage, research on these types of pilot ground trainers is needed so that the Federal Aviation Administration (FAA) may have a sound basis for developing regulations to authorize their use.

On the basis of our present knowledge there is no question that pilot ground trainers have value for training. The FAA has recognized the effectiveness of aircraft simulators and training devices and has over the years continued to provide for a more extensive use of these devices as improvements are made in their design and capabilities. This recognition is reflected in the following excerpts from revisions to Federal Aviation Regulation (FAR), Part 61, effective in November 1973:

1. FAR 61.129 allows an applicant for a commercial pilot certificate to "acquire 50 hours of flight instruction, in a pilot ground trainer acceptable to the Administrator, from an authorized instructor towards the 250 total."

2. FAR 61.57 (e) (2) allows an instrument-rated pilot to regain his instrument flight qualification by means of a competency flight check, "part or all of which may be conducted in an aircraft simulator or pilot ground trainer equipped for instrument flight and acceptable to the Administrator."

3. FAR 61.65 (c) (3) permits the use of an instrument pilot ground trainer "for training instrument-rating applicants in automatic direction finder (ADF) and instrument landing system (ILS) approaches."

In many geographic areas radio/navigation/terminal approach facilities are not available or readily accessible for training pilots in approach procedures. Use of these facilities often is precluded because of air traffic congestion. Frequently an applicant being tested is unable to accomplish a requested approach because of an opposing flow of traffic as in the case of attempting a back course ILS approach into oncoming front course traffic.

The FAA has recognized the difficulties such situations create to the extent that for training purposes as specified in the aforementioned FAR 61.65 (c)(3), an instrument ground trainer can be used for instruction in ADF and ILS approaches.

Before trying to determine if a pilot ground trainer could be used effectively in a flight test situation, it was necessary to define the capabilities and limitations of the trainer used as the experimental test bed for this study. Stage 1 provided this information. This method of approach enabled the investigators to discriminate between acceptable and nonacceptable pilot performance in terms of what capabilities the pilot ground trainer does or does not have for the effective teaching of instrument approaches and procedures.

Briefly, the results of the first stage of activity indicated a positive transfer of training between observed pilot performance in the PGT and observed pilot performance in the aircraft (A/C). The results provided information about trainer equipment and capabilities which contributed to the positive transfer and consequently to PGT effectiveness for instrument flight training.

Procedural maneuver situations which resulted in minimal training transfer were defined in terms of PGT capabilities which could enhance the effectiveness of the PGT for performing instrument flight approaches. Furthermore, the findings of stage I activity supported the minimum instrumentation and equipment requirements for a PGT to obtain maximum flight training credit as defined in FAR 141.41 al-(i), (ii), (iii), (v), and FAR 91.33.

The additional information now needed relates to the role of PGT's in a flight test situation rather than a flight training situation. What needs to be determined is if specific portions of the initial instrument flight test, namely very high frequency omnirange radio (VOR), ADF, and ILS approaches, and related instrument procedures, can be conducted effectively in a PGT in lieu of a flight test in an aircraft. If such a determination can be made, supplemental information can be derived which should answer these questions:

1. What equipment and capabilities should a PGT have to accomplish effectively the instrument flight approaches mentioned above, and

2. Are special skills required of the pilot for the PGT to be used as a substitute for an aircraft to accomplish the instrument approaches?

For example, is prior ground trainer experience necessary for a pilot to make effective use of a PGT in a flight test situation? If this is true,

and an inordinate amount of familiarization time is required, then the validity of using PGT's for flight checks on the instrument approaches specified is diminished, if not completely invalidated.

DISCUSSION

GENERAL TEST PLAN.

This activity is ground trainer oriented and ultimately seeks to determine if a PGT can be used effectively as a flight-checking device for accomplishing instrument approaches and procedures instead of accomplishing them in an aircraft on the initial instrument flight test.

A fixed-based PGT, which was used in stage I for instrument flight training, served as the test bed for stage II experimentation. The PGT is representative of a light single-engine fixed landing gear, general-aviation aircraft, and is equipped for simulating instrument flight.

Two groups of selected pilots, one serving as a control and the other as an experimental group participated as subjects. All subjects were required to fly the PGT on a two-hour simulated part-task cross-country flight which included three instrument approaches to minimum altitudes at three different airports. An objective scoring system, based primarily on flight instrument indications throughout the flight was used to assess pilot performance.

After completing the PGT flight check, all subjects flew a similar but not identical cross-country flight in a Cessna 172 equipped for instrument flight. The same scoring system was used to evaluate pilot performance during the aircraft flight check. The resultant data were analyzed statistically to elicit information on the feasibility of using a PGT for flight-checking instrument pilot applicants on instrument flight approaches and related procedures.

PILOT GROUND TRAINER EQUIPMENT.

The instrument flight simulation test environment consisted of a fixed-base PGT representing a light general-aviation aircraft with three-axes flight controls (figure 1). Appropriate flight and engine instruments responded to movements of the flight and engine controls. A complete listing of the pilot ground trainer equipment is provided in table 1.

The PGT was equipped with a plotting board, commonly called an X-Y flightpath recorder, which was visible only to the investigator. An automatic inked stylus traced the "aircraft's" flightpath on the plotting board. Speed and directional movement of the stylus were regulated by PGT airspeed (groundspeed with wind input) and heading. A record of each subject's flight was retained for overall analysis.

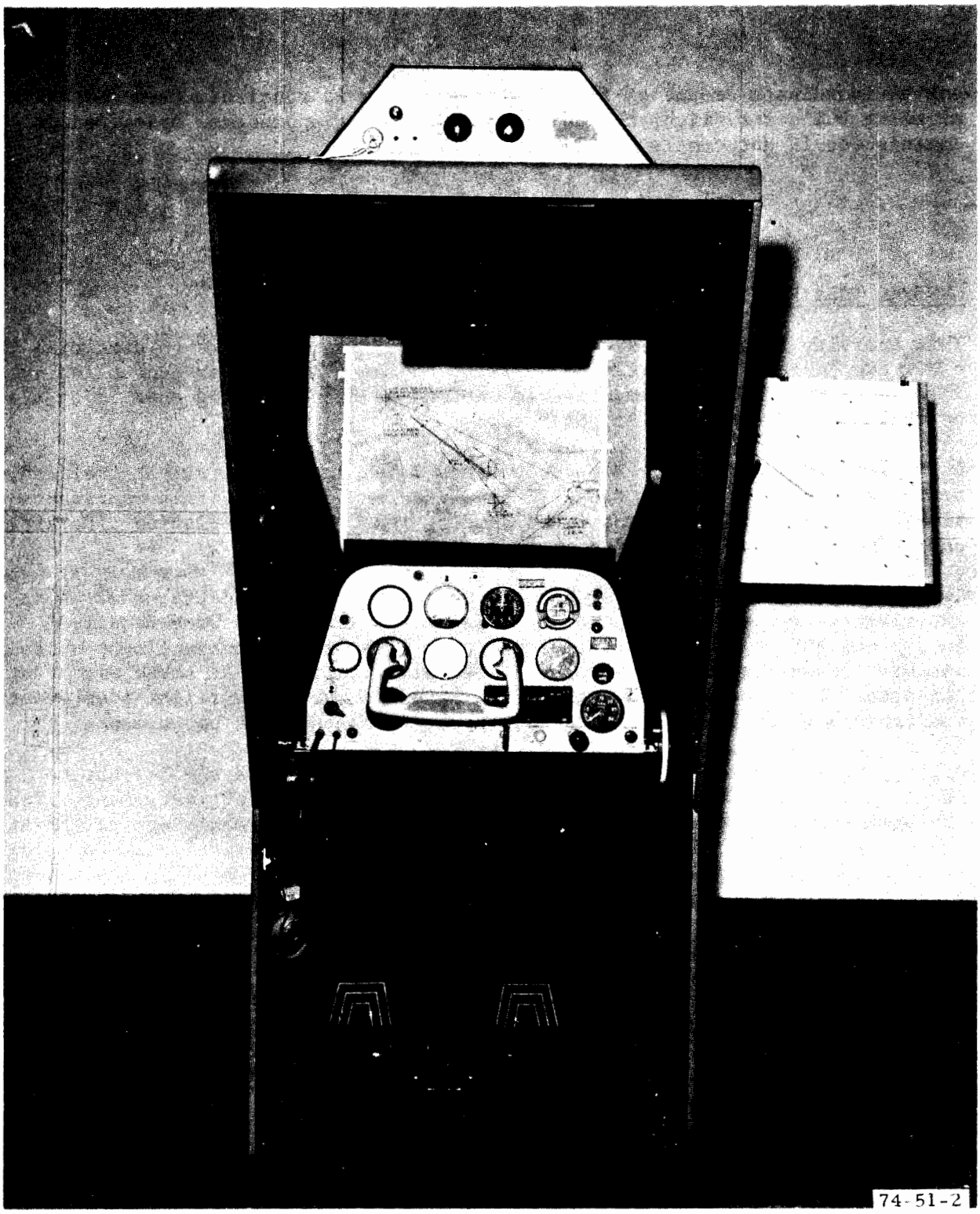

FIGURE 1. PILOT GROUND TRAINER

TABLE 1. PILOT GROUND TRAINER EQUIPMENT

Controls

1. Elevator control
2. Aileron control
3. Rudder control
4. Elevator trim control
5. Throttle
6. Mixture control
7. Carburetor heat control
8. Freeze/parking brake control
9. Flap control
10. Wind direction/force control

Flight and Engine Instruments

11. Airspeed indicator
12. Attitude gyro--adjustable aircraft reference control
13. Altimeter--barometric pressure setting control
14. Turn/slip indicator
15. Directional indicator
16. Vertical speed indicator
17. Tachometer

Communications/Navigation

18. VOR/ILS localizer display (1)
19. VOR/ILS navigation frequency tuning head (1)
20. Communication frequency tuning head (1)
21. ADF display--fixed card, moving pointer
22. Distance measuring equipment display
23. Omni-bearing selector

Other Features

24. Master switch
25. Magneto/start switch
26. Headphones and jack
27. Microphone and jack
28. Marker beacon light/aural signal/ volume control
29. Clock, sweep-second hand
30. Engine noise, volume control
31. Stall warning light and aural signal
32. Geographic aircraft/position light
33. Plotting board (2) X-Y
34. Adjustable seat

SUBJECTS AND FLIGHT-TESTING PROCEDURES.

Thirty subjects, 15 control and 15 experimental, were selected for stage II experimentation from the National Aviation Facilities Experimental Center (NAFEC) personnel and the surrounding local areas of southern New Jersey.

The control group of subjects was comprised of pilots who had a current instrument rating. The experimental group of subjects were pilots who had completed all of the required training for an instrument rating, but had yet to take their instrument flight test in an aircraft. All subjects were active, current pilots with experience in single-engine aircraft and the 30 covered a respresentative range of ages and educational backgrounds.

Thirteen of the control subjects had previous PGT/simulator experience ranging from 10 to 200 hours (hrs) within the last 5 years. Two of the control subjects had never flown a PGT or simulator. Seven of the experimental subjects had previous PGT flight experience ranging from 1 to 25 hrs, while eight of this group had never flown a PGT or simulator. The flight experience and type of pilot certification of all subjects are listed in table 2.

Before starting the instrument flight rules (IFR) flight test in the PGT, each subject received a thorough briefing on the entire IFR mission and what

TABLE 2. SUBJECT GROUP FLIGHT EXPERIENCE (IN HOURS)

Subject	Control Group Hours Certified	Simulation Experience	Experimental Group Hours Certified	Simulation Experience
A	600 Commercial	Yes	200 Private	Yes
B	305 Private	Yes	2,800 Commercial	Yes
C	1,900 Commercial	Yes	500 Commercial	Yes
D	11,000 Commercial	Yes	470 Private	No
E	350 Commercial	Yes	210 Private	No
F	1,000 Commercial	Yes	2,200 Commercial	No
G	450 Commercial	Yes	780 Private	Yes
H	9,000 Commercial	Yes	675 Commercial	Yes
I	1,500 Commercial	Yes	305 Commercial	No
J	600 Commercial	Yes	1,060 Commercial	Yes
K	550 Commercial	Yes	275 Private	No
L	375 Commercial	No	250 Commercial	Yes
M	1,000 Commercial	Yes	650 Commercial	No
N	1,500 Commercial	No	240 Private	No
O	2,500 Commercial	Yes	720 Commercial	No

he was expected to accomplish. All were supplied with appropriate low altitude enroute and instrument approach charts. Subjects were given a PGT cockpit checkout to become acquainted with the location and type of flight/engine instruments, location of various switches and controls as well as the operation of the navigation and communications equipment.

When the subject stated he was ready to begin the flight, he started the PGT and made an IFR takeoff to altitude. The investigator occupied a seat to the right and in back of the subject and assumed the role of an air traffic controller. While the subject was climbing to altitude a simulated wind of 15 knots from a northeasterly direction was injected into the system.

The PGT instrument flight tasks are listed in table 3. The list is a summary of the tasks required and does not show all of the various communications, altitude changes, and voice reports actually requested of the pilot. Furthermore, the "flight test" given was not a full and comprehensive test as would normally be given by a flight examiner. The subjects were not required to preflight the "aircraft," file a flight plan, nor were they subjected to any oral examination on instrument knowledge, procedures, or weather, nor were they required to be familiar with aircraft performance and limitations. Essentially the flight test was limited to basic airwork, IFR navigation including VOR, ADF, and ILS approaches and missed approaches, holding procedures and air traffic control (ATC) communications, the major areas of concern. Mention is also made of the fact that subjects did not receive any PGT flight familiarization time before starting the IFR flight tasks, since one of the objectives of this study was to determine if familiarization time in the PGT is necessary, and if so, to what extent.

In addition to providing the ATC communications of center, approach, tower and ground facilities the investigator scored the subjects performance throughout the flight (see Scoring Criteria and Grading section). The investigator made no attempt to point out any errors the pilot made or to provide any flight instruction. If the pilot erred and corrected his mistake this was documented. However if the pilot was tracking in the wrong direction or not in the area he was supposed to be, the investigator as the control specialist would report "November 20372, radar shows you to be X miles south of the Y facility (or holding pattern), what are your intentions?" This line of advisory put the responsibility of the flight on the pilot exactly as if he were on a solo IFR flight. In the event of geographic disorientation and only as a response to the pilot request for assistance he was given radar vectors to put him on the necessary flight track and scored accordingly. At the completion of the PGT flight test, the subject was permitted to look at the track of his flight as recorded by the X-Y recorder. His performance scores, however, were not made known to him.

The subject then received briefing instructions on the aircraft flight test mission which, as a rule, was scheduled for the following day. Before starting the aircraft flight test, the subjects were given an on-ground cockpit familiarization checkout similar to that for the PGT flight. The subject

occupied the left front seat of the Cessna 172 with a certificated flight instructor, instruments (CFII) in the right seat. (The unpredictability of subject availability, scheduling, and weather precluded obtaining the service of an authorized FAA examiner for the conduct of this study. The CFII, a pilot from the NAFEC flight operations staff, while acting as safety pilot, contributed extensively to the results of this study with astute observations, comments, and recommendations to the investigator on each subject's performance.)

TABLE 3. PGT INSTRUMENT FLIGHT TASKS

1. Takeoff.
2. Depart airport area.
3. Climb to and maintain 2,500-foot altitude.
4. VOR orientation using the Atlantic City (ACY) VORTAC.
5. Cleared from present position to the ACY VORTAC via the 270° radial of ACY.
6. Report established on the 270° radial.
7. Hold at ACY on the 270° radial using correct entry method for a standard right-turn pattern. Report in the holding pattern.
8. Cleared for a full VOR approach to runway 13 at Atlantic City airport.
9. Report when at the airport.
10. Execute a missed approach (not carried out to completion on advice of ATC clearance below).
11. Climb on present heading to and maintain 2,500-foot altitude.
12. ADF orientation using Millville beacon (RAINBOW).
13. Cleared from present position to the nondirectional beacon (NDB) of Millville airport via the 250° bearing of RAINBOW.
14. Report established inbound on the 250° bearing of RAINBOW NDB.
15. Cleared to hold at RAINBOW NDB using correct entry method for a standard right-hand pattern. (Hold on the 144° bearing of the NDB).
16. Cleared for a full ADF approach to runway 14 of Millville airport.
17. Report when at Millville airport.
18. Execute a missed approach (not carried out to completion on advice of ATC clearance below).
19. Climb on present heading to and maintain 2,500-foot altitude.
20. Contact Atlantic City Approach Control for radar vectors for an ILS approach.
21. Intercept localizer.
22. Cleared for an ILS approach to runway 31 of Atlantic City airport.
23. Intercept glide slope.
24. Report decision height.
25. Cleared to land.
26. Land.

