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Effectiveness of Personal Computers to Meet Recency of Experience Requirements

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16. Abstract

The purpose of the current study was to investigate the effectiveness of Personal Computer Aviation Training Devises (PCATDs) and Flight Traning Devices (FTDs) to meet FAA recency of experience requirements for instrument flight. Two types of training devices were tested: 1) an FAA approved PCATD; and 2) a Frasca 141 FTD. An Instrument Proficiency Check (IPC) was given to all subjects in the airplane to establish a performance baseline (IPC #1). After the completion of IPC #1 in the airplane, the subjects were randomly assigned to one of four groups: the PCATD, the FTD, the aircraft or the control group with a balancing constraint so that the subjects successfully completing IPC #1 were equally distributed among the four groups. During the six-month period, each subject received two recency of experience flights of about 1.8 hours each in either the PCATD, the FTD or the aircraft; the control group received no recency training. These recency of experience flights included three instrument approaches, holding procedures, and intercepting and tracking navigation radials and courses. After the six-month period, performance on an IPC in the airplane (IPC #2) compared pilots who received recency of experience in the training devices to a control group. The subjects in the PCATD and FTD group were also compared to the aircraft group who received recency of experience in the airplane. A comparison of the three training groups with the control group performance on the final instrument proficiency check indicated that the training groups performed significantly better than the control group. The study also indicated that PCATDs are effective in maintaining recency of experience for instrument rated pilots over a period of six months. The two recency of experience practice sessions resulted in significantly better performance for the PCATD group on an IPC compared to the control group. Practice in either the PCATD or the FTD resulted in higher pass rates compared to the control group and practice in the PCATD and the FTD was found to be at least as effective as practice in the airplane. Finally, the performance of the PCATD group was statistically indistinguishable from the FTD group. These findings present compelling evidence that the FAA should permit the use of PCATDs to maintain recency of experience for instrument pilots.

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FOREWORD

This study was prompted by the FAA Advisory Circular (AC) No. 61-126 (1997), which authorized the use of a Personal Computer Aviation Training Device (PCATD) to be used for 10 of the 15 hours authorized for an approved ground training device. The advisory circular, however, did not authorize the use of PCATDs for recency of experience requirements. The study was supported under Federal Aviation Administration (FAA) contract DFTA 98-G-003 with the Institute of Aviation, University of Illinois at Urbana-Champaign during 1998-2001. The study was sponsored by FAA Headquarters AFS-840, Mr. Michael Henry. Dr. Kevin Williams, Civil Aerospace Medical Institute (CAMI), served as the contracting officer's technical representative for FAA-CAMI. We express our appreciation to Ms. Mary Wilson who scheduled subjects, to Ms. Diana Christenson who assisted in manuscript preparation, and to Ms. Karen Ayers who assisted with report formatting. We also thank all of the Institute of Aviation flight instructors who provided instrument training in the Flight Training Device (FTD), the PCATD and the aircraft; the Institute flight instructors who served as IPC check pilots; and the instrument pilots for their participation in the study.

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EXECUTIVE SUMMARY

The purpose of the current study was to investigate the effectiveness of PCATDs and FTDs to meet FAA recency of experience requirements for instrument flight. Two types of training devices were tested: 1) an FAA approved PCATD; and 2) a Frasca 141 FTD. An Instrument Proficiency Check (IPC) was given to all subjects in the airplane to establish a performance baseline (IPC #1). After the completion of IPC #1 in the airplane, the subjects were randomly assigned to one of four groups: the PCATD, the FTD, the aircraft or the control group with a balancing constraint so that the subjects successfully completing IPC #1 were equally distributed among the four groups. During the six-month period, each subject received two recency of experience flights of about 1.8 hours each in either the PCATD, the FTD or the aircraft; the control group received no recency training. These recency of experience flights included three instrument approaches, holding procedures, and intercepting and tracking navigation radials and courses. After the six-month period, performance on an IPC in the airplane (IPC #2) compared pilots who received recency of experience in the training devices to a control group, which received no recency of experience. The subjects in the PCATD and FTD group were also compared to the aircraft group who received recency of experience in the airplane.