The investigator occupied the rear right seat of the Cessna 172 and had a clear view of all flight instruments and radio/navigation equipment. The scoring system employed for the PGT flight test was used for the aircraft

flight test. Simulated ATC communications were provided by the investigator for the VOR phase of flight, and actual ATC communications were employed for the ADF and ILS phases of the instrument flight.

The IFR flight tests were conducted in the southern New Jersey area and made use of three separate navigation/approach facilities at three airports. The flight was planned so that a different instrument approach was conducted at each facility as listed in table 4.

TABLE 4. IFR APPROACHES, FACILITIES, AND AIRPORTS

Type Approach	Airport	Runway	Facility
VOR	Cape May County, N.J.	23	Sea Isle VORTAC
ADF	Millville, N.J.	14	Nondirectional beacon
ILS	Atlantic City, N.J. (NAFEC)	31	Instrument Landing System
ILS	Atlantic City, N.J. (NAFEC)	13	Instrument Landing System

The tasks and procedures to be accomplished on the aircraft flight test are listed in table 5.

The aircraft flight test took an average of 2.0 hrs to complete. With the exception of the holding pattern orbits there were no repetitions of any approach, procedure, or task. In the event that the initial holding pattern orbit was not successful, i.e., the flightpath of the aircraft was not on the appropriate radial, bearing, or holding side, the investigator as ATC would defer clearing the flight for a final approach until the holding pattern was established; however, no more than three holding pattern orbits were permitted.

MAJOR TASK PROCEDURES. The major task procedures of the IFR flight test are listed in table 6 and duplicated on the sample performance scoring sheet displayed as figure 2.

SCORING CRITERIA AND GRADING.

Throughout the PGT and aircraft flight tests subjects were required to adhere to acceptable performance tolerances listed in the Flight Test Guide for Instrument Pilots AC61-56:

Airspeed ± 10 knots
Heading ± 10 degrees
Altitude ± 100 feet
Initial approach altitude--no lower than 100 feet

TABLE 5. AIRCRAFT INSTRUMENT FLIGHT TASKS

1. Takeoff.
2. Depart airport area.
3. Climb to and maintain 2,500-foot altitude in south Atlantic City, N.J., area.
4. Aircraft familiarization--15 minutes of VFR basic airwork.
5. Don instrument hood.
6. VOR orientation using the Sea Isle VORTAC.
7. Cleared from present position to the Sea Isle VORTAC via the 054° radial.
8. Report reaching Sea Isle VORTAC.
9. Hold at Sea Isle VORTAC using correct entry method for a standard right-turn pattern.
10. Cleared for a full VOR approach to runway 23 at Cape May County airport.
11. Report when at the airport.
12. Execute a missed approach (revised to ATC clearance below).
13. Climb on present heading to and maintain 2,500-foot altitude.
14. ADF orientation on Millville nondirectional beacon (NDB) RAINBOW beacon.
15. Cleared from present position to Leesburg intersection via the 333° radial of the Sea Isle VORTAC.
16. Report Leesburg intersection (a two-radial position fix).
17. Cleared to Millville nondirectional beacon (RAINBOW) via the 324° bearing of RAINBOW.
18. Report over the beacon (communications with Millville Flight Service Station and Atlantic City approach control).
19. ADF holding pattern entry and standard right turn pattern.
20. Cleared for a full ADF approach to runway 14 of Millville airport.
21. Report when at Millville airport.
22. Execute a missed approach (revised to ATC clearance below).
23. Climb on present heading to and maintain 2,500-foot altitude.
24. Contact Atlantic City Approach Control for radar vectors for an ILS approach.
25. Intercept ILS localizer.
26. Cleared for an ILS low approach to runway 31 (or 13) of Atlantic City airport (NAFEC).
27. Execute missed approach.
28. Climb to and maintain 1,000-foot altitude.
29. Remove IFR hood.
30. Return to airport.
31. Land.

Name Subject A Date 0-0-0 Weather Clear-Stable Tach Stop 037.1
Wheels Down 1100 Wind SW 12-15 Tach Start 034.9
Wheels Up 0900 Total Clock Time 2.0 Hrs Total Tach 2.2

VOR NAV/APP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	A Σ	B $\bar{X}$	
1 Station Tuning	1	1	1																		3	1.0	
2 Identification	1																				1	1.0	
3 Orientation	1																				1	1.0	
4 Tracking	2	1	1	1	2	1	1														9	1.3	
5 Holding Entry	1	1	2																		4	1.3	
6 Hold Pattern	1	1	1																		3	1.0	
7 Approach Letdown	1	1																			2	1.0	
8 Tracking	2	3	2	1	1	1	2														12	1.7	
9 Minimum Alt.	1																				1	1.0	
10 Time to MAP	1																				1	1.0	$\frac{C}{n} = \frac{14.7}{13} = 1.1$
11 Missed App.	1																				1	1.0	
12 Basic Airwork	1	2	2	1	1	1	1	2	1												12	1.4	1.1 = Overall VOR Task Index For Subject A
13 Communications	1	1	1	1	1																5	1.0	
																				Σ		14.7	C
ADF NAV/APP																							
1 Orientation																							
2 Bearing Intercept																							
3 Tracking																							
4 Holding Entry																							
5 Hold Pattern																							
6 Approach Pattern																							
7 Approach Letdown																							
8 Tracking																							
9 Minimum Alt.																							
10 Time to MAP																							$\frac{D}{n} = \frac{17.0}{13} = 1.3$
11 Missed App.																							
12 Basic Airwork																							1.3 = Overall ADF Task Index For Subject A
13 Communications																							
																				Σ		17.0	D
ILS APP																							
1 Station Tuning																							
2 Identification																							
3 Radar Vectors																							
4 Loc. Intercept																							
5 G/S Intercept																							
6 Tracking Loc.																							
7 Tracking G/S																							
8 Minimum Alt. (DH)																							$\frac{E}{n} = \frac{16.0}{10} = 1.6$
9 Basic Airwork																							
10 Communications																							1.6 = Overall ILS Task Index For Subject A
																				Σ		16.0	E

Comments:

n = number of procedures per task.
A = horizontal summation of scoring marks per procedure.
B = mean score achieved for each procedure.
C,D,E = vertical summation of procedure mean scores.
The overall task index score is obtained by dividing the summated mean scores of each task by the number of procedures in the task. The overall index is a relative indication of flight performance.

FIGURE 2. IFR PERFORMANCE SCORE SHEET

TABLE 6. FLIGHT TEST PROCEDURES

VOR Tasks	ADF Tasks	ILS Tasks
1. Station tuning.	1. Orientation.	1. Station tuning.
2. Station identification.	2. Bearing intercept.	2. Station identification.
3. Orientation.	3. Tracking (enroute).	3. Radar vectors.
4. Tracking (enroute).	4. Holding pattern entry.	4. Localizer intercept.
5. Holding pattern entry.	5. Holding pattern.	5. Glide slope intercept.
6. Holding pattern.	6. Approach pattern.	6. Localizer tracking.
7. Approach letdown.	7. Approach letdown.	7. Glide slope tracking.
8. Tracking (approach pattern).	8. Tracking (approach pattern).	8. Minimum altitude (decision height).
9. Minimum altitude (achieved and maintained).	9. Minimum altitude (achieved and maintained).	9. Basic airwork.
10. Time to missed approach (map).	10. Time to missed approach (map).	10. Communications.
11. Missed-approach procedures.	11. Missed-approach procedure.	
12. Basic airwork.	12. Basic airwork.	
13. Communications.	13. Communications.	

The foregoing procedures constitute the total number of procedures on which the experimental and control groups were scored in both the PGT and in the aircraft. With 15 control and 15 experimental subjects, and 13 VOR, 13 ADF, and 10 ILS procedures, the experimental block design is depicted in figure 3.

PROCEDURES X SUBJECTS

15 S x 13 VOR PROCEDURES = 195 SCORES
15 S x 13 ADF PROCEDURES = 195 SCORES
15 S x 10 ILS PROCEDURES = 150 SCORES
TOTAL 540 SCORED PROCEDURES

540 SCORED PROCEDURES PILOT GROUND TRAINER
540 SCORED PROCEDURES AIRCRAFT
1080 SCORED PROCEDURES PER GROUP
x2 GROUPS
2160 TOTAL SCORED PROCEDURES

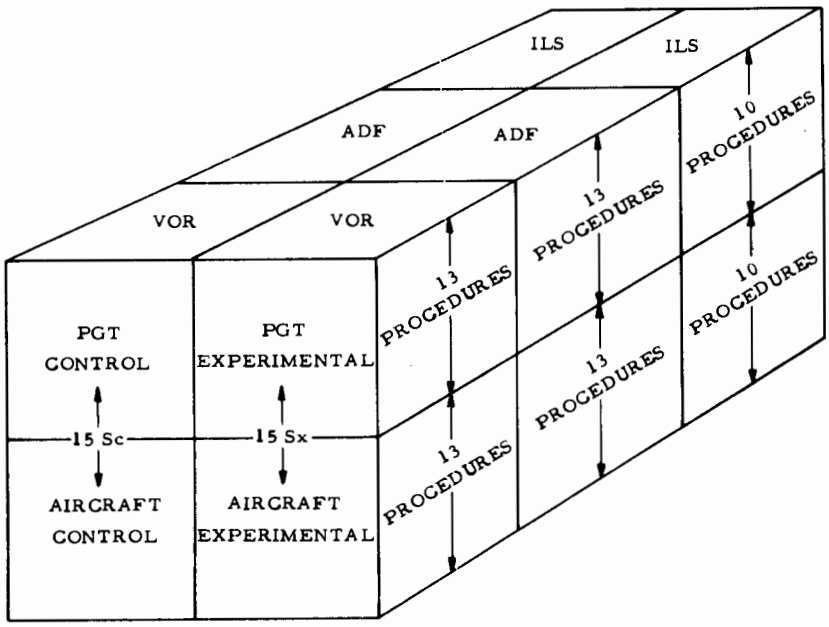

FIGURE 3. EXPERIMENTAL BLOCK DESIGN

In addition to the above tolerances, the occurrence of any event listed below was considered disqualifying:

- Descent below decision height (DH) or minimum descent altitude (MDA).
- Full-scale deflection of course deviation indicator (localizer) or glide slope indicator after glide slope interception.
- Exceeding the radius of turn dictated by published visibility minimums for circling approaches, or descending below the MDA prior to reaching a position from which a normal approach to the landing runway can be made.
- Any procedure or action, or the lack thereof, which requires the intervention of the examiner to maintain safe flight.

While these tolerances represent the minimum performance expected in good flying conditions and are used effectively for flight-checking pilot applicants for the instrument rating, they establish a basic binary decision (pass or fail) which, not only does not provide for a detection of differential performance between pilot performance ability of the control group and the experimental group, but it does not allow for detectable differences between PGT and aircraft performance. In order to discriminate differences between group performance in the PGT and aircraft, a four-point grading system was adopted and applied to the procedures as the performance scoring criteria. The general definitions which were set for the four-level grade system are as follows:

TABLE 7. GRADING LEVEL DEFINITIONS

Grade	Definition
1	Outstanding performance approaching perfection. Not only safe but extremely smooth in controlling the aircraft.
2	Clearly above average performance with only slight control roughness or slight deviations from superior performance. Faultless on safety.
3	Moderately rough control usage, occasionally hesitant, unnecessarily repetitious, but always essentially safe performance.
4	Incorrect, grossly uncoordinated, poor execution, failure to use controls properly, lost, or unsafe.

With this broad classification of pilot performance, the four-point grading system was applied to each task procedure and was based primarily on various flight instrument indications throughout the PGT and aircraft flight tests. The performance grading criteria for task procedures are listed in the appendix. (NOTE: The grading system is an adaptation of that employed in "Study of Capabilities, Necessary Characteristics and Effectiveness of Pilot Ground Trainers, "Vol. 1. Report FAA-RD-72-127.)

Figure 2 shows a sample of the VOR IFR pilot performance scoring sheet. The format was used for the PGT and aircraft flight tests. The tasks and task procedures are listed vertically in the left-hand column. The running scores for each procedure are summed horizontally by rows and result in the figures listed in column A. Depending upon the number of scores assigned to each procedure, the sums in column A are divided by the number of assigned scores resulting in an average performance score for that procedure which is listed in the right-hand column B. The scores for each procedure listed in column B are then summed vertically and divided by the number of maneuvers in the whole task. The net result is a figure depicted by C and is regarded as an overall task index of the pilot's performance of the entire VOR task. As the example indicates, the separate scores for each VOR procedure listed in column B are summed vertically and equal 14.7. This figure is divided by 13, the number of procedures and results in an overall index number of 1.1 for VOR performance. The same method is used to compute the overall task indices for ADF and ILS. The three indices may then be summed and divided by the number of tasks, three, to provide a final figure for total IFR performance, which in the sample case would be $\frac{1.1 + 1.3 + 1.6}{3} = 1.3$.

(NOTE: This last summation was performed during the tabulation of all data, but was not used in any of the analyses. The total IFR performance figures provided supplementary information to the investigator and was used primarily as a check of both groups' performance.)

This method of data tabulation resulted in six major indices or total task scores for each subject; three for PGT VOR, ADF, ILS performance, and three for aircraft VOR, ADF, and ILS performance. Thus the vertical summation of each subject's tabulated scores provides for 15 indices (15 subjects) per task for both the PGT and aircraft and are the data used for comparison in the total task performance analysis within and between the control and experimental groups. The individual procedure PGT scores, 13 for VOR, 13 for ADF, and 13 for ILS were then compared with the 13 VOR, 13 ADF, and 10 ILS scores for aircraft performance for a within and between group analysis.

The reader is reminded that the overall task index scores do not reflect a passing or failing performance since both passing and failing scores are summed and averaged to provide an overall index of pilot performance. Since all subject data were treated in the same manner, the overall index provides a practical and relative means of comparing each groups' performance in the PGT and aircraft as well as a means for comparing the performance of the control group with that of the experimental group. Passing and failing performances are derived from each subjects procedure performance scores, which are handled separately and discussed under table 8.

TABLE 8. OVERALL IFR FLIGHT PERFORMANCE EVALUATION (CONTROL GROUP)

Task	VOR		ADF		ILS	
Subject	Pilot Ground Trainer	Aircraft	Pilot Ground Trainer	Aircraft	Pilot Ground Trainer	Aircraft
A	P	P	P	P	P	P
B	P	P*	P	P	P	P
C	P	P	P	P	P	P
D	P	P	P	F[1]	P	P
E	P	P	P	P	P	P
F	P	P	P	P	P	P
G	P	P	P	P	P	P
H	F[2]	P	P	P	P	P
I	F[3]	P	P	P	P	P
J	P	P*	F[4]	F[4]*	P	P*
K	P	P	F[5]	P	P	P
L	F[6]	P*	P	P	P	P
M	P	P	P	P	P	P
N	P	P	P	P	P	P
O	P	P	P	P	P	P
Total	P = 12 F = 3	P = 15 F = 0	P = 13 F = 2	P = 13 F = 2	P = 15 F = 0	P = 15 F = 0

P = Passed F = Failed * = Did not reset precessed directional gyro

1. Not on the correct bearing in the ADF holding pattern. Homing technique employed to get to the beacon rather than tracking. Disorientation in the pattern coupled with wind correction problems. Ten months since last ADF work.
2. Wrong holding entry for VOR holding pattern. Holding on wrong side using reciprocal radial.
3. Did not fly VOR approach chart pattern. Initiated approach from the VOR holding facility, descending in the VOR holding pattern (on the VOR facility located on the airport) to minimum approach altitude.
4. Forgot ADF procedures. Failure to reset badly precessed gyro in the aircraft. One year since last ADF work.
5. Neglected to hold at ADF beacon after receiving holding clearance. Continued full ADF approach to minimum altitude.
6. Improper holding pattern entry. Holding on wrong side, i.e., holding reciprocal radial.

In order to minimize the number of tables and excessive data, individual performance scores and score sheets were not included in the report. The analysis of all data deals with group performance scores only. Furthermore, to facilitate data handling and analyses, group scores, i.e., group indices of task and procedural performance were increased by a multiple factor of 10. Therefore, as will be noted in the following tables in the results section, a displayed group index of 177 for a task or procedure stands for a group index of 17.7, the sum of all subjects' task or procedure performance index. An associated mean of 12 for the same task or procedure, derived by dividing the group index by 15, the number of subjects, actually represents a mean performance score of 1.2.

SCORING RESULTS

The analysis of variance and "t" tests were the statistical treatments used to determine if there were significant differences between PGT performance scores and aircraft performance scores, within each group and between groups.

Control and experimental group flight performance scores were analyzed in the following order:

Overall Analysis--this was an instrument flight performance evaluation of individual subjects from both groups on a pass or fail basis, in both the PGT and in the aircraft.

1. Separate task analysis (VOR, ADF, and ILS).

   a. Control group PGT performance scores and aircraft performance scores.

   b. Experimental group PGT performance scores and aircraft performance scores.

2. Comparative group task analysis (VOR, ADF, and ILS):

   a. Control group PGT performance scores and experimental group PGT performance scores.

   b. Control group aircraft performance scores and experimental group aircraft performance scores.

3. Procedure analysis (VOR, ADF, and ILS):

   a. Control group PGT procedure performance scores and aircraft procedure performance scores.

   b. Experimental group PGT procedure performance scores and aircraft procedure performance scores.

4. Comparative group procedure analysis (VOR, ADF, and ILS):

a. Control group PGT procedure performance scores and experimental group PGT procedure performance scores.

b. Control group aircraft procedure performance scores and experimental group aircraft procedure performance scores.

5. Separate task analysis--experimental group only (VOR, ADF, and ILS):

a. Simulation experience group PGT task performance scores and nonsimulation experience group PGT task performance scores.

b. Simulation experienced group aircraft task performance scores and nonsimulation experienced group aircraft task performance scores.

6. Procedure analysis (VOR, ADF, and ILS) (experimental group only):

a. Simulation experienced group PGT procedure performance scores and nonsimulation experienced group PGT procedure performance scores.

b. Simulation experienced group aircraft procedure performance scores and nonsimulation experienced group aircraft procedure performance scores.

The discussion which follows pertains to the analyses listed above and follows the same numerical order.

CONTROL GROUP OVERALL ANALYSIS.

Tables 8 and 9 show, respectively, control and experimental group IFR flight test results. Subjects are listed alphabetically from A to O in the left column of the tables. The tables are divided across the top into the three major instrument flight tasks of the instrument flight test. The results of PGT and aircraft (A/C) performance are listed separately under each task. The notations "P" and "F" indicate a passing or failing performance. The reasons for a failing performance are reported in the remarks section below the tables.

Table 8, IFR flight performance of the control group, shows that 10 of the 15 subjects passed all phases of the PGT flight test and five failed. Three of the failures occurred in the VOR task (subjects H, I, and L) and two in the ADF task (subjects J and K). There were no failures in the ILS task.

Explanations for failing performance indicate that the errors contributing to a disqualifying performance during the PGT flight test are primarily pilot procedural errors and were not caused by limited capabilities of the PGT. (Later analyses on task procedures does highlight some PGT limitations.)

Thirteen of the fifteen control subjects passed all phases of the aircraft instrument flight tests and only two failed, both failures occurring in the ADF task.

TABLE 8. OVERALL IFR FLIGHT PERFORMANCE EVALUATION
(CONTROL GROUP)

Task	VOR		ADF		ILS	
Subject	Pilot Ground Trainer	Aircraft	Pilot Ground Trainer	Aircraft	Pilot Ground Trainer	Aircraft
A	P	P	P	P	P	P
B	P	P*	P	P	P	P
C	P	P	P	P	P	P
D	P	P	P	F[1]	P	P
E	P	P	P	P	P	P
F	P	P	P	P	P	P
G	P	P	P	P	P	P
H	F[2]	P	P	P	P	P
I	F[3]	P	P	P	P	P
J	P	P*	F[4]	F[4]*	P	P*
K	P	P	F[5]	P	P	P
L	F[6]	P*	P	P	P	P
M	P	P	P	P	P	P
N	P	P	P	P	P	P
O	P	P	P	P	P	P
Total	P = 12 F = 3	P = 15 F = 0	P = 13 F = 2	P = 13 F = 2	P = 15 F = 0	P = 15 F = 0

P = Passed F = Failed * = Did not reset precessed directional gyro

1. Not on the correct bearing in the ADF holding pattern. Homing technique employed to get to the beacon rather than tracking. Disorientation in the pattern coupled with wind correction problems. Ten months since last ADF work.
2. Wrong holding entry for VOR holding pattern. Holding on wrong side using reciprocal radial.
3. Did not fly VOR approach chart pattern. Initiated approach from the VOR holding facility, descending in the VOR holding pattern (on the VOR facility located on the airport) to minimum approach altitude.
4. Forgot ADF procedures. Failure to reset badly precessed gyro in the aircraft. One year since last ADF work.
5. Neglected to hold at ADF beacon after receiving holding clearance. Continued full ADF approach to minimum altitude.
6. Improper holding pattern entry. Holding on wrong side, i.e., holding reciprocal radial.

TABLE 9. OVERALL IFR FLIGHT PERFORMANCE EVALUATION (EXPERIMENTAL GROUP)

Task	VOR		ADF		ILS	
Subject	Pilot Ground Trainer	Aircraft	Pilot Ground Trainer	Aircraft	Pilot Ground Trainer	Aircraft
A	P	P*	P	P	P	P
B	P	P	P	P	P	P
C	F[1]	P	F[1]	P	P	P
D	P	P	P	P	P	P
E	P	P*	F[2]	F[2]*	P	P*
F	P	P	P	P	P	P
G	F[3]	P	P	P	P	P
H	F[4]	F[4]*	F[4]	F[4]*	P	F[4]*
I	P	F[5]*	P	F[5]*	P	F[5]*
J	P	P	P	P	P	P
K	P	P*	P	F[6]*	P	P*
L	P	P	P	P	P	P
M	P	P	F[7]	P	F[7]	P
N	P	F[8]	P	P	P	P
O	F[9]	P	F[9]	P	P	P
Total	P = 11 F = 4	P = 12 F = 3	P = 10 F = 5	P = 11 F = 4	P = 14 F = 1	P = 13 F = 2

P = Passed F = Failed * = Did not reset precessed directional gyro

1. Selected wrong radial. Tracked away from station instead of to the station. Used ADF homing technique instead of tracking specific ADF bearing as cleared by ATC. Subject never trained to intercept specific bearings. Had general knowledge of tracking.
2. Not knowledgeable in ADF tracking or holding techniques. Did not reset directional gyro which precessed.
3. Initial tension--got disoriented in VOR holding pattern entry and holding pattern.
4. Disqualifying VOR holding pattern entry and holding pattern--lost in holding pattern. Disregraded bearing tracking clearance for ADF work, used homing technique. Did not reset precessed directional gyro. Full glide slope deflection on ILS approach--high on glide slope--insufficient drift corrections throughout PGT and aircraft flights.
5. VOR holding on wrong side of radial--wind and directional gyro problems--ILS full localizer deflection on final approach (35° gyro precession).
6. ADF gyro precession--not on required bearing on ADF approach to airport.
7. Lost initially in ADF holding entry--homing not tracking. Full ILS glide slope deflection on ILS approach in the PGT.
8. Holding pattern on wrong side of VOR radial--did not correct enough for wind drift.
9. Forgot to letdown to VOR minimums in PGT. Could not get on desired ADF bearing for tracking in PGT. Not enough wind drift correction.

Comment: It appears that the VOR pilot procedural errors of subjects H, I, and L, occurring during the PGT flight test, served to alert the subjects to their particular mistakes to the extent that similar errors did not occur during the aircraft flight check.

On the ADF task, subject D passed the PGT flight test and failed the aircraft flight test. Subject J failed in both the PGT and aircraft. Both of these subjects stated that they had not performed any ADF navigation or approaches for approximately 1 year. Subject D's procedural errors in the aircraft, started with a wrong entry into the ADF holding pattern, and he became geographically disoriented thereafter. Subject D attributed his failing performance to "losing the picture," or mental image of his position in terms of the ADF beacon. The subject also exceeded minimum approach altitudes by a 100-foot altitude while attempting to get on the correct inbound bearing to the airport.

Subject J's ADF performance in the aircraft was predicted on the basis of his performance in the PGT. In addition to his acknowledged forgetting of ADF procedures, subject J neglected to reset a badly precessed (30°) directional gyro throughout the entire flight.

Subject K's failing ADF performance in the PGT was caused by his failure to hold on the nondirectional ADF beacon after receiving a holding clearance. The subject realized his error when he was departing the ADF beacon inbound. The entire ADF flight, with this exception, was rated as excellent. The subject did not fail to adhere to the holding clearance on his aircraft flight test.

EXPERIMENTAL GROUP OVERALL ANALYSIS.

Table 9 lists the results of the PGT and aircraft flight tests of the experimental group. The format is identical to that of table 8. The results show that 9 of the 15 experimental subjects passed all phases of the PGT flight test and 6 subjects failed in one or more of the 3 major IFR tasks. Subjects C, G, H, and O failed portions of the VOR task, subjects C, E, H, M, and O failed portions of the ADF task and subject M failed the ILS task. Reasons for disqualifying performances are listed in the remarks section below the table. The errors committed were attributed to pilot procedural errors and were not caused by limited capabilities of the PGT.

The results of the aircraft flight test show that 10 of the 15 subjects passed all phases of IFR work and that 5 subjects failed in one or more of the 3 major IFR tasks. Subjects H, I, and N failed portions of the VOR task, subjects E, H, I, and K failed portions of the ADF task and subjects H and I failed the ILS phase of the instrument flight test.

Comment: Subjects C, G, M, and O, who failed one or more of the major tasks during the PGT flight check had successful performances in the aircraft, i.e., the procedural errors committed in the PGT were not repeated during the aircraft flight test. This outcome is identical to that of the performances of control subjects H, I, and L in that the PGT flight served to alert the

subjects to their procedural errors so that identical mistakes were not repeated on the aircraft flight test.

The ADF aircraft flight test results of subjects E and H are exactly as expected, based on their performance in the PGT. Subject E, who stated that he had about 5 hours of ADF training was not familiar with ADF bearing intercepts or tracking. The subject used the "homing" technique to get to the radio beacon and heading information from the beacon inbound on the ADF approach to the airport. His apparent minimal knowledge of ADF relative bearing information precluded an acceptable performance of ADF holding pattern entry and holding. Furthermore subject E was one of four experimental subjects who neglected to check and reset a badly precessed directional gyro in the aircraft. This omission by this subject, and three other subjects (H, L, and K) was one of the major errors contributing to their disqualifying performance in ADF navigation and approach procedures.

Subject H became lost during pilot ground trainer and aircraft VOR and ADF phases of flight. The ILS approach in the aircraft was performed with full glide slope deflection from the outer compass locator (LOM) to decision height (DH). With the exception of the ILS work (in the pilot ground trainer), the disqualifying performance of this subject in the PGT was repeated in the aircraft and was predicted on the basis of his PGT performance.

Subject I had difficulty with a 22-25 knot wind when flying the aircraft. The VOR holding pattern was maintained on the nonholding side of the required holding radial. A wind problem in conjunction with a directional gyro precessed 30° accounted for the disqualifying performance in the ADF holding pattern and approach to the airport. The entire ADF approach pattern was flown on bearings other than those depicted on the ADF approach chart. During the ILS approach, the subject failed to make a sufficient wind drift correction to maintain the ILS localizer approach course, but did manage to capture and maintain the glide slope. The ILS approach to DH was flown with a fully deflected localizer indication.

Subject N had difficulty with wind and wind drift corrections during the VOR holding pattern entry and holding pattern on the aircraft flight test. After three unsuccessful holding pattern orbits, the aircraft flightpath was still on the nonholding side of the holding radial. The subject had no difficulty with the ADF and ILS phases of the flight test.

The results of the overall analysis of pilot performance highlight several important facts with regard to the use of a PGT as a part task IFR flight-checking device. Considering the performance of both groups, all of the errors contributing to a disqualifying performance in the ground trainer are pilot procedural errors and not attributable to limitations or deficiencies of the trainer. Thus an appropriately equipped and acceptable ground trainer is an excellent tool for determining if pilots are thoroughly familiar with the procedures associated with instrument flight.

Looking at the ground trainer flight test results of control subjects H, I, K, and L (table 8) it is reasonable to assume that these subjects would have committed the same errors in the aircraft, if the airborne flight check had not been preceded by the ground trainer check, and which, as a consequence, alerted them to their errors. In reality, the "errors," while documented as disqualifying are regarded as singular, isolated type errors and essentially not attributable to a gross lack of procedural knowledge. As examples, control subjects H and L cleared to hold west of the VOR facility on a 270° radial, held east on the 090° radial. Subject K (ADF task) completely forgot he was cleared to hold at the nondirectional beacon, and commenced and completed (successfully) a full ADF approach to minimums before realizing his error. In contrast to this so called "singlar and isolated" error situation, control subject J had completely forgotten, his ADF procedures for intercepting bearings, tracking bearings, and interpreting ADF relative bearing information. Thus the term "gross lack of procedural knowledge" applies, and no improvement in his ADF procedural ability was expected when he performed in the aircraft.

An identical error performance was demonstrated by subjects in the experimental group (table 9). Subjects C, G, M, and O failed one or more tasks in the PGT, but successfully completed their aircraft flight checks. Subjects E and H had disqualifying performances in both the PGT and aircraft. On the basis of knowledge gained from the performance of the control group, an assumption was made that experimental subjects C, G, M, and O, having failed portions of the PGT flight check because of "singular," isolated-type errors would not commit the same errors, and would in all probability pass the aircraft flight check if other errors did not occur. Furthermore, it was assumed that experimental subjects E and H would not qualify in the aircraft because of their poor performance in the PGT. The assumptions in both cases proved to be correct. What was not predicted were the disqualifying aircraft performances of experimental subjects I, K, and N. In retrospect, the reasons for a failing performance are not only understandable but underscore two major capabilities that PGT's should have if they are to be considered acceptable for flight-checking instrument-pilot applicants in ADF navigation and ADF/ILS approaches.

Experimental subjects I and N had difficulty making sufficient wind drift corrections during the aircraft flight test to maintain a desired ground track, and establishing and maintaining an acceptable holding pattern. Subject N, after three unsuccessful VOR holding pattern orbits, realized his problem and compensated for wind drift on the ADF and ILS tasks for a successful performance of these tasks.

Subject I never managed to "pin down the wind (22-25 knots)" throughout the entire flight test. The PGT had a capability of simulating wind from various directions and forces. Wind input for the PGT flight test was set for 15 knots of force from a direction that provided a crosswind, and, was kept constant throughout the PGT flight test. Perhaps, the introduction of a wind of higher intensity or variable direction during the PGT flight test may have induced subject I to be prepared for flying the aircraft under the stronger wind conditions that prevailed during his aircraft flight test.

Subject I's ADF problems with wind were compounded by an aircraft directional gyro that had precessed 35°and which he had neglected to check and reset during the course of the entire aircraft flight test. This same oversight was a contributing factor to the disqualifying ADF performances of experimental subjects E, H, and K, and accounts for five out of six of the ADF task failures. (This type of ADF error or failure to check and reset a precessed directional gyro was prevalent in stage I of instrument training and is discussed fully in that report, reference, interim report FAA-RD-75-36.)

The results of these initial, overall, analyses indicate that if PGT's are to be considered acceptable as flight-checking devices for ADF and ILS procedures, the following two major equipment capabilities in addition to those PGT equipment requirements specified under FAR part 141.41 should be included:

The first PGT equipment capability should be a provision for simulating wind conditions of varying direction and intensity. This accessory would enable the FAA flight examiner to observe how instrument pilot applicants cope with wind conditions that one encounters in normal everyday flight. It affords the examiner an opportunity to observe that instrument pilot applicants can correctly compensate for an existing wind condition and maintain appropriate ground, holding, and approach pattern tracks in the course of instrument flight tasks.

The second accessory, a resettable directional gyro with a capability of simulated precession, in reality is covered by FAR part 141.41(b) Training Aids and Equipment, which states "Each training aid, including any audio visuals, mockup, chart or aircraft component listed in the approved training course outline must be accurate and appropriate to the course for which it is used."