This study clearly demonstrated the benefit of recency of experience training in maintaining instrument currency for instrument rated pilots. A comparison of the three training groups with the control group performance on the final instrument proficiency check indicated that the training groups performed significantly better than the control group. The study also indicated that PCATDs are effective in maintaining recency of experience for instrument rated pilots over a period of six months. The two recency of experience practice sessions resulted in significantly better performance for the PCATD group on an IPC compared to the control group, which had no practice. Practice in either the PCATD or the FTD resulted in higher pass rates compared to no practice by the control group and practice in the PCATD and the FTD was found to be at least as effective as practice in the airplane. Finally, the performance of the PCATD group was statistically indistinguishable from the FTD group. These findings present compelling evidence that the FAA should permit the use of PCATDs to maintain recency of experience for instrument pilots.

The study showed that only 45 of 106 (42%) of instrument current pilot subjects passed the initial IPC (IPC #1) in the airplane. This finding raises questions concerning the relationship between instrument currency and instrument proficiency. The results indicated that many subjects had difficulty with the ILS approach. Recency of experience requirements require six instrument approaches, but do not specify that any must be a precision approach. This suggests the need for the FAA to consider changing the recency of experience requirements for instrument currency. An alternative approach would be to require a periodic IPC to demonstrate instrument proficiency in addition to the current currency requirements.

Only thirty-seven percent of the subjects who pass an IPC in a FTD were able to subsequently pass the initial IPC in the airplane. This calls into doubt the effectiveness of a FTD as a viable platform to administer an IPC. It should be noted that all subjects in this category were more than one year out of currency. All retraining was done in an FTD. We recommend that the FAA sponsor a study specifically designed to test the effectiveness of both FTDs and PCATDs for administering IPCs. This study should include instrument pilots from all three currency groups.

A comparison of the pass/fail rates for IPC #1 and IPC #2 indicated that the performance on the baseline IPC was the best predictor of performance on the final IPC. Seventy-five percent of the subjects who passed IPC #1 also passed IPC #2 and 66 percent of the subjects who failed IPC #1 also failed IPC #2. Regardless of the intervening training during the six-month currency period, 70 percent of the subjects either passed both tests or failed both tests. Thirty percent of the subjects passed IPC #1 and failed IPC #2 or failed IPC #1 and passed IPC #2. A analysis of improvement and deterioration on IPC #2 compared to IPC #1 indicated a trend of improvement for the FTD group and PCATD group which approached statistical significance. The control group showed a trend for deterioration which was not significant. These results support the earlier finding of the benefit of the PCATD and FTD in maintaining instrument proficiency and suggest that improvement may be possible for some pilots when these devices are used.

Effectiveness of Personal Computers to Meet Recency of Experience Requirements

INTRODUCTION

Recently there has been an increased emphasis on the use of Personal Computers (PCs) in flight training (Campbell, 1998; Falun, 1992; Lert, 1990; Miller, 1996; Kolano, 1997). A summary of a joint industry-FAA conference concerned with the development and use of personal computers documents this emphasis (Williams, 1994). Koonce and Bramble (1998) have provided an overview of the use of personal computer-based flight training devices. As computer capability has improved and cost decreased, the PC has become a viable tool for presenting realistic, high-quality, full-size graphic representations of aircraft instrument displays. Current PC technology can provide aerodynamic characteristics that are as accurate as current Flight Training Devices (FTDs) and that closely mimic those experienced in flight. Also, they have realistic flight controls and aerodynamics models that are at least as accurate as current FTDs. In addition, navigation databases are unlimited in geographic coverage. Desktop computer devices offer a low-cost alternative for instruction of instrument tasks. A computer, software, flight-control system, monitor, and an instructor station monitor can be acquired at a cost of less $7,000. Studies by Phillips, Hulin, and Lamermayer (1993), Ortiz (1994), and Dennis (1994) have provided evidence of positive transfer of training from desktop computers to the airplane, but these empirical evaluations have been limited in scope. A report by Hampton, Moroney, Kirton, and Biers (1994) reported that students trained in a Personal Computer Aviation Training Device (PCATD) performed as well on instrument procedures in the airplane as students trained in a Frasca 141. No airplane control group was used in this study, so it was not possible to determine the transfer effectiveness of the PCATD or the Frasca 141. Recently, Karp (2001) has described the use of PCATDs in the classroom. PCATDs provide many features required to practice instrument tasks; but their fidelity is low in areas normally thought to be important in instrument training, such as displays, switches, out-of-cockpit scenes, control loading, and flight dynamics. PCATDs also accept control inputs from low-fidelity devices that range from computer keyboards, single joysticks, and yoke/pedal combinations of varying quality (Peterson, 1993), but realistic flight controls are currently available.