The directional gyro, with a precession capability is mentioned here because such an adjunct requires the addition of a magnetic compass or at least another source of heading information, to which the precessed directional gyro could be reset. Without this capability the flight examiner has no knowledge of whether or not the instrument applicant has developed a habit of checking, and, if necessary, correcting a precessed directional gyro. Correct heading information is absolutely essential for safe and proper ADF instrument navigation and approaches. Failing to insure that the directional gyro heading is the same as or closely approximates magnetic heading, the pilot has no other source of information to tell him that he is not on the proper ADF bearing. For all practical purposes the displayed and uncorrected heading information combined with the ADF relative bearing reading indicates to the pilot that he is where he is supposed to be. Unfortunately, this is not the case and this finding is further supported by the results of stage I instrument training and stage II flight testing activity. Even with accurate heading and relative bearing information the ADF approach like the VOR approach is still classified as a nonprecision approach.

The data analyses that follow starting with the separate task analysis (item 1) were performed to provide answers to the following questions:

1. Do the PGT performance scores of both groups differ significantly from their aircraft performance scores?

2. Are there significant differences between the performance scores of the control group and experimental group for the PGT flight test? for the aircraft flight test?

3. Do the PGT and aircraft performance scores of those pilots with previous simulation experience differ significantly from the PGT and aircraft scores of pilots who had no previous simulation experience?

If significant differences are revealed between the PGT and aircraft performance score, the chief concern becomes an identification of those factors which contributed to the difference.

The results of the analyses should elicit specific information concerning the feasibility of (a) using PGT's as part-task instrument flight-checking devices, (b) the PGT equipment deemed necessary for their use in this role and (c) whether or not special skills (training) are required of pilots for them to "fly" the PGT within acceptable flight test tolerances in the performance of ADF and ILS approaches.

The reader is reminded that the tabulated scores accumulated for analysis do not reflect passing or failing grades. The scores as such represent a summation of group performance, which includes passing and failing grades, and are to be regarded only as comparative indices to discriminate significant differences, if any, within and between control and experimental group performances.

CONTROL GROUP SEPARATE TASK ANALYSIS.

Table 10 shows the performance scores achieved by the control group for the PGT and aircraft flight checks. The table lists performance scores for the major IFR tasks of VOR, ADF, and ILS. The procedures on which pilots were scored are listed in rows in the left-hand column of the table. Thus, under the block tasks of VOR, ADF, and ILS, there are, respectively, 13, 13, and 10 procedures. Looking at the VOR block, the first column of figure's (A) under the pilot ground trainer heading, represents the summary of scores achieved by the 15 control subjects for each procedure listed. The second column of figures (B) shows the mean score of all 15 subjects for each particular procedure. Thus the number 207 in the first row, first column (A) of the VOR block indicates the summary score of 15 subjects for tuning in a VOR station, and the mean score for this procedure is 14 as displayed in the second or B column. Columns C and D represent the group scores and means for the aircraft flight test. Column E, labeled PGT ~A/C indicates the difference between PGT and aircraft scores. Column F indicates the level of probability resulting from the test of significance, with the notation N.S. meaning "not significant." As mentioned previously, subjects were scored on their performance on a range of 1.0 for excellent performance through 4.0 for a failing performance. To facilitate data handling the scores were increased by a multiple factor of 10, so that actually the figure 207 in column A first row

TABLE 10. COMPARATIVE ANALYSIS OF CONTROL GROUP PERFORMANCE SCORES BY TASK

Procedure No.	VOR Tasks	Pilot Ground[1] Trainer Scores A Sum	B Mean	Aircraft Scores C Sum	D Mean	PGT ∿ A/C[2] E Sum	Level of Significance[3] F Mean
1	Station Tuning	207	14	177	12	30	N.S.
2	Station Identification	275	18	315	21	-40	N.S.
3	Orientation	195	13	185	12	10	N.S.
4	Tracking (Enroute)	261	17	195	13	66	.025*
5	Holding Pattern Entry	295	20	175	12	120	.01 *
6	Holding Pattern	365	24	302	20	63	N.S.
7	Approach Letdown	339	23	210	14	129	.005*
8	Tracking (Pattern)	272	18	202	13	70	.025*
9	Minimum Altitude	357	24	242	16	115	.025*
10	Time to Missed Approach	320	21	210	14	110	N.S.
11	Missed-Approach Procedure	215	14	160	11	55	N.S.
12	Basic Airwork	249	17	258	17	- 9	N.S.
13	Communication	203	14	186	12	17	N.S.
	Total	3553	237	2817	188	736	
	Total Task Mean ($\bar{m}$)	273	18	217	14	56	.005*
	ADF Tasks						
1	Orientation	300	20	295	20	5	N.S.
2	Bearing Intercept	275	18	256	17	19	N.S.
3	Tracking (Enroute)	299	20	285	19	14	N.S.
4	Holding Pattern Entry	370	25	238	16	132	.005*
5	Holding Pattern	323	22	317	21	6	N.S.
6	Approach Pattern	251	17	274	18	-23	N.S.
7	Approach Letdown	247	16	318	21	-71	N.S.
8	Tracking (Pattern)	331	22	263	18	68	.025*
9	Minimum Altitude	312	21	295	20	17	N.S.
10	Time to Missed Approach	280	19	310	21	-30	N.S.
11	Missed-Approach Procedure	193	13	180	12	13	N.S.
12	Basic Airwork	260	17	267	18	- 7	N.S.
13	Communications	213	14	184	12	29	N.S.
	Total	3655	244	3482	232	173	
	Total Task Mean ($\bar{m}$)	282	19	268	18	14	N.S.
	ILS Tasks						
1	Station Tuning	203	14	210	14	- 7	N.S.
2	Station Identification	420	28	315	21	105	N.S.
3	Radar Vectors	155	11	160	11	- 5	N.S.
4	Localizer Intercept	172	11	305	21	-133	.005*
5	Glide Slope Intercept	322	21	185	12	137	.005*
6	Localizer Tracking	196	13	227	15	- 31	N.S.
7	Glide Slope Tracking	259	17	249	17	10	N.S.
8	Minimum Altitude	210	14	195	13	15	N.S
9	Basic Airwork	248	17	226	15	22	N.S.
10	Communications	168	11	168	11	0	N.S.
	Total	2353	157	2240	150	113	
	Total Task Mean ($\bar{m}$)	235	16	224	15	12	N.S.

1. Summated scores of 15 subjects
2. ∿ = Difference between PGT and A/C scores
3. N.S. = Not significant
* = Significance

under the PGT heading represents a group score of 20.7. The mean of 14 in the adjacent column B represents a mean group performance score of 1.4 for performing the station tuning procedure. While table 10 contains scores for each individual procedure, the first analysis is restricted to the overall task performance results between the control groups PGT scores and their aircraft flight test scores. The analysis treats the data of each major task. Individual procedure analyses are treated later in the report under the Procedure Analysis section.

For example, the overall total VOR scores are shown in the last row of the VOR tasks and are labeled "Total Task Mean ($\bar{m}$). The group score for VOR achieved in the PGT was 273 with a mean of 18 while that of the aircraft VOR performance was 217 with a mean of 14. These untreated data show that the VOR score achieved in the aircraft is relatively lower, indicating a better score than that achieved in the PGT. The means differ by a factor of four. Are the mean differences significant? To make this determination, the "t" test for means, or more accurately, the difference between the two means for correlated observations, was employed. This test of significance is used to determine the probability of an event occurring. If the test results in a large probability the conclusion drawn is that such a result could have occurred by chance alone. If the test results in a small probability it may then be inferred that either a rare event has actually occurred or that the original assumption or hypothesis being tested is false. For this analysis the stated hypothesis basically is that there are no differences between performance scores achieved in the PGT and performance scores achieved in the aircraft. If the resultant probability is small, the hypothesis is regarded as false and the hypothesis is "rejected," with the knowledge that something other than chance is contributing to the significant difference indicated by the small probability level resulting from the test. The 0.05 level of probability was selected as the significant level for all statistical analyses, since for most experimental work, it appears to be generally agreed that differences are significant if they could occur by chance less than 5 percent (.05) of the time. An event that occurs once in 100 times (.01) is conceded to be highly significant.

The test for significant differences between the VOR task performance mean score achieved in the PGT and the mean score achieved in the aircraft resulted in a 0.005 level of probability. Essentially this means that by chance alone, the difference between the VOR mean scores would occur only one out of two hundred times. Therefore the result is regarded as highly significant and indicates that for some reason, unknown at this time, control subjects performed the overall VOR task better in the aircraft than they did in the PGT. (The reason for the VOR significance is made clear in later analyses and is reported in the "interpretation of results" section.)

The "t" test as applied to the performance scores achieved by the control group for total ADF and ILS tasks did not result in significant data. For ADF the total scores and means for PGT and aircraft performance were, respectively, 282 with a mean of 19 and 268 and a mean of 18. For ILS the total performance scores were 235 and a mean of 16 for the PGT and 224 and a mean of 15 for the aircraft.

The reader is reminded that the term "no significance" for these analyses is a relative term, and does not infer satisfactory performance in both the PGT and aircraft. The term refers to the fact that control subject performance in the PGT, whether passing or failing, is relatively similar to their performance in the aircraft.

EXPERIMENTAL GROUP SEPARATE TASK ANALYSIS.

Table 11 shows the performance scores achieved by the experimental group for the PGT and aircraft flight tests. The displayed data have the same format as that of table 10, control group performance, and were analyzed statistically in the same manner. The total VOR task performance scores are shown in the last row ($\bar{m}$) of the outlined VOR block.

The PGT score achieved was 318 with a mean of 21 and the aircraft score was 235 with a mean of 16. The "t" test resulted in a highly significant difference between PGT scores and aircraft scores at the 0.005 level of probability. As was the case with the control group, experimental subjects, for some as yet, undefined reason achieved a relatively better VOR performance score (235) in the aircraft than they did in the PGT (318).

The "t" test for significant differences between the means of pilot ground trainer and aircraft performance scores for the ADF and ILS task resulted in a marginal significance at the 0.05 level of probability for both tasks. Referring to the total ADF and ILS scores in row $\bar{m}$ it can be seen that the lower or better performance scores were achieved by the experimental group on the aircraft flight check.

A summary of this first total task analysis resulted in significant differences between the total VOR performance scores achieved on the PGT and aircraft flight tests for both groups. The levels of probability reached were identical at 0.005 for the control and experimental groups.

There were no significant differences between the control group's PGT and aircraft scores for the ADF and ILS tasks. Marginal significant differences at the 0.05 level of probability were achieved for experimental group performances of ADF and ILS.

For the tasks in which significant differences did occur a lower or better performance score was achieved in the aircraft.

COMPARATIVE GROUP TASK ANALYSIS.

Whereas tables 10 and 11 compared PGT and aircraft scores within each group, an analysis of variance was employed to test for significant differences between the scores of the control and experimental groups. The data of tables 12 and 13 are identical to the data of tables 10 and 11 but were rearranged for the comparative analysis between groups. The analysis applied relates only to the total performance scores of the three major IFR tasks and each block score is so outlined. The results of the analysis of variance for differences between control and experimental group performance of VOR, ADF,

TABLE 11. COMPARATIVE ANALYSIS OF EXPERIMENTAL GROUP PERFORMANCE SCORES BY TASK

Procedure No.	VOR Tasks	Pilot Ground[1] Trainer Scores A Sum	B Mean	Aircraft Scores C Sum	D Mean	PGT ∿ A/C[2] E Sum	Level of Significance[3] F Mean
1	Station Tuning	168	11	160	11	8	N.S.
2	Station Identification	310	21	255	17	55	N.S.
3	Orientation	290	19	230	[illegible]	60	N.S.
4	Tracking (Enroute)	332	22	215	[illegible]	117	.005*
5	Holding Pattern Entry	350	23	226	[illegible]	124	.025*
6	Holding Pattern	362	24	355	[illegible]	7	N.S.
7	Approach Letdown	319	21	236	[illegible]	83	.005*
8	Tracking (Pattern)	337	22	226	[illegible]	111	.005*
9	Minimum Altitude	470	31	29[illegible]	20	172	.025*
10	Time to Missed Approach	350	23	[illegible]	13	160	.010*
11	Missed-Approach Procedure	305	20	180	12	125	.005*
12	Basic Airwork	289	19	274	18	15	N.S.
13	Communication	251	17	207	14	44	N.S.
	Total	4133	272	3052	204	1081	
	Total Task Mean ($\bar{m}$)	318	21	235	16	83	.005*
	ADF Tasks						
1	Orientation	260	17	245	16	15	N.S.
2	Bearing Intercept	295	20	210	14	85	N.S.
3	Tracking (Enroute)	321	21	270	18	51	N.S.
4	Holding Pattern Entry	284	19	220	15	64	N.S.
5	Holding Pattern	330	22	320	21	10	N.S.
6	Approach Pattern	321	21	282	19	39	N.S.
7	Approach Letdown	334	22	254	17	80	.05*
8	Tracking (Pattern)	369	25	302	20	67	N.S.
9	Minimum Altitude	265	18	210	14	55	N.S.
10	Time to Missed Approach	260	17	250	17	10	N.S.
11	Missed-Approach Procedure	270	18	170	11	100	.025*
12	Basic Airwork	317	21	302	20	15	N.S.
13	Communications	246	16	216	14	30	N.S.
	Total	3872	257	3249	216	623	
	Total Task Mean ($\bar{m}$)	297	20	250	17	47	.05*
	ILS Tasks						
1	Station Tuning	185	12	150	10	35	N.S.
2	Station Identification	360	24	220	15	140	.025*
3	Radar Vectors	195	13	160	11	35	
4	Localizer Intercept	210	14	300	20	-90	.05*
5	Glide Slope Intercept	330	22	230	16	100	.005*
6	Localizer Tracking	259	17	268	19	- 9	N.S.
7	Glide Slope Tracking	291	19	282	20	9	N.S.
8	Minimum Altitude	240	16	160	11	80	N.S.
9	Basic Airwork	336	22	291	19	45	N.S.
10	Communications	213	14	173	12	40	N.S.
	Total	2619	173	2234	153	385	
	Total Task Mean ($\bar{m}$)	262	17	223	15	39	.05*

1. Summated scores of 15 subjects
2. PGT ∿A/C = Difference between scores
3. N.S. = Not significant
* = Significance

TABLE 12. COMPARATIVE ANALYSIS OF CONTROL GROUP AND EXPERIMENTAL GROUP PILOT GROUND TRAINER PERFORMANCE SCORES BY TASK

Procedure No.	VOR Tasks	Control Group A Sum[1]	Control Group B Mean	Experimental Group C Sum[1]	Experimental Group D Mean	Difference Between E A~C[2]	Difference Between F B~D	Level of Significance[3] G 1
1	Station Tuning	207	14	168	11	39	3	N.S.
2	Station Identification	275	18	310	21	-35	3	N.S.
3	Orientation	195	13	290	19	-95	6	N.S.
4	Tracking (Enroute)	261	17	332	22	-71	5	.05*
5	Holding Pattern Entry	295	20	350	23	-55	3	N.S.
6	Holding Pattern	365	24	362	24	3	0	N.S.
7	Approach Letdown	339	23	319	21	20	2	N.S.
8	Tracking (Pattern)	272	18	337	22	-65	4	N.S.
9	Minimum Altitude	357	24	470	31	-113	7	N.S.
10	Time to Missed Approach	320	21	350	23	-30	2	N.S.
11	Missed-Approach Procedure	215	14	305	20	-90	6	N.S.
12	Basic Airwork	249	17	289	19	40	2	N.S.
13	Communication	203	14	251	17	48	3	N.S.
	Total	3553	237	4133	272	-580	35	
	Total Task Mean ($\bar{m}$)	273	18	318	21	- 45	3	N.S.
	ADF Tasks							
1	Orientation	300	20	260	17	40	3	N.S.
2	Bearing Intercept	275	18	295	20	- 18	2	N.S.
3	Tracking (Enroute)	299	20	321	21	- 22	1	N.S.
4	Holding Pattern Entry	370	25	284	19	86	6	N.S.
5	Holding Pattern	323	22	330	22	- 7	0	N.S.
6	Approach Pattern	251	17	321	21	- 70	4	N.S.
7	Approach Letdown	247	16	334	22	- 87	6	N.S.
8	Tracking (Pattern)	331	22	369	25	- 38	3	N.S.
9	Minimum Altitude	312	21	265	18	47	3	N.S.
10	Time to Missed Approach	280	19	260	17	20	2	N.S.
11	Missed-Approach Procedure	193	13	270	18	- 77	5	N.S.
12	Basic Airwork	260	17	317	21	- 56	4	N.S.
13	Communications	213	14	246	16	- 33	2	N.S.
	Total	3655	244	3872	257	-217	13	
	Total Task Mean ($\bar{m}$)	282	19	297	20	- 15	1	N.S.
	ILS Tasks							
1	Station Tuning	203	14	185	12	18	2	N.S.
2	Station Identification	420	28	360	24	60	4	N.S.
3	Radar Vectors	155	11	195	13	- 40	2	N.S.
4	Localizer Intercept	172	11	210	14	- 38	3	N.S.
5	Glide Slope Intercept	322	21	330	22	- 8	1	N.S.
6	Localizer Tracking	196	13	259	17	- 63	4	N.S.
7	Glide Slope Tracking	259	17	291	19	- 32	2	N.S.
8	Minimum Altitude	210	14	240	16	- 30	2	N.S.
9	Basic Airwork	248	17	336	22	- 88	5	.025*
10	Communications	168	11	213	14	- 45	3	N.S.
	Total	2353	157	2619	173	-266	16	
	Total Task Mean ($\bar{m}$)	235	16	224	17	11	1	N.S.