Taylor, Lintern, Hulin, Talleur, Emanuel, and Phillips (1996, 1999) and Taylor, Talleur, Phillips, Emanuel, and Hulin (1998) reported a study to determine the extent to which a PCATD can be used to develop specific instrument skills that are taught in instrument flight training and to determine transfer of these skills to the aircraft. A commercially available PCATD was used to teach instrument tasks to students in instrument training at the Institute of Aviation, University of Illinois. In order to evaluate transfer of training, the performance of a group of subjects trained in a PCATD and later trained to criterion in an airplane (PCATD Group) was compared to the performance of a control group of subjects trained only in the airplane (Airplane Group). For the PCATD Group, all new maneuvers and procedures were introduced and trained to proficiency in a PCATD prior to training and skill validation in the aircraft. For the Airplane Group, all new maneuvers were introduced and trained to proficiency in the airplane. Comparisons of trials to criterion in the airplane for the two groups, their times to complete each flight lesson in the airplane, and their course completion times were used to assess the training effectiveness of the PCATD. The data from this study indicated that the PCATD was an effective training device for teaching instrument tasks. Transfer savings were generally positive and statistically significant when new tasks were introduced, but lower transfer was found when tasks already learned in previous lessons were reviewed. A comparison of course completion times showed a statistically significant saving of about four hours in the airplane for the PCATD Group compared to the Airplane Group. The cumulative transfer effectiveness ratio was 0.15 or a savings of 1.5 flight hours for each ten hours of PCATD time.

In a follow-on study concerning incremental transfer of training effectiveness Taylor, Talleur, Emanuel, Rantanen, Bradshaw, and Phillips (2001) found that the PCATD was effective in teaching basic instrument tasks to private pilots. Prior training in the PCATD for 5, 10, or 15 hours resulted in a smaller number of trials in the airplane for each of the three PCATD groups when compared to the Airplane group which was trained only in the airplane. However, the transfer effectiveness ratio was not a simple function of the amount of practice in the PCATD. Although it seems reasonable to believe that greater training in the PCATD would reduce the amount of training needed in the aircraft this prediction was not borne out. For five of the eight instrument tasks, the PCATD 10-hour group needed the fewest number of trials in the airplane, for two tasks the PCATD 5-hour group had the fewest number of trials in the airplane and the PCATD 15-hour group had one task with the fewest number of trials in the airplane. Of course, all groups benefited to some extent from their practice. The mean times to complete the flight lesson in the airplane for the four flight lessons in which there was prior training in the PCATD were less for all three PCATD groups than for the Airplane group. These studies document the complex relationship between "flying" a PCATD and flying an airplane. Clearly there are important similarities that lead to positive transfer. But just as clearly, mastery in a training device does not necessarily imply mastery in an airplane. For this reason, it is important to continue to investigate the potential of PCATD devices in acquiring and maintaining instrument flight skills.

Williams and Blanchard (1995) discussed the development of qualification guidelines for personal computer-based aviation training devices. In 1997, the Federal Aviation Administration (FAA) published an advisory circular concerned with the qualification and approval of PCATDs (U.S. Department of Transportation, 1997). The advisory circular permitted the use of PCATDs in instrument training programs conducted under FAR Part 61 and FAR Part 141 and authorized the use of a PCATD to be substituted for 10 of the 15 hours authorized for an approved ground training device. The advisory circular did not authorize the use of PCATDs for practical tests or for recency of experience requirements.

In order to maintain instrument currency, every six months instrument pilots must meet a recency of experience requirement by tracking courses, completing six approaches and one instrument holding pattern under either simulated or actual instrument meteorological conditions (IMC). The simulated recency of experience requirements may be conducted in an airplane or an approved FTD with a Certified Instrument Flight Instructor, (CFII). If an instrument pilot fails to meet the recency of experience requirements within the six month period, the requirements can be met within the following six months to regain instrument currency. If an instrument pilot fails to meet recency of experience requirements within the 12-month period, an instrument proficiency check (IPC) must be accomplished with a CFII for the pilot to regain instrument currency.

Evaluations by a certified flight instructor (CFI), which are primarily based on direct observation, meet the validity and reliability requirements for performance evaluation for training and proficiency assessment. However, these evaluations have some important prerequisites. They depend heavily on the expertise and skill of the evaluator. Observer expertise is critical because differences in pilot performance can be subtle and may not be sufficiently salient for an inexperienced observer to detect. Efficient usage of a standardized checklist where all the items to be evaluated are explicitly defined is also essential. Such checklists, based on the FAA requirements and criteria, were created for the purposes of this project. The evaluators must also be sufficiently trained to achieve reasonable inter-rater and intra-rater reliability. In the present project, evaluator pilot training and standardization were explicitly emphasized as well.

If these prerequisites are met, this method is probably the best currently available performance evaluation technique. Experienced evaluators not only have detailed knowledge of the appropriate procedures and techniques, but also knowledge of the pitfalls and most common mistakes. Thus, they may be able to follow the subject's performance and detect subtle errors. The observation method also captures the "whole" of the task, including the use of aids and equipment, communication, and performance on several secondary tasks, which may not be part of a particular piloting task but which are nevertheless critical for a safe conduct of the flight.

Pilot performance evaluation by a CFI has, however, a number of significant disadvantages. First, the practice is labor-intensive, with a one-to-one CFI-subject ratio. Additionally, a human evaluator may not be able to provide sufficiently accurate quantitative data for research purposes, due to the limitations of human observation capabilities. Likewise, the check pilot may not be able to provide data at a sufficient frequency to study the variable in question. This is particularly the case in observation of simultaneous events. For these reasons, there is a need to develop valid and reliable automatic performance data collection and evaluation methods to be used in conjunction with instructor pilot evaluations. Toward this end, an in-flight data logger was also used to record a number of flight parameters during the IPC #1 and IPC #2 flights, from which pilot performance measures were derived for analysis.

The purpose of the current study was to investigate the effectiveness of PCATDs and FTDs to meet FAA recency of experience requirements for instrument flight. Two types of training devices were tested: a PCATD and a Frasca 141 FTD. An IPC was given to all instrument pilots in the airplane to establish a performance baseline (IPC #1). After a six-month period, performance on an IPC in the airplane (IPC #2) was compared for pilots who received recency of experience in the training devices to a control group which received no recency of experience and to pilots receiving recency of experience in an airplane.

Interim reports, and earlier reports and presentations of the work including reports of the airborne performance measuring device are listed in Appendix A.

METHOD

Subjects

One hundred and six subjects participated in the experiment. All subjects were instrument pilots who were instrument current when they began the experiment. The subjects agreed to refrain from instrument flight for six months. They also agreed not to use a PCATD for instrument training during those six months. The initial pool of subjects were volunteers primarily within a 50 mile radius of Champaign, IL. Their participation was solicited using a mail survey which was sent to all instrument-rated pilots in the area. A total of 596 invitations were mailed; 152 instrument pilots responded with a statement of interest. A Pilot Experience and Biographical Data Questionnaire was mailed to those instrument pilots who expressed interest (see Appendix B). The questionnaire collected information about the pilot's experience and instrument currency status. Subsequent mailings were made to a 75 mile radius and to the larger metropolitan areas within Illinois in order to achieve the desired subject pool.

The average age of the subjects was 50 with a range of 22 to 76 years. Average total flight experience was 2460 hours with a range of 150 to 24,000 hours. Average experience in aircraft similar to the type used in the experiment was 1540 hours with a range from zero to 24,000 hours.