1. Summated scores of 15 subjects
2. ~ = Difference between scores
3. N.S. = Not significant
* = Significance

TABLE 13. COMPARATIVE ANALYSIS OF CONTROL GROUP AND EXPERIMENTAL GROUP AIRCRAFT PERFORMANCE SCORES BY TASK

Procedure No.	VOR Tasks	Control Group A Sum[1]	Control Group B Mean	Experimental Group C Sum[1]	Experimental Group D Mean	Difference Between E A~C[2]	Difference Between F B~D	Level of Significance G 1
1	Station Tuning	177	12	160	11	17	1	N.S.[3]
2	Station Identification	315	21	255	17	60	4	N.S.
3	Orientation	185	12	230	15	-45	3	N.S.
4	Tracking (Enroute)	195	13	215	14	-20	1	N.S.
5	Holding Pattern Entry	175	12	226	15	-51	3	.025*
6	Holding Pattern	302	20	355	24	-53	4	N.S.
7	Approach Letdown	210	14	236	16	-26	2	N.S.
8	Tracking (Pattern)	202	13	226	15	-24	2	N.S.
9	Minimum Altitude	242	16	298	20	-56	4	N.S.
10	Time to Missed Approach	210	14	190	13	20	1	N.S.
11	Missed-Approach Procedure	160	11	180	12	-20	1	N.S.
12	Basic Airwork	258	17	274	18	-16	1	N.S.
13	Communication	186	12	207	14	-21	2	N.S.
	Total	2817	188	3052	204	-235	16	
	Total Task Mean ($\bar{m}$)	217	14	235	16	-18	2	N.S.
	ADF Tasks							
1	Orientation	295	20	245	16	50	4	N.S.
2	Bearing Intercept	256	17	210	14	46	3	N.S.
3	Tracking (Enroute)	285	19	270	18	15	1	N.S.
4	Holding Pattern Entry	238	16	220	15	18	1	N.S.
5	Holding Pattern	317	21	320	21	- 3	0	N.S.
6	Approach Pattern	274	18	282	19	- 8	1	N.S.
7	Approach Letdown	318	21	254	17	64	4	N.S.
8	Tracking (Pattern)	263	18	300	20	-37	2	N.S.
9	Minimum Altitude	295	20	210	14	85	6	N.S.
10	Time to Missed Approach	310	21	250	17	60	4	N.S.
11	Missed-Approach Procedure	180	12	170	11	10	1	N.S.
12	Basic Airwork	267	18	302	20	-35	2	N.S.
13	Communications	184	12	216	14	-32	2	N.S.
	Total	3482	232	3249	216	233	16	
	Total Task Mean ($\bar{m}$)	268	18	250	17	18	1	N.S.
	ILS Tasks							
1	Station Tuning	210	14	150	10	60	4	.025*
2	Station Identification	315	21	220	15	95	6	N.S.
3	Radar Vectors	160	11	160	11	0	0	N.S.
4	Localizer Intercept	305	21	300	20	5	1	N.S.
5	Glide Slope Intercept	185	12	230	16	-45	4	N.S.
6	Localizer Tracking	227	15	268	19	-41	4	N.S.
7	Glide Slope Tracking	249	17	282	20	-33	3	N.S.
8	Minimum Altitude	195	13	160	11	35	2	N.S.
9	Basic Airwork	226	15	291	19	-65	4	.025
10	Communications	168	11	173	12	- 5	1	N.S.
	Total	2240	150	2334	153	-194	3	
	Total Task Mean ($\bar{m}$)	224	15	233	15	- 9	0	N.S.

and ILS in both the PGT and aircraft did not produce significant data. These results infer that the PGT and aircraft performance scores of the control group achieved on VOR, ADF, and ILS as total task scores are no better or worse than those achieved by the control group.

The summated scores of both groups for PGT and aircraft performance extracted from tables 12 and 13 are shown below. The lack of major differences between the group scores is apparent and indicative of nonsignificance.

Pilot Ground Trainer Scores

	Control Group Sum/mean	Experimental Group Sum/mean
VOR	273/18	318/21
ADF	282/19	297/17
ILS	235/16	224/17

Aircraft Scores

Control Group Sum/mean	Experimental Group Sum/mean
217/14	235/16
268/18	250/17
224/15	233/15

An examination of the group scores shows the slightly better performance (lower score) of the control group for VOR and ADF work in the PGT and slightly better VOR and ILS work in the aircraft. The differences however are not significant.

PROCEDURE ANALYSIS.

CONTROL GROUP VOR PROCEDURES. The data for these analyses are tabulated in table 14. The application of the "t" test analyzes specific procedure performance scores achieved by the control group in the PGT and compares them with their performance scores achieved in the aircraft on a procedure-by- procedure basis. In essence, these procedure scores comprise the summed total scores of the three tasks which were analyzed previously. Since the results of that analysis indicated significance at the 0.005 level, the singular procedural analysis is performed to determine what factors (procedure scores) contributed to the significant difference in scores between the VOR PGT flight check and the aircraft flight check.

The figures in column E of table 14, as previously explained, indicate the difference between PGT and aircraft scores. When a figure in this column is preceded by a minus sign (-), it indicates that a slightly better performance score was achieved in the PGT but not significantly so unless significance is shown in column F of that procedure and marked by an asterisk (*). (For example, the reader will note that the control group's performance scores for

TABLE 14. COMPARATIVE ANALYSIS OF CONTROL GROUP PERFORMANCE SCORES BY PROCEDURE

Procedure No.		Pilot Ground Trainer Scores[1] A Sum	B Mean	Aircraft Scores C Sum	D Mean	PGT ~ A/C[2] E Sum	Level of Significance[3] F Mean
	VOR Tasks						
1	Station Tuning	207	14	177	12	30	N.S.
2	Station Identification	275	18	315	21	- 40	N.S.
3	Orientation	195	13	185	12	10	N.S.
4	Tracking (Enroute)	261	17	195	13	66	.025*
5	Holding Pattern Entry	295	20	175	12	120	.01*
6	Holding Pattern	365	24	302	20	63	N.S.
7	Approach Letdown	339	23	210	14	129	.005*
8	Tracking (Pattern)	272	18	202	13	70	.025*
9	Minimum Altitude	357	24	242	16	115	.025*
10	Time to Missed Approach	320	21	210	14	110	N.S.
11	Missed-Approach Procedure	215	14	160	11	55	N.S.
12	Basic Airwork	249	17	258	17	- 9	N.S.
13	Communication	203	14	186	12	17	N.S.
	Total	3553	237	2817	188	736	
	Total Task Mean ($\bar{m}$)	273	18	217	14	56	.005*
	ADF Tasks						
1	Orientation	300	20	295	20	5	N.S.
2	Bearing Intercept	275	18	256	17	19	N.S.
3	Tracking (Enroute)	299	20	285	19	14	N.S.
4	Holding Pattern Entry	370	25	238	16	132	.005*
5	Holding Pattern	323	22	317	21	6	N.S.
6	Approach Pattern	251	17	274	18	- 23	N.S.
7	Approach Letdown	247	16	318	21	- 71	N.S.
8	Tracking (Pattern)	331	22	263	18	68	.025*
9	Minimum Altitude	312	21	296	20	17	N.S.
10	Time to Missed Approach	280	19	310	21	- 30	N.S.
11	Missed-Approach Procedure	193	13	180	12	13	N.S.
12	Basic Airwork	260	17	267	18	- 7	N.S.
13	Communications	213	14	184	12	29	N.S.
	Total	3655	244	3482	232	173	
	Total Task Mean ($\bar{m}$)	282	19	268	18	14	N.S.
	ILS Tasks						
1	Station Tuning	203	14	210	14	- 7	N.S.
2	Station Identification	420	28	315	21	105	N.S.
3	Radar Vectors	155	11	160	11	- 5	N.S.
4	Localizer Intercept	172	11	305	21	-133	.005*
5	Glide Slope Intercept	322	21	185	12	137	.005*
6	Localizer Tracking	196	13	227	15	- 31	N.S.
7	Glide Slope Tracking	259	17	249	17	10	N.S.
8	Minimum Altitude	210	14	195	13	15	N.S.
9	Basic Airwork	248	17	226	15	22	N.S.
10	Communications	168	11	168	11	0	N.S.
	Total	2353	157	2240	150	113	
	Total Task Mean ($\bar{m}$)	235	16	224	15	12	N.S.

1. Summated Scores of 15 subjects
2. ~ = Difference between PGT and A/C scores
3. N.S. = Not significant
* = Significance

11 VOR procedures of table 14 are lower, or better, in the aircraft than in the PGT. And 2 VOR procedures are lower or better in the PGT as noted by the minus sign).

Of the 13 procedures comprising the VOR portion of the IFR flight tests, significant differences occurred in five procedures, and are listed below:

4 - VOR tracking enroute (0.025 level)
5 - Holding pattern entry (0.01 level)
7 - Approach pattern letdown (0.005 level)
8 - Approach pattern tracking (0.025 level)
9 - Minimum altitude--reached and maintained (0.025 level).

Without further analysis three possible reasons for the significance occurring in the five procedures are suggested:

1. The PGT, for some reason, was more difficult to fly than the aircraft.

2. Flying the PGT before flying the aircraft alerted pilots to their mistakes, and, consequently, identical errors were not made during the aircraft flight test, resulting in better aircraft performance scores.

3. Pilots were unfamiliar with the handling and flight characteristics of the PGT.

Sufficient evidence was obtained from the first overall analysis (pass-fail) of control group VOR performance to lend support to reason No. 2, especially for the significant difference noted for the holding pattern entry procedure. For example, a single isolated error of using a reciprocal radial was responsible for a subject's wrong entry into a holding pattern. Having erred on the PGT flight check the pilot was alerted not to duplicate this mistake when performing in the aircraft. This explanation for significant data does not, however, provide substantive evidence to support the differences occurring for tracking, procedures 1 and 4, approach pattern letdown, procedure 7 and minimum altitude reached and maintained, procedure 5. Thus additional analyses are required to determine if either of the other two suggested reasons contributed to the differences between VOR PGT and aircraft flight test scores.

CONTROL GROUP ADF PROCEDURES. The analysis for the ADF procedure scores of table 14 show significance at the 0.005 and 0.025 levels of probability, respectively, for procedure 4, ADF holding pattern entry, and procedure 8, ADF approach pattern tracking. Note that under the PGT and A/C columns, the significance of the difference between the means for the two listed maneuvers is attributed to the better performance scores achieved on the aircraft flight check. Again, as with the significance appearing in five of the VOR procedures, at this stage of analysis, it is suggested that the ADF procedures where significance does appear may be caused either by a difficulty in flying the PGT, the "error alerting factor" of flying the PGT prior to the aircraft flight check or pilot unfamiliarity with the handling characteristics of the PGT. An examination of the raw data for control group performance tends to support the second reason or "error alerting factor," for both procedures

mentioned. The reader will also note that the number of significant differences appearing has decreased from five procedures in the VOR task to two procedures in the ADF task. Note also that the scores for procedures 6, 7, 10, and 12 (those differences preceded by a minus sign (-) in column E) show a slightly better performance in the PGT than in the aircraft, but not to a significant degree.

CONTROL GROUP ILS PROCEDURES. Significant differences occur in the analysis of two of the ILS procedures, 4 localizer interception and 5, glide slope interception. The significance for both procedures is the same at the 0.005 level of probability. The figure -133 appears in column E for the localizer intercept procedure score as does 137 for the glide slope intercept procedure score. The first figure indicates that the PGT localizer intercept performance score is significantly better than that of the aircraft performance score. In contrast, the second figure of 137 for glide slope interception performance shows that a significantly better score is achieved in the aircraft than in the PGT.. These significant score differences suggest an idiosyncrasy of the PGT which makes localizer interception in the PGT relatively easier to accomplish than in the aircraft, with the reverse true for glide slope interception, i.e., more difficult to perform in the PGT than in the aircraft. Note that the relative ease or difficulty for accomplishing these two procedures is limited to interception only. No significant differences occur for tracking either the localizer or glide slope indicators.

A definitive interpretation of significant differences occurring in the control group's procedure analysis for the VOR, ADF, and ILS task is provided after completion of the comparative group procedure performance analysis.

EXPERIMENTAL GROUP VOR PROCEDURES. The data for these analyses are tabulated in table 15. The data shown were treated in the same manner as that for the control group procedural analyses, i.e., the data were subjected to "t" tests to determine if there were significant differences between the means of PGT procedure and A/C procedure performance scores.

Of the 13 procedures comprising the VOR portion of the IFR flight checks significant differences appear in 7 procedures. The figures in table 15 under column E titled "PGT A/C" are interpreted as "the difference (~) between PGT performance scores and aircraft performance scores." The levels of significance occurring are listed to the right of the difference in scores and are marked with an asterisk. In the event that group performance scores in the PGT were better (i.e., a lower score achieved) the figures in column E are preceded by a minus (-) sign.

The VOR procedures in which significant differences appear are procedures 4, 5, 7, 8, 9, 10, and 11.

In every instance experimental group performance of these procedures was significantly better in the aircraft than in the PGT. A comparison of tables 14 and 15 shows that the first 5 significant procedure differences are the same as those of the control group.

TABLE 15. COMPARATIVE ANALYSIS OF EXPERIMENTAL GROUP PERFORMANCE SCORES BY PROCEDURE

Procedure No.	VOR Tasks	Pilot Ground Trainer Scores[1] A Sum	B Mean	Aircraft Scores C Sum	D Mean	PGT∿A/C[2] E Sum	Level of Significance[3] F Mean
1	Station Tuning	168	11	160	11	8	N.S.
2	Station Identification	310	21	255	17	55	N.S.
3	Orientation	290	19	230	15	60	N.S.
4	Tracking (Enroute)	332	22	215	14	117	.005*
5	Holding Pattern Entry	350	23	226	15	124	.025*
6	Holding Pattern	362	24	355	24	7	N.S.
7	Approach Letdown	319	21	236	16	83	.005*
8	Tracking (Pattern)	337	22	226	15	111	.005*
9	Minimum Altitude	470	31	298	20	172	.025*
10	Time to Missed Approach	350	23	190	13	160	.010*
11	Missed-Approach Procedure	305	20	180	12	125	.005*
12	Basic Airwork	289	19	274	18	15	N.S.
13	Communication	251	17	207	14	44	N.S.
	Total	4133	272	3052	204	1081	
	Total Task Mean ($\bar{m}$)	318	21	235	16	83	.005*
	ADF Tasks						
1	Orientation	260	17	245	16	15	N.S.
2	Bearing Intercept	295	20	210	14	85	N.S.
3	Tracking (Enroute)	321	21	270	18	51	N.S.
4	Holding Pattern Entry	284	19	220	15	64	N.S.
5	Holding Pattern	330	22	320	21	10	N.S.
6	Approach Pattern	321	21	282	19	39	N.S.
7	Approach Letdown	334	22	254	17	80	.05*
8	Tracking (Pattern)	369	25	302	20	67	N.S.
9	Minimum Altitude	265	18	210	14	55	N.S.
10	Time to Missed Approach	260	17	250	17	10	N.S.
11	Missed-Approach Procedure	270	18	170	11	100	.025*
12	Basic Airwork	317	21	302	20	15	N.S.
13	Communications	246	16	216	14	30	N.S.
	Total	3872	257	3249	216	623	
	Total Task Mean ($\bar{m}$)	297	20	250	17	47	.05*
	ILS Tasks						
1	Station Tuning	185	12	150	10	35	N.S.
2	Station Identification	360	24	220	15	140	.025*
3	Radar Vectors	195	13	160	11	35	
4	Localizer Intercept	210	14	300	20	-90	.05*
5	Glide Slope Intercept	330	22	230	16	100	.005*
6	Localizer Tracking	259	17	268	19	- 9	N.S.
7	Glide Slope Tracking	291	19	282	20	9	N.S.
8	Minimum Altitude	240	16	160	11	80	N.S.
9	Basic Airwork	336	22	291	19	45	N.S.
10	Communications	213	14	173	12	40	N.S.
	Total	2619	173	2234	153	385	
	Total Task Mean ($\bar{m}$)	262	17	223	15	39	.05*

1. Summated scores of 15 subjects
2. PGT∿A/C = Difference between scores
3. N.S. = Not significant
* = Significance

The same reasons offered for differences occurring between PGT and aircraft performance are applicable to the experimental group where significant results were obtained. Evidence obtained from the first overall analysis of experiment group VOR performance on a pass or fail basis supports the "error alerting factor" reason for the higher (poorer) scores achieved for the holding entry procedure but the evidence does not support the differences demonstrated for VOR tracking, procedures 1 and 4, approach pattern letdown procedure 3, and minimum altitude reached and maintained, procedure 5. Since the performance of both groups resulted in significant differences for five identical procedures the reason for the difference in the other four PGT and aircraft scores appears to be reduced to either a PGT idiosyncrasy or pilot unfamiliarity with the handling and flight characteristics of the PGT or possibly a combination of both factors.