The instrument pilots who were potential subjects for the study were in one of three categories of instrument currency: 1) instrument current, 2) within one year of currency, or 3) outside of one year of currency. Pilots in category one began the experiment with a baseline instrument proficiency check (IPC #1) in the airplane following an oral/familiarization session described below. The pilots who were within one year of currency completed the recency of experience requirement in a Frasca FTD under the supervision of a CFII to become current. A standardized session was used to complete the currency requirement (see Appendix C). The pilots who were more than one year outside of currency were required to complete an IPC in a Frasca FTD to become current. Most pilots in this category required several training sessions before they passed an IPC (see Appendix D). Several potential subjects failed to reach proficiency and were subsequently released from the project prior to their involvement in the experiment. All subjects had the option of receiving payment for flight time flown during the experiment, as well as mileage costs to and from Willard Airport in Savoy, IL, where all sessions took place.

Apparatus

Two FAA-approved Jeppesen FS-200 PCATDs with a Beechcraft Sundowner performance model and two FAA approved Frasca 141 FTDs with a generic single-engine, fixed gear, fixed pitch propeller performance model were used. The FTDs were approved for instrument training towards the instrument rating, instrument recency of experience training, and IPCs, as well as for administering part of the instrument rating flight test. Two 180 hp Beechcraft Sundowner aircraft (BE-C23) which have a single engine, fixed-pitch propeller, and fixed under carriage were used as the training aircraft for IPC #1 and IPC #2. An airborne performance measurement system was installed in each aircraft to record flight data during the IPC flights (Lendrum, Taylor, Talleur, Hulin, Bradshaw, & Emanuel, 1999, 2000; Rantanen, Talleur, Taylor, Bradshaw, Emanuel, Lendrum, & Hulin, 2001).

As a part of this project, a flight data recorder (FDR) system that automatically tracked a number of important flight parameters was developed and used to collect airborne performance measurement data. A number of performance measures were derived to objectively assess the subject's performance during IPC #1 and IPC #2. The FDR was built specifically to support research on pilot performance at the University of Illinois, Institute of Aviation. The FDR is based on a commercial single board computer, which measures approximately 22 x 24 x 12 inches, and weighs about 42 pounds. The FDR was installed in a Beechcraft BE23 Sundowner aircraft in the rear seats and cargo bin area of the aircraft's cabin. The FDR recorded aircraft position by global positioning system (GPS) and differential correction receivers, altitude, pitch, roll, yaw, magnetic heading, vertical speed, and airspeed. In addition, VHF omnirange receiver and localizer (VOR/LOC), as well as glideslope (GS) indications were recorded. A handheld terminal allowed instructor pilots to start and stop recording of data, mark the data record, and view the progress of recording. The FDR recorded the data at a rate of one frame per second (1 Hz) (Lendrum et al., 2000).

Procedure

All subjects participated in an "Oral/ Familiarization" session, during which pertinent instrument flight regulations and emergency procedures were reviewed. The subjects also received an overview of the first flight in the aircraft as well as a review of the aircraft systems and instrumentation (see Appendices E and F). Following the Oral/Familiarization session, all subjects received a baseline IPC flight in the airplane (IPC#1), which started the six month experimental period. IPC#1 was flown with a CFII who acted both as a flight instructor and as an experimental observer. The IPC is a standardized test of the instrument pilot's skills in the aircraft. The types of maneuvers, as well as completion standards for an IPC, are listed in the instrument rating practical test standards (PTS) (U.S. Department of Transportation, 1998). A flight scenario, that followed the current guidelines for the flight maneuvers required by the PTS, was developed (see Appendix G). This scenario was used to collect baseline data and established the initial level of proficiency for each subject who participated in the project. The IPC#1 flight included a brief (15-20 minutes) in-flight aircraft checkout under Visual Flight Rules (VFR) followed by a VOR approach, holding procedures, steep turns, unusual attitude recovery procedures, an ILS approach, and tracking and intercepting of navigation courses.

The IPC #1 flight contained six maneuvers (VOR approach, holding patterns, steep turns, unusual altitude recovery, ILS approach and ATC procedures and communication). The CFIIs for the IPC#1 flight used a form that was designed to facilitate the collection of three types of data (Phillips, Taylor, Lintern, Hulin, Emanuel, & Talleur, 1995). First, within each maneuver there were up to 24 variables (e.g., altitude, airspeed) which were scored as pass/fail indicating whether performance on those variables met PTS requirements. Second, the flight instructor judged whether the overall performance of the each maneuver was pass/fail. Third, the CFII recorded if the overall performance of the subject met the PTS for the IPC.

All instructors who administered the IPC#1 flight were standardized on the scenario to be flown and the scoring procedure. Appendix H shows the document that was used for instructor training to assure that all instructors used the same criteria for scoring performance during an IPC flight. After the completion of IPC#1 flight in the airplane, the subjects were randomly assigned to one of four groups: the PCATD, the FTD, the aircraft or the control group. After the assignment of 47 subjects, a balancing constraint was added so that those successfully completing the IPC#1 flight were equally distributed among the four groups.

Depending on group assignment, each subject received two recency of experience flights of about 1.8 hours each in either the PCATD, the FTD, or the aircraft during the six-month period. These recency of experience sessions included three instrument approaches, holding procedures, and intercepting and tracking navigation radials and courses (see Appendices I and J). The second recency of experience flight also included a partial-panel non-precision approach. The control group received no training but received IPC #1 and IPC #2 flights in the airplane. Table 1 shows the experimental design.

After a six-month period, all subjects flew a final IPC (IPC#2) in the aircraft to assess instrument proficiency. IPC#2 consisted of the maneuvers in IPC#1, but also included a partial-panel non-precision approach at the end of the flight (see Appendix K). Since the subjects were already familiar with the Sundowner's flight characteristics, the visual familiarization segment, as flown at the beginning of IPC#1, was not flown in IPC#2. This final session contained all required maneuvers that a pilot must satisfactorily complete in order receive an endorsement of instrument proficiency. Completion of IPC#2 marked the end of a subject's involvement in the experiment. Subjects in the Control or PCATD group who did not receive an endorsement of instrument proficiency during IPC#2 were allowed to return for a final session in the FTD in order to complete the recency of experience requirements and reestablish instrument currency.

FDR Data Collection, Preprocessing and Reduction

An IPC flight consists of a series of specific maneuvers, which the student pilot is required to perform within certain criteria. The FDR, which was installed in the aircraft, collected raw data at a rate of 1 Hz. Flight instructors marked flight segments of specific maneuvers in the data file during the flight using a handheld terminal to facilitate later evaluation. It was

Table 1. Experimental design.

Group	Sessions: IPC#1	Two-month Recency of Experience	Four-month Recency of Experience	IPC#2
Aircraft	In Aircraft	In Aircraft	In Aircraft	In Aircraft
FTD	In Aircraft	In FTD	In FTD	In Aircraft
PCATD	In Aircraft	In PCATD	In PCATD	In Aircraft
Control	In Aircraft	none	none	In Aircraft

not, however, always possible to mark the data file accurately while in-flight. Therefore, a data visualization tool was developed for post-flight examination of the data and re-marking the flight segments.

To analyze the flight segments, a tool that allows for an accurate and efficient marking of the flight segments was developed. Because an IPC flight follows a standardized scenario, the aircraft's position relative to airports and ground-based navigational aids (navaids) is the best indicator for making segments of the specific maneuvers being executed during flight. Therefore, a plot of the aircraft's flight path facilitates differentiating between critical flight segment transitional portions of the flight. To be effective, the tool must therefore allow a high level of interaction between the analyst and the data, and must permit several variables to be viewed simultaneously. Thorough analysis of the data collected by the airborne FDR required two distinct steps: (1) specification of the flight segments for further analysis of the flight data, and (2) the detailed analysis of the data.

A computer program was developed to provide a visualization tool for the analyst and an interface between the analyst and the raw data collected by the FDR. A typical IPC data file contained 23 fields (for the 23 variables measured) and about 3600 records from a one-hour flight (collected at 1 Hz). The product of the visualization tool was a plot of the horizontal position data on a fixed background in the Cartesian coordinate system. Other selected variables were plotted in a similar manner, with record number on the x-axis and the variable of interest on y-axis. The range of the data for these plots can be selected either from the x, y plot of from the tabular display. The program also allowed editing of the raw data file so that the head and tail of the data file (unimportant data) could be trimmed. In addition, the program allowed for selection of the variables of interest to be plotted and displayed in tabular form. These were cross-referenced between the windows depicting different variables, which were used to select a single data point or range of data points for further examination. The program also permitted zooming in and out for detailed visual inspection of any particular point in the flight. The analyst was also able to mark the beginning and end of a selected segment or several segments in each data file could be marked and save the marked segments of the data file could be saved to new files for further analysis.