The significance for the remaining procedures, 10 and 11, is more readily explainable. The VOR approach in the PGT had the VOR facility located at the airport (simulating the actual VOR approach at the Atlantic City (NAFEC) airport). This particular approach had no final approach fix by which one could time the inbound leg. The actual VOR approach at Sea Isle had the VOR NAV facility located 6.8 miles from the airport thus providing a final approach fix for subjects to time the inbound approach leg. Six of the fifteen experimental subjects stated they planned no time estimate to the airport when the VOR facility was located at the field but relied on the VOR display to change its "TO" indication to "FROM" before executing the missed-approach procedure. (As a point of interest the instrument rated control group generally estimated their time on the outbound and inbound legs of the VOR approach pattern to give them a rough idea of when a missed-approach procedure should be executed with the opinion that a "TO-FROM" change of the VOR display would be too late for them to make a letdown from minimum approach altitude and land on the designated runway for other than a circling approach.) Thus the significant difference displayed is caused by a combination of pilot technique and VOR approach pattern difference.

The significant difference occurring in the missed-approach procedure was due to a failure by five of the fifteen experimental subjects to retract the flaps that had been deployed during the final phase of the VOR approach. While considered a pilot procedure error, it is a fact that the deployment or retraction of the flaps in the PGT did not produce a corresponding change in control yoke force. With added power for the aborted approach and no sensation of drag or change in the feel of the yoke (pitch) control it is entirely possible to overlook the procedure for retracting flaps on the missed approach. Therefore, in addition to pilot procedural error, lack of control force change with a change of aircraft configuration was partially responsible for the significant difference that had occurred for the "missed-approach procedure."

EXPERIMENTAL GROUP ADF PROCEDURES. Of the 13 ADF procedures listed in table 15, significant results were obtained for procedure 7 and 11, respectively, ADF approach letdown (0.05 level of probability) and the missed-approach procedure (0.025 level of probability). The significance of the latter or missed-approach procedure was due to a failure on the part of five experimental

subjects to retract the flaps on the aborted approach during the ADF portion of the PGT flight test. (This procedural error was a recurrence of that same error for three of the five subjects who neglected to retract flaps on the VOR missed approach procedure which was explained previously.)

The ADF approach letdown procedure significance was understandable when the raw data for individual performances were examined. Two significant pilot procedural errors were clearly responsible for the poorer performance in the PGT. The entire ADF approach requires a 3 stage letdown from an initial approach altitude of 2,500 to 2,000 feet on the outbound leg. Upon completion of the procedure "turn inbound" the descent is continued to an altitude of 1,100 feet inbound to the beacon. After passing the beacon a descent is made to a minimum approach altitude of 520 feet. In the performance of the PGT ADF approach, three subjects failed to initiate their descent on the outbound leg from the beacon to minimum procedure turn altitude (2,000 feet) after having been cleared by ATC for the full ADF approach. Three other subjects made their outbound leg descent to minimum procedure "turn altitude," but failed to continue the descent to an altitude of 1,100 feet after completing the procedure "turn inbound" and prior to reaching the nondirectional beacon.

The latter three subjects realized their error after departing the beacon to the airport. These procedural errors were not repeated on the ADF aircraft flight test, and the reason offered is that of the "error alerting factor" resulting from the PGT flight test flown prior to the aircraft flight test. It is not unreasonable to assume that these same errors would have been made in the aircraft if the experiment consisted of only an aircraft flight test.

A review of the experimental group's ADF procedure performance in the PGT and aircraft shows that the group's performance was better in the aircraft than in the PGT, but with the two exceptions noted, not to a significant degree. The reader also will note that the number of significant procedural differences has diminished from the seven significant procedures of the VOR phase of flight testing to two in the ADF phase of flight testing, an identical trend to that observed with the control group performance.

EXPERIMENTAL GROUP ILS PROCEDURES. Three of the 10 procedures listed for the ILS task in table 15 resulted in significant differences between PGT and aircraft performance scores. The procedures were 2, station identification, 4, localizer interception, and 5, glide slope interception. With the exception of the localizer interception procedure the significant differences are attributable to better performance scores achieved on the aircraft flight test.

Failure to identify the ILS frequency when flying the PGT occurred because the navigation radio receiver has no identification capability other than an "identify" switch which can be pushed but which does not result in an aural identification of the station. Subjects were told for both the VOR and ILS tasks to push the identification switch anytime they tuned in to a radio navigation facility. This verbal "cueing" helped while in the early stages

of VOR flight testing since subjects adhered to this instruction and no significant difference appeared for this procedure in the VOR task. However, subject retention of the verbal cue to identify diminished in the latter stage of the PGT ILS task with seven of the 15 subjects failing to "identify" the ILS frequency resulting in the significant difference for this procedure.

The localizer and glide slope interception procedure performance scores are similar to the scores obtained by the control group. A relatively better performance for intercepting the localizer is achieved in the PGT and a poorer performance in the PGT for intercepting the ILS glide slope. The performance scores for these two procedures listed in table 15 show significance at the 0.05 level of probability for localizer intercept and a 0.005 level of probability for glide slope intercept. Similar performances by both groups, is suggestive of a PGT idiosyncrasy as the contributing factor to the significant probability results obtained, and is discussed in the interpretation of results section.

COMPARATIVE GROUP PROCEDURE ANALYSIS.

COMPARATIVE GROUP PGT PROCEDURES. The data for this analysis are displayed in table 16. The analysis of variance was used to compare specific procedure scores achieved by the control group in the PGT with those achieved by the experimental group in the PGT, a between groups analysis. The data were examined previously (Comparative Group PGT Task Analysis--table 12) for significant differences between PGT group performance scores for accomplishing the three major tasks of VOR, ADF, and ILS. (The reader may recall that the analysis of variance did not produce any significant results between each groups task performance scores obtained for the VOR, ADF, and ILS phases of the PGT flight check.)

Table 16 is identical in format to that of table 12, the only difference is that the analyses now concerns specific PGT procedure performance scores. The reader is reminded that column E of table 16 lists differences between group scores and the notation of a minus sign (-) now indicates a relatively better performance score achieved by the control group, although not significantly better unless notated by an asterisk (*). Conversely the absence of the minus sign indicates a slightly better performance by the experimental group.

COMPARATIVE GROUP VOR PROCEDURES. An analysis of variance performed on each of the 13 VOR PGT procedure performance scores resulted in marginal significance for procedure 4, VOR tracking enroute. The difference in the performance scores between groups was -71 (column E) and the significance was attributed to the better performance score achieved by the control group. The mean score (column B) of the control group for this procedure was 17, while the mean score for the experimental group on the same procedure was 22 (column D). Decreasing the mean scores by a multiple of 10 results in scores of 1.7 and 2.2. These scores indicate that the control group on the average tracked radials within a one-dot displacement of the VOR display while the experimental group on the average tracked VOR radials with slightly more than a one-dot deflection (see the appendix for procedure scoring criteria).

TABLE 16. COMPARATIVE ANALYSIS OF CONTROL AND EXPERIMENTAL GROUP PILOT GROUND TRAINER PERFORMANCE SCORES BY PROCEDURE

Procedure No.		Control Group A Sum[1]	Control Group B Mean	Experimental Group C Sum[1]	Experimental Group D Mean	Difference Between E A~C[2]	Difference Between F B~D	Level of Significance G 1
	VOR Tasks							
1	Station Tuning	207	14	168	11	39	3	N.S.
2	Station Identification	275	18	310	21	-35	3	N.S.
3	Orientation	195	13	290	19	-95	6	N.S.
4	Tracking (Enroute)	261	17	332	22	-71	5	.05*
5	Holding Pattern Entry	295	20	350	23	-55	3	N.S.
6	Holding Pattern	365	24	362	24	3	0	N.S.
7	Approach Letdown	339	23	319	21	20	2	N.S.
8	Tracking (Pattern)	272	18	337	22	-65	4	N.S.
9	Minimum Altitude	357	24	470	31	-113	7	N.S.
10	Time to Missed Approach	320	21	350	23	-30	2	N.S.
11	Missed-Approach Procedure	215	14	305	20	-90	6	N.S.
12	Basic Airwork	249	17	289	19	40	2	N.S.
13	Communication	203	14	251	17	48	3	N.S.
	Total	3553	237	4133	272	-580	35	
	Total Task Mean ($\bar{m}$)	273	18	318	21	- 45	3	N.S.
	ADF Tasks							
1	Orientation	300	20	260	17	40	3	N.S.
2	Bearing Intercept	275	18	295	20	- 18	2	N.S.
3	Tracking (Enroute)	299	20	321	21	- 22	1	N.S.
4	Holding Pattern Entry	370	25	284	19	86	6	N.S.
5	Holding Pattern	323	22	330	22	- 7	0	N.S.
6	Approach Pattern	251	17	321	21	- 70	4	N.S.
7	Approach Letdown	247	16	334	22	- 87	6	N.S.
8	Tracking (Pattern)	331	22	369	25	- 38	3	N.S.
9	Minimum Altitude	312	21	265	18	47	3	N.S.
10	Time to Missed Approach	280	19	260	17	20	2	N.S.
11	Missed-Approach Procedure	193	13	270	18	- 77	5	N.S.
12	Basic Airwork	260	17	317	21	- 56	4	N.S.
13	Communications	213	14	246	16	- 33	2	N.S.
	Total	3655	244	3872	257	-217	13	
	Total Task Mean ($\bar{m}$)	282	19	297	20	15	1	N.S.
	ILS Tasks							
1	Station Tuning	203	14	185	12	18	2	N.S.
2	Station Identification	420	28	360	24	60	4	N.S.
3	Radar Vectors	155	11	195	13	- 40	2	N.S.
4	Localizer Intercept	172	11	210	14	- 38	3	N.S.
5	Glide Slope Intercept	322	21	330	22	- 8	1	N.S.
6	Localizer Tracking	196	13	259	17	- 63	4	N.S.
7	Glide Slope Tracking	259	17	291	19	- 32	2	N.S.
8	Minimum Altitude	210	14	240	16	- 30	2	N.S.
9	Basic Airwork	248	17	336	22	- 88	5	.025*
10	Communications	168	11	213	14	- 45	3	N.S.
	Total	2353	157	2619	173	-266	16	
	Total Task Mean ($\bar{m}$)	235	16	224	17	11	1	N.S.

1. Summated scores of 15 subjects
2. ~ = Difference between scores/means
3. N.S. = Not significant
* = Significance

In the VOR analysis of VOR procedure performance within groups, tables 14 and 15, this procedure performance score was significant for both groups. It was suggested after the completion of that analysis that two of three possible reasons for the significant data were that (2) the PGT was for some reason more difficult to fly than the aircraft and (3) pilots were unfamiliar with the handling and flight characteristics of the PGT. Since the mean scores of both groups, in this analysis, for tracking radials are within acceptable tolerance limits, approximately a one-dot displacement, the PGT did not appear to be excessively difficult to fly in the performance of radial tracking. The second reason offered, that of pilot unfamiliarity with the handling and flight characteristics of the PGT as a contributing factor to the significant result obtained, while becoming prominent, requires further proof and is explained under interpretation of scoring results.

COMPARATIVE GROUP ADF PROCEDURES. An analysis of variance performed on the ADF procedure scores of both groups did not result in significant differences. The ADF block of table 16, column E, shows that the control group performed slightly better than the experimental group on a majority of the ADF procedures but not to any significant degree.

COMPARATIVE GROUP ILS PROCEDURES. An analysis of variance performed on each of the ILS procedure performance scores resulted in a significant probability level of 0.025 for procedure 9, the basic airwork procedure. The significant result is attributable to the better performance score of the control group than the experimental group in the PGT. The individual score data provided the answer to the significant difference occurring. The basic airwork procedure is actually composed of four performance parameters. They are altitude, heading, airspeed, and bank angle. The performance scores assigned reflect the ability of pilots to maintain altitude within ±100 feet, heading within ±10°, and airspeed within ±10 knots. The fourth parameter scored, but not defined in the performance criteria, was bank angle with a maximum allowable bank angle of 30° permitted throughout the flight tests for normal flight operations.

Excessive altitude, heading, and bank deviations would reflect a poor performance in localizer tracking or glide slope tracking but such was not the case. The remaining parameter, airspeed or more precisely, deviations in airspeed exceeding the ±10 knot tolerance, was the contributing factor for the relatively poorer and significant performance of the experimental group in comparison with that of the control group under the basic airwork procedure. The raw performance data show that 7 of the 15 experimental subjects exceeded the ±10-knot airspeed tolerance on their ILS approach to the simulated airport. The airspeed deviation for these subjects was on the minus side, that is less than the recommended approach speed of 90 miles per hour (mi/h) or 78 knots. Each of the seven subjects permitted PGT airspeed to decrease from 90 to 78 mi/h or slightly less than 68 knots. At this reduced airspeed, the PGT is programmed to activate the stall warning signal.. Each one of the seven subjects caused the stall signal to be activated at least three times during the final ILS approach and one subject activated the stall signal eight times during the final ILS approach. None of the subjects permitted the aircraft to stall but made either the appropriate pitch or power change thus deactivating

the signal. The majority of PGT's do not provide a sensation of speed or kinesthetic cues for vertical speed rates. Monitoring the airspeed and vertical speed rate is essential for maintaining acceptable airspeed tolerances throughout the approach. An interesting fact relative to the activation of the stall signal is that five of the seven subjects, who let the PGT airspeed diminish on final ILS approach, had no previous ground trainer experience.

COMPARATIVE GROUP AIRCRAFT PROCEDURES. The data for this analysis are displayed in table 17. The analysis of variance was used to compare specific procedure scores achieved by the control group in the aircraft with those achieved by the experimental group in the aircraft. The data were examined previously (Comparative Group Aircraft Task Analysis--table 13) for significant differences between aircraft group performance scores for accomplishing the three major tasks of VOR, ADF, and ILS. The previous analysis of variance for task performance scores achieved on the aircraft flight test showed no significant difference between groups for VOR, ADF, and ILS total task performance.

Table 17 is identical in format to table 13, the only difference is that the analysis now concerns specific aircraft procedure performance scores instead of total task performance scores. As explained previously column E of table 17 lists differences between group scores and the notation of a minus sign indicates a relatively better performance score for the control group but not significantly better unless the specific procedure is marked with an asterisk (*) in the G column. Conversely the absence of a minus sign indicates a slightly better performance by the experimental group.

COMPARATIVE GROUP VOR PROCEDURES. Significance at the 0.025 level of probability appeared for VOR aircraft procedure 5, holding pattern entry. Differences between the aircraft performance scores of both groups for the other 12 procedures were not significant. The significance of this procedure is due to the relatively better performance score of the control group. The aircraft performance means of both groups for this maneuver are well within acceptable tolerances as reflected by a 1.2 (12) mean for the control group and a 1.5 (15) for the experimental group. There were two failing scores (4.0) assigned to the control group and four to the experimental group as determined from the overall, Pass/Fail, analysis. The emphasis then for this procedure's significance is on a better performance by the control group than the performance of the experimental group. It is conceivable that these subjects of the experimental group may have experienced an initial apprehension generally associated with aircraft flight tests. Note also that in column E, control group performance is better than that of the experimental group on 10 of the 13 VOR procedures.

COMPARATIVE GROUP ADF PROCEDURES. The analysis of variance for the 13 aircraft ADF procedure performance scores showed no significant differences between group performance scores. An examination of the ADF block column E, shows that control group performance is better than experimental performance in only 5 of the 13 ADF procedures listed. The resultant figures for procedure 4,

TABLE 17. COMPARATIVE ANALYSIS OF CONTROL GROUP AND EXPERIMENTAL GROUP AIRCRAFT PERFORMANCE SCORES BY PROCEDURE

Procedure No.		Control Group A Sum[1]	B Mean	Experimental Group C Sum[1]	D Mean	Difference Between E A∿C[2]	F B∿D	Level of Significance G 1
	VOR Tasks							
1	Station Tuning	177	12	160	11	17	1	N.S.[3]
2	Station Identification	315	21	255	17	60	4	N.S.
3	Orientation	185	12	230	15	-45	3	N.S.
4	Tracking (Enroute)	195	13	215	14	-20	1	N.S.
5	Holding Pattern Entry	175	12	226	15	-51	3	.025*
6	Holding Pattern	302	20	355	24	-53	4	N.S.
7	Approach Letdown	210	14	236	16	-26	2	N.S.
8	Tracking (Pattern)	202	13	226	15	-24	2	N.S.
9	Minimum Altitude	242	16	298	20	-56	4	N.S.
10	Time to Missed Approach	210	14	190	13	20	1	N.S.
11	Missed Approach Procedure	160	11	180	12	-20	1	N.S.
12	Basic Airwork	258	17	274	18	-16	1	N.S.
13	Communication	186	12	207	14	-21	2	N.S.
	Total	2817	188	3052	204	-235	16	
	Total Task Mean ($\bar{m}$)	217	14	235	16	-18	2	N.S.
	ADF Tasks							
1	Orientation	295	20	245	16	50	4	N.S.
2	Bearing Intercept	256	17	210	14	46	3	N.S.
3	Tracking (Enroute)	285	19	270	18	15	1	N.S.
4	Holding Pattern Entry	238	16	220	15	18	1	N.S.
5	Holding Pattern	317	21	320	21	- 3	0	N.S.
6	Approach Pattern	274	18	282	19	- 8	1	N.S.
7	Approach Letdown	318	21	254	17	64	4	N.S.
8	Tracking (Pattern)	263	18	300	20	-37	2	N.S.
9	Minimum Altitude	295	20	210	14	85	6	N.S.
10	Time to Missed Approach	310	21	250	17	60	4	N.S.
11	Missed Approach Procedure	180	12	170	11	10	1	N.S.
12	Basic Airwork	267	18	302	20	-35	2	N.S.
13	Communications	184	12	216	14	-32	2	N.S.
	Total	3482	232	3249	216	233	16	
	Total Task Mean ($\bar{m}$)	268	18	250	17	18	1	N.S.
	ILS Tasks							
1	Station Tuning	210	14	150	10	60	4	.025*
2	Station Identification	315	21	220	15	95	6	N.S.
3	Radar Vectors	160	11	160	11	0	0	N.S.
4	Localizer Intercept	305	21	300	20	5	1	N.S.
5	Glide Slope Intercept	185	12	230	16	-45	4	N.S.
6	Localizer Tracking	227	15	268	19	-41	4	N.S.
7	Glide Slope Tracking	249	17	282	20	-33	3	N.S.
8	Minimum Altitude	195	13	160	11	35	2	N.S.
9	Basic Airwork	226	15	291	19	-65	4	.025
10	Communications	168	11	173	12	- 5	1	N.S.
	Total	2240	150	2334	153	-194	3	
	Total Task Mean ($\bar{m}$)	224	15	233	15	- 9	0	N.S.

1. Summated scores of 15 subjects
3. N.S. = Not significant
2. ∿ = Difference between scores/means
* = Significance

holding pattern entry show a slightly better performance by the experimental group than that of the control group, which lends some credence to the initial "apprehension" suggested for the same procedure in the VOR phase of the aircraft flight test.

COMPARATIVE GROUP ILS PROCEDURES. The analysis of variance performed for the 10 ILS procedures listed in the ILS block of table 17 resulted in significant differences for two procedures, namely procedure 1, ILS station frequency tuning and procedure 9, basic airwork. The probability level of significance for both procedures was 0.025.

The better performance of the experimental group contributed to the significance of the ILS station tuning procedure. All 15 of the experimental subjects had perfect scores for tuning.

Two control subjects tuned in a wrong ILS frequency and three subjects had not tuned in the ILS frequency until they were within a mile of intercepting the ILS localizer.

The significance of the basic airwork procedure in the ILS is attributed to the better or lower performance score of the control group. The raw data of individual subjects in the experimental group show that the altitude deviations of four subjects exceeded ±100-foot altitude in the course of being radar vectored to the final ILS localizer course. Thus the basic airwork altitude excesses of four subjects contributed to the relatively lower performance scores of the experimental group.

An examination of the difference between scores of both groups listed in column E of table 17 shows the procedure scores to be evenly divided, i.e., the control group has a slightly better score on five procedures and the experimental group has a slightly better performance score on the remaining five procedures.

SEPARATE TASK AND PROCEDURES ANALYSIS (EXPERIMENTAL GROUP ONLY). Four separate analyses were undertaken to determine if the performance of pilot subjects with previous PGT experience was significantly different from that of pilot subjects who had no previous PGT experience. Since the performance results of the experimental group of subjects are paramount to this study only the performance score of subjects from the experimental group were analyzed.

Eight subjects had no prior experience with PGT's while seven subjects had some experience in PGT's which ranged from 1 to 25 hours over the last 5 years. Their experience had been acquired in a variety of commercially available PGT's.

The statistical analyses applied to the performance scores achieved by the two groups are analogous to those performed for the control and experimental groups. Thus the analyses concern a comparison between each groups' scores achieved in the PGT and in the aircraft. Both total task scores and procedure scores for each task were tested for statistical significance.

Table 18 lists the experimental subjects simulation (PGT) experience in hours and year of their last PGT flight. Of those pilots having PGT experience, subject G had had the most recent experience, having flown a PGT one week prior to his participation in this study. Five subjects had not flown a PGT for at least 8 months and subject J had not flown a PGT during the past 3 years.

The results of the four analyses of variance to determine significant differences between the groups performance scores in the PGT and aircraft, for both total task and procedures proved negative. That is to say that for this sample of subjects, there were no significant results by which the performance of those subjects with prior PGT experience could be distinguished from those who had never flown a PGT. The most logical explanation for non-significant results appears to be that any advantage previous PGT experience might have provided, and as a result, influenced the outcome of the performance results, diminishes over some period of time, which for these subjects in general happened to be 8 months.

INTERPRETATION OF SCORING RESULTS.

The statistical analyses applied to the performance scores of the control and experimental groups resulted in significant differences in the performance score within and between both groups for the various IFR tasks and procedures within those tasks. The following review of the performance of both groups in toto is intended to explain the significant differences that appeared in the results of the PGT and aircraft flight tests.

It was suggested earlier in this report that there appeared to be at least three plausible reasons for the significant differences resulting between PGT and aircraft performance scores of both groups. The reasons suggested were:

1. The PGT for some reason was more difficult to fly than the aircraft, i.e., an idiosyncrasy of the PGT might have accounted for the "poorer" performance scores achieved by both groups in the PGT in comparison to the scores obtained in the aircraft.

2. The PGT flight check, prior to the aircraft flight check served as a pre-testing ground or "pilot error alerting" flight. Having committed a procedural error in the PGT, subjects took the necessary measures to avoid duplicating that error during the aircraft flight check.

3. Pilots were unfamiliar with the handling and flight characteristics of the PGT because they had never flown this particular PGT or any PGT prior to this study. (For brevity the reasons above shall be referred to as 1, 2, or 3.)

From a statistical viewpoint lower performance scores could be attributed to poor performance scores of two or three subjects resulting in significant differences. However such an outcome is easily detected by examining individual scores and hence doesn't present a problem in defining what caused the significance. The chief concern other than poor performance scores is to determine why and what contributed to the lower performance scores achieved.

TABLE 18. SIMULATION (PGT) EXPERIENCE OF EXPERIMENTAL GROUP SUBJECTS

Subject		Hours	Year
A	Yes	20	1974
B	Yes	5	1974
C	Yes	1	1974
D	No	-	-
E	No	-	-
F	No	-	-
G	Yes	25	1975
H	Yes	20	1974
I	No	-	-
J	Yes	1	1972
K	No	-	-
L	Yes	6	1974
M	No	-	-
N	No	-	-
O	No	-	-

The first analysis, 1, separate task analyses, compared task PGT scores with task aircraft scores for both groups. For the control group, a highly significant difference at the 0.005 level of probability was the result for the VOR task, but no significance resulted for the ADF, and ILS tasks. Analysis of the experimental groups' performance resulted in an identical, highly significant probability level of 0.005 for the VOR task and marginal significance (0.05) for the ADF and ILS tasks. When the PGT and aircraft scores of both groups were compared, i.e., a between groups analysis of variance (analysis 2, comparative group task analysis for VOR, ADF and ILS), no significant differences between group performance were detected. This latter finding in essence, tells us the performance of the experimental group for accomplishing the VOR, ADF, and ILS tasks, both in the PGT and in the aircraft, is no better or worse than the performance of the control group.

To determine what accounted for the significance appearing for both groups in the first analysis, each procedure of each major task was subjected to a separate third analysis, 3, procedures analysis (VOR, ADF, and ILS).

The control group procedures analysis showed significant differences appearing in 5 of the 13 VOR procedures (resulting in the VOR task significance of the first analysis), 2 of 13 ADF procedures (no task significance), and 2 of 10 ILS procedures (no task significance).

The experimental group procedures analysis showed significant differences appearing in 7 of 13 VOR procedures (resulting in the VOR task significance of the first analysis); 2 of 13 ADF procedures (marginal task significance), and 2 of 10 ILS procedures (marginal task significance).

Starting with the procedures of the VOR task an examination of individual performance data of both groups supported the "error alerting" factor of the PGT flight test for the better aircraft performance score for procedure 5, the holding pattern entry. The error alerting factor did not support the significant differences occurring for VOR tracking (4 and 8), approach pattern letdown (7), and minimum altitude achieved and maintained (9).

The performance data of both groups for the VOR enroute and approach pattern tracking procedures showed mean scores of the control group (table 14) to be 17 (1.7) and 13 (1.3), respectively, in the PGT and aircraft, while the mean scores of the experimental group (table 15) were 22 (2.2) and 14 (1.4) in the PGT and aircraft. The scoring criteria for tracking VOR radials were based on the degree of course deviation indicator (CDI) displacement from the center of the VOR display. A score of 1.0 was assigned for being on the radial, a score of 2.0 for a one dot deflection, a score of 3.0 for a two dot deflection and so on. Thus the PGT mean scores of 1.7 and 2.2 of the control and experimental groups indicate the average tracking capability of the control group to be less than a one dot deflection and slightly over a one dot deflection for the experimental group. The mean aircraft performance scores for tracking are almost identical at 1.3 for control and 1.4 for experimental subjects.

An analysis of post flight pilot comments indicated that 24 of the 30 pilots

tested felt that the tracking capabilities of the PGT with respect to the VOR display and meter movement of the CDI were equivalent to the operation and meter movement of the aircraft VOR display. This opinion, supported by the data indicates that differences between PGT and aircraft tracking scores were not attributed to an idiosyncrasy of the VOR tracking capability of the PGT. Hence, suggestion 1, that the "PGT is, for some reason, more difficult to fly than the aircraft" is not substantiated and thus strengthens the support for suggestion 3, that pilots may be unfamiliar with the handling and flight characteristics of the PGT.

An examination of tables 14 and 15 for both of the groups VOR, ADF, and ILS procedures performance scores shows a diminishing number of significant differences occurring as the IFR flight test tasks proceed from VOR to ADF to ILS. Since the VOR task was the first task to be performed it seems most likely that the 45 minutes required to accomplish the VOR phase of the flight test was in effect a learning or familiarization period in which all subjects acquired a "feel" for flying the PGT. Had the PGT flight test commenced with the ADF or ILS phase of flight, it is most probable that significant differences would have been observed in the lead off task with less significant differences appearing in the final or VOR phase of the flight test. This interpretation of the results is indicative of a need for PGT familiarization time of at least 45 minutes prior to a PGT IFR flight test on the ADF or ILS approaches.

Can the above reasoning be applied to the significant differences occurring in the VOR approach pattern letdown and the minimum altitude procedures? The differences in both procedures favored the better aircraft performance of both groups (refer to tables 14 and 15).

Subjects were scored on the basis of starting the letdown approach procedure after initial arrival over the VOR facility, descending on the outbound radial of the VOR approach pattern, reaching and maintaining minimum procedure turn altitude and then continuing the descent inbound to the airport to minimum altitude. Tables 14 and 15 show the mean scores for the PGT VOR approach letdown to be 23 (2.3) for the control group and 21 (2.1) for the experimental group. In comparison the mean aircraft scores for this procedure were 14 (1.4) and 16 (1.6) for the control and experimental groups.

The minimum altitude procedure scores achieved in the PGT were 24 (2.4) for the control group and 31 (3.1) for the experimental group, with aircraft scores of 16 (1.6) and 20 (2.0) for the respective groups.

An analysis of individual performance data for these two procedures made clear the reasons for the significant differences between PGT and aircraft scores. The data reveal slow descent rates throughout the approach pattern, and an excess of altitude (200 to 800 feet) above minimum approach altitude on final approach. The simulation of the VOR approach was conducted with the VOR station situated at the airport which duplicated the VOR approach to runway 13 at the Atlantic City airport (NAFEC). For this approach there is no final

approach fix (FAF) to time the approach pattern descent or to plan a time estimate to initiate a missed-approach procedure. (The chart for a VOR 13 approach to Atlantic City has been revised to include a final approach fix.)

The normal procedure employed was to obtain VOR station passage on the initial approach, start a descent from initial approach altitude on the outbound radial of the approach pattern and then make a procedure turn inbound for the final approach. For the PGT VOR approach, subjects flew an outbound leg which varied in time from 90 seconds to 2 minutes before starting the turn inbound. The rate of descent capability of the PGT with a normally reduced power setting for descent in a no-flap configuration was approximately 350 to 375 feet per minute (ft/min). With flaps deployed and a fully retarded throttle the vertical descent rate was 600 ft/min. Therefore, the combination of a short outbound leg in terms of time plus the limited vertical descent rate resulted in an excess of altitude above that of the minimum approach altitude. There are no requirements for the final approach to the airport to be conducted from a minimum approach altitude, other than the requirement that descent below minimum altitude does not occur.

Under marginal weather conditions (marginal ceilings at or near MDA for VOR approaches), the final approach conducted at the minimum altitude at least provides the pilot a chance to see the airport and make the landing. If not down to minimum altitude under marginal weather conditions, the pilot has no opportunity to make a landing and the only other alternative is to proceed with the missed-approach procedure.

While the investigator was aware of the limited vertical descent rate of the PGT, subject pilots were not informed of this limitation. Such a forewarning would obscure their performance results and preclude a definition of PGT requirements for use as a flight-checking device for instrument approach tasks.

The significance of the difference between PGT and aircraft scores for the experimental group performance of the time to missed approach and missed-approach procedures was explained earlier in the report as technique errors committed by the pilots, because of varied VOR approach patterns and procedural error in subjects' failure to retract the flaps on the aborted approach.

The significant differences for two of the ADF procedures, holding pattern entry 4 and tracking pattern 8 for the control group were charged to the "error alerting" factor of the PGT.

For the experimental group, ADF scores for the approach letdown, procedure 7, and the missed-approach, procedure 11, the significance of the former procedures was attributed to the failure of subjects to descend to the required ADF approach pattern altitudes (thus a PGT error alerting factor) while the latter was due to pilot procedure error or failure to retract flaps on the aborted approach. Furthermore, the lack of control force change in the PGT with retraction or deployment of the flaps contributed to the pilot procedural error, especially related to subjects who had never flown a PGT.

The remaining task, the ILS phase of the IFR flight tests resulted in two significant differences in procedure scores for the control group and three for the experimental group.