Criteria for the various flight parameters for the particular segments were also entered in the data files. Another computer program was developed to further reduce these data and to derive pilot performance measures for detailed analysis. The raw data in this experiment was contained in 171 data files which represented 65 IPC #1 flights and 106 IPC #2 flights. The data files were collected at a sampling rate of 1 Hz. The files had up to 6,000 lines in length for a typical 105-minute flight, but were reduced by the program to a single row in a spreadsheet for analyses.

Performance Measures Derived From the FDR Data

Criteria and tolerances were clearly defined for each flight parameter that was recorded using the FAA as Practical Test Standards. Separate criteria and tolerances were determined for the performance indices derived from the FDR data. For the purposes of the current study, five primary performance measures were derived from the FDR data for nine flight parameters. The flight parameters are (1) altitude, (2) roll, (3) pitch, (4) yaw, (5) vertical speed, (6) indicated airspeed, (7) magnetic heading, (8) course deviation, and (9) glide slope deviation. The five primary performance measures are described in detail as follows:

Standard deviation. Standard deviation (SD) describes the amount of variability around the mean of any measure. A small SD will usually be indicative of good performance.

Root mean square error. Root mean square error (RMSE) is a widely used measure of tracking performance (e.g., Scallen, Hancock, & Duley, 1995). It can be used to reduce the tracking performance along a specified parameter (e.g., altitude, or VOR radial) in the entire segment of an IPC flight into a single number. A low number typically indicates good performance. Squaring individual errors, adding them, dividing this sum by the total number of errors, and then taking a square root of this quantity provides the RMSE of a function. The RMSE summarizes the overall error, but it does not contain information about the direction of deviations or the frequency of deviations from the criterion. The latter is a particularly important dimension of tracking performance, as it would allow for detection of high velocity error in tracking while the position error (measured by the RMSE) might be minimized (Wickens & Holland, 2000). To overcome these limitations, additional measures were developed.

Number of deviations. The number of deviations outside tolerance (ND) is a measure that tallies the occurrences of the aircraft straying outside predetermined tolerances (Reynolds, Purvis, & Marshak, 1990). This is essentially a measure of velocity error in tracking and it complements the RMSE, which contains the error magnitude information. A low number typically indicates good performance. A low ND value can, however, be obtained if the pilot makes few deviations outside the tolerances but stays there for a substantial proportion of the flight segment. Therefore, the ND measure must be considered together with the total time spent outside tolerance in a given segment.

Time outside tolerance. The cumulative time the aircraft spends outside a given tolerance (TD) provides an indication of tracking performance beyond the RMSE and ND. This measure is computed by summing the time the pilot spends outside of a given tolerance. A small number indicates good performance.

Mean time to exceed tolerance. The mean time to exceed tolerance at any time (MTE) is computed from the rate of change between successive data points and the aircraft's position relative to a given tolerance. This provides a tracking performance measure within the tolerance region, as opposed to the ND and TD measures described above. A large mean (and small SD) indicate good performance.

Because a number of the measures require predetermined criterion (e.g., RMSE) or tolerance values (e.g., ND, TD, and MTE), separate files containing the criteria and tolerance information were created and read by the data reduction program prior to processing of the IPC data files. In cases where the tolerances or criteria differed from segment to segment, these were included in the IPC data files. In general, the tolerances were the same used by the flight instructors in their evaluation of pilot performance during the IPC flights.

Analysis

The effectiveness of the PCATD for maintaining instrument currency was assessed by comparing IPC#2 pass rates for each experimental group to the control group using Chi-Square analysis. Performance changes that occurred between IPC#1 to IPC#2 were analyzed using both Chi-Square and ANOVA procedures in order to ascertain the relative benefits that can be expected when using the various training methods employed in this study. The McNemar intervening activity statistic was used for a finer grain analysis of individual maneuver pass rates within each group to determine if one currency maintenance method was particularly better for certain maneuvers than other methods. ANOVA