ILS procedures 4 and 5, respectively ILS localizer intercept and glide slope intercept proved to be significant for both groups. The ILS localizer of the PGT was easier to intercept than the actual ILS localizer of the airport ground facility. The reason is attributed to a lesser sensitivity of the ILS localizer than that of the actual ILS ground facility. Note that the significance occurs only for the interception procedure and not for the ILS-tracking procedure. From tables 14 and 15, the mean scores for the control group performance of the localizer intercept were 11 (1.1) for PGT and 21 (2.1) for the aircraft. The scores for the experimental group were 14 (1.4) for the PGT and 20 (2.0) for the aircraft. Both groups intercepted the localizer in the PGT with a slight "override" beyond a one-dot deflection. (A perfect asymptotic interception of the localizer would have resulted in a score of 10 (1.0) which the control group almost achieved in the PGT. While the differences between PGT and aircraft scores are significant, the results obtained in the aircraft, as a mean, are well within acceptable tolerances, i.e., a one-dot deflection before the localizer is re-intercepted again for tracking in the final approach course.)

The performance results for capturing the ILS glide slope are in direct contrast to the results for localizer interception. The mean scores from tables 14 and 15 for the control group were 21 (2.1) for the PGT and 12 (1.2) for the aircraft. The experimental group achieved scores of 22 (2.2) for the PGT and 16 (1.6) for the aircraft performance of this procedure. The results indicate that capture of the glide slope in the PGT was more difficult to accomplish than it was in the aircraft. The reason is charged to a slightly oversensitive glide slope at the point of intercept. Again the significance is only in the intercept procedure and not in the tracking glide slope procedure. The results like those of the localizer intercept are within tolerances. Furthermore, they emphasize the importance of acceptable meter movement rates of simulated instrumentation.

The PGT ILS localizer, while not quite as sensitive as the actual ILS localizer, was twice as sensitive in the ILS mode than in the VOR mode. Since subjects had no great difficulty in tracking the ILS localizer, they should have had less difficulty tracking radials in the VOR phase, but did not since the VOR-tracking procedure scores were significantly better in the aircraft than in the PGT. This point of information confirms the suggestion that pilots were unfamiliar with the PGT at the outset of this first flight test, but became accustomed to its handling characteristics within the first hour of flight. This result substantiates the need for some familiarization time in the PGT before evaluating a pilot's ability to perform instrument approaches and related instrument procedures.

SUMMARY OF RESULTS

Fifteen control and fifteen experimental pilot subjects were tested on their ability to fly a PGT under simulated flight test conditions involving VOR and ADF navigation and VOR, ADF, and ILS approaches. Their performance of these tasks was also examined in an aircraft for comparative analyses. A summary of the results of this study are listed below:

1. Ten control subjects passed all phases of the PGT flight test and five control subjects failed. Three of the failures occurred in the VOR phase of flight and two in the ADF phase of flight. There were no failures in the ILS phase of flight testing. All failures were attributable to pilot procedural errors. Thirteen of the fifteen control subjects passed the aircraft flight test and two failed. The two failures occurred in the ADF phase of the flight test. There were no failures in the VOR or ILS phases. The two ADF failures were attributable to pilot procedural errors.

2. Nine experimental subjects passed all phases of the pilot ground trainer flight tests and six subjects failed in one or more tasks. Four failures occurred in the VOR phase, five failures occurred in the ADF phase and one failure occurred in the ILS phase. All failures were attributable to pilot procedural errors. Ten of the fifteen subjects passed all phases of the aircraft flight test. Three failures occurred in the VOR phase, four in the ADF phase and two in the ILS phase. All failures were attributable to pilot procedural errors.

3. Five of the six failures of both groups in the ADF phase of the aircraft flight test were caused by a failure on the pilots' part to reset a precessed directional gyro to magnetic compass heading information.

4. A comparison of control group performance scores in the PGT with aircraft performance scores, by task, resulted in a significant difference (0.005) for the VOR performance task and no significance for the ADF and ILS tasks. The same comparison of experimental group performance score resulted in a significant difference for the VOR task (0.005) and marginal significance (0.05) for the ADF and ILS tasks.

5. A comparative analysis of variance between both group's performance scores in the PGT and in the aircraft did not produce any significant data for the VOR, ADF, and ILS tasks.

6. A comparison between control group procedure scores achieved in the PGT and in the aircraft resulted in significant differences for the listed procedures. The chief factors contributing to the significance are given:

VOR tracking--pilot unfamiliarity with the PGT.

VOR holding pattern entry--error-alerting factor of the PGT.

VOR approach pattern letdown--limited vertical rate of the PGT and pilot procedures.

Minimum altitude--limited vertical rate of the PGT and pilot procedures.

ADF holding pattern entry--error-alerting factor of the PGT.

ADF tracking--error-alerting factor of the PGT.

ILS localizer interception--lesser sensitivity of PGT localizer.

ILS glide slope interception--greater sensitivity of PGT glide slope.

7. A comparison between experimental group procedure scores achieved in the PGT and in the aircraft resulted in significant differences for the listed procedures. The chief factors contributing to the significance for better aircraft performance scores are given:

VOR tracking--pilot unfamiliarity with the PGT.

VOR holding pattern entry--error-alerting factor of the PGT.

VOR approach pattern letdown--limited vertical rate of the PGT and pilot procedures.

Minimum altitude--limited vertical rate of the PGT and pilot procedures.

Time to missed approach--pilot procedure error.

Missed approach procedure--lack of familiarity (control force feel) with the PGT.

ADF letdown--error-alerting factor of the PGT.

ADF missed-approach procedure--pilot procedure error and lack of familiarity (control force feel) with the PGT.

ILS station identification--PGT lack of functional aural signal for station identification.

ILS localizer interception--lesser sensitivity of the PGT localizer.

ILS glide slope interception--greater sensitivity of the PGT glide slope.

8. A comparative analysis between both groups procedure performance scores in the PGT indicated a marginal significance favoring the better performance of the control group for VOR tracking attributable to control group pilot experience.

There were no significant differences between both groups ADF procedure performance scores in the PGT. A significant difference favoring the control group in the performance of ILS basic airwork was attributed to activation of the PGT stall warning signal caused by experimental subject's unfamiliarity with the PGT, i.e., no kinesthetic cues of speed loss or vertical rate are available to the pilot.

9. A comparative analysis between both groups procedure performance scores in the aircraft resulted in significant differences for:

The VOR holding pattern entry--control group pilot experience.

ILS station tuning--control group pilot procedural errors.

ILS basic airwork--excessive altitude deviations of four experimental subjects.

10. There were no significant differences between PGT task and procedure scores of pilots with ground trainer experience and pilots with no ground trainer experience. The lack of significance was attributable to an average lapse of eight months since those pilots with simulation experience had flown a PGT.

CONCLUSIONS

Based on the PGT and aircraft validation flight test results of 15 control and 15 experimental subjects, it is concluded that:

1. An appropriately equipped PGT may be used as an adjunct to the initial instrument flight test to flight check instrument pilot applicants on their ability to perform VOR, ADF, and ILS instrument approaches and related instrument procedures.

2. The equipment and capabilities which contributed to the effectiveness of the PGT in a flight test situation, and which define the term "appropriately equipped PGT," were: the provision of three-axes of flight control; flight and navigation displays with acceptable, functional meter (needle) movement representative of aircraft instrumentation; an x-y recorder plot of a part-task cross-country navigation simulation; communications equipment appropriate to the ground facilities used. Furthermore, the performance data indicate a wind force/wind direction capability as a major requirement for using a PGT in a flight test situation. With the exception of wind simulation, the above equipment capabilities are consonant with the current minimum equipment requirements for a PGT to obtain maximum flight training credit as defined in FAR 141.41 a1-(i), (ii), (iii), (v), (a2b) and FAR 91.33.

3. A credible and accurate assessment of a pilots' ability to perform ADF navigation and ADF instrument approaches in a PGT is difficult if not impossible to make unless the trainer is equipped with a resettable directional gyro, capable of simulating precession and a magnetic compass or heading information to which the precessed directional gyro may be set. Without this capability the flight examiner has no knowledge of whether or not the instrument applicant has developed a habit of checking, and if necessary, correcting a precessed directional gyro for accurate tracking.

4. Pilot ground trainer familiarization time of at least 45 minutes is necessary before an accurate judgment of a pilot's instrument flight ability can be made. Significant differences between trainer performance scores and aircraft performance scores in the initial phases of the PGT flight check diminish considerably as the flight test progresses to the last testing phase.

5. Pilot ground trainer idiosyncrasies which resulted in significant but within tolerance differences between PGT scores and aircraft scores were not contributing factors to the disqualifying performances of nine of the thirty subjects tested. The disqualifying trainer flight tests resulted from pilot procedural errors unrelated to the PGT. The significant differences that did occur emphasize the importance of the simulation of acceptable instrument meter (needle) movement as related to vertical speed, localizer and glide slope sensitivity.

6. On the basis of total task performance scores, the performance of the control group is no better or worse than that of the experimental group.

The control group performs slightly better on a specific procedures basis, in both the PGT and aircraft.

7. Pilots with previous ground trainer experience do not perform significantly better than those without PGT experience, if there is a considerable time lapse from when the PGT experience was gained. Any advantage prior ground trainer experience might have provided, diminished over an 8-month period when the PGT was flown last.

APPENDIX

Scoring and Grading Criteria

The basic airwork grading criteria were applied as follows:

Grade	Performance
1	The application of all flight, trim, and power controls should be smooth, correct, and prompt in order to qualify for a grade of 1.
2	Slightly rough (pitch, bank, and yaw oscillations) of all controls results in a grade not better than 2.
3	Moderately rough and slightly hesitant but correct use of all controls results in a grade not better than 3.
4	Incorrect, uncoordinated, and rough control usage, repeated unsuccessful corrective action result in grade 4.

Atmospheric turbulence was considered in granting these grades and time to reach stabilized flight was allowed before subject's performance was observed and graded.

The performance elements of the basic airwork procedure for altitude, heading and bank maneuvers were:

			Grades			
	Elements	Dim.*	1	2	3	4
a.	Altitude	±ft.	25	50	100	>100
b.	Heading	±deg.	2.5	5	10	>10
c.	Bank (Medium)	±deg.	2.5	5	10	>10

*The "Dimensions" are ±ft = feet, ±deg = degrees, ± kns = knots, and ft/min = feet per minute.

The grading criteria for subject performance of radio communications including station tuning reporting, and copying clearances were:

Grade	Performance
1	Subject is able to obtain correct frequency quickly from appropriate charts, tunes to the correct frequency without delay, uses faultless phraseology. Responds to requests and initiates contacts exactly as required.
2	Subject is slightly hesitant in determining and tuning to the correct frequency or requires extra time to decide what to say. Slight deviations from proper phraseology or hesitation before or during transmission is observed.
3	Subject is hesitant in determining correct frequency, uses several trials to select correct frequency. Significant deviations from proper phraseology and communication delays result in occasional repetitive calls and requests for acknowledgement by the controller. The microphone is misplaced in the cockpit and not used in the most effective manner. However, information exchanged with the controller is essentially correct.
4	A grade of 4 is assigned if one of the following occur: a. Subject is unable to determine and to tune to correct radio frequency, b. Uses improper phraseology, c. Fails to acknowledge calls, d. Delays in calls and repetitions are excessive, e. Talks into the back of microphone, f. Fails to select correct COM set in a two radio installation, g. Gives incorrect response or wrongly initiates communication, and h. Obviously does not understand the situation.

The grades which apply to procedural elements are as follows:

Reporting:

Grade	Performance
1	Subject always reports on time or whenever asked exactly with properly phrased report.
2	Subject reports on time in most cases but is not prepared.
3	Subject occasionally misses a report but always recovers.
4	Subject fails to report or reports incorrectly.

Clearances:

Grade:	Performance
1	Subject is prepared for and correctly copies clearances. Readback is faultless. Understanding is verified by subsequent action.
2	Occasionally makes mistakes in clearance readback. Subsequent performance is essentially correct.
3	Subject is hesitant in copying and readback. Repetitive transmissions are common. Delays are encountered but/subsequent performance is essentially correct.
4	Fails to understand clearance, fails to readback. Shows that clearance was not understood.

The grading criteria for navigation including station tuning and identification, orientation and tracking were:

Grade	Performance
1	Subject obtains correct navigation radio frequency quickly from pertinent references, tunes to and identifies the station correctly without delay and uses correct procedures for tracking, wind correction, and intercepts of radials or tracks. Unless close to the station, the CDI is never deflected more than 1 dot (2°) while tracking and heading changes are within 5° at a time to center the CDI. Subject always knows his position and time estimate to next fix.

2 Subject obtains correct navigation radio frequency, tunes in and identifies the station correctly, uses slightly rough techniques for tracking wind corrections and intercepts. The CDI is never deflected more than 2 dots (4°) and heading corrections are within 10° in an effort to center the CDI. Subject always knows his position and may exhibit hesitation in computing time to next fix.

3 Subject is hesitant to obtain correct frequency, tunes to and identifies station correctly, uses rough techniques for tracking, wind corrections, and intercepts. The CDI is frequently deflected as much as 20°. Subject has only general knowledge of his relative position.

4 A grade of 4 is assigned if:

a. Subject is unable to determine and to tune to correct frequency assigned.
b. Does not positively identify station.
c. Does not correct for wind drift.
d. Sets OBS incorrectly.
e. CDI is frequently deflected more than 3 dots.
f. Does not know how to intercept.
g. Heading corrections are frequently more than 20°.
h. Subject is lost.

The grading criteria for subject performance of tracking VOR radials, ADF bearings and ILS localizer/glide slope were:

		Grades			
Elements	Dim.	1	2	3	4
Radial tracking	± dots	1	2	3	>3
Localizer/glide slope	± dots	1	2	3	>3
ADF bearings	± deg.	2.5	5	10	>10
Intercepts	±dots	1	2	3	>3

The grading criteria for "time to missed-approach report were".

		Grades			
Elements	Dim.	1	2	3	4
± Seconds		10	20	30	>30

The grading criteria for subject performance of holding pattern entry and holding pattern were:

Grade	Performance
1	Subject correctly enters pattern with recommended procedure.
2	Subject is hesitant, although identifies holding fix and enters holding pattern and holds correctly.
3	Subject does not understand entry technique and finally enters correct holding pattern after repeated attempts and holds correctly.
4	Subject fails to enter holding as assigned, holds on the wrong radial or wrong side of the correct radial or gets lost.

The general grading criteria for instrument approaches, approach patterns, and letdown to altitude are as follows:

Following approach clearance,

Grade	Performance
1	Subject uses correct letdown plate and understands all markings. Subject is always aware of his position and notes time at inbound fixes. Execution is to within one dot deviation at all times. Missed approach is initiated at minimums promptly and correctly at appropriate time.
2	Subject uses correct plate with understanding. He is aware of his position and notes time at inbound fixes. Execution is to within a two-dot deviation. Missed approach is initiated at minimum correctly at appropriate time with some hesitation. MDA minimums are never violated; DH never violated by more than 50 feet and is corrected.
3	Subject occasionally has wrong plate or fails to understand restrictions. He is occasionally confused about his position. Execution is to within a 3-dot derivation. Subject occasionally fails to execute missed approach at minimums or on time. MDA minimums are never violated by more than 100 feet and subject corrects deviation. DH never violated by more than 50 feet and is corrected. Performance is essentially safe. Letdown may be slightly delayed.
4	A grade of 4 is assigned if: a. Subject does not understand let down plate, fails to letdown, b. Execution is occasionally marked by full-scale needle deflections, c. Subject is clearly lost, d. Subject fails to execute missed approach to above standards, and e. Grossly exceeds altitude minimums. Does not correct.

Missed-approach procedures are graded as follows:

Grade	Performance
1	Subject applies all flight and power controls correctly, smoothly, promptly, and in a coordinated manner such that dangerous attitudes or airspeeds do not result. The airplane transitions promptly from a descent to a safe climb speed and configuration without further loss of altitude.
2	Subject applies all controls smoothly, correctly, and in a coordinated manner after slight hesitation. The airplane transitions from a descent to safe climb with very little loss of altitude. Slight delay changing configuration (flap retraction).
3	Subject applies all controls correctly, after some hesitation. Moderate oscillations in pitch and yaw are evident due to rough control use. The airplane transitions from a descent to a climb after considerable speed above climb speed has been obtained thus delaying the desired climb unnecessarily. Long delay changing configuration.
4	a. Subject applies controls incorrectly, b. Dangerous attitudes and airspeeds result, c. Considerable delay occurs, d. Touchdown on the runway occurs, and e. Fails to change configuration.

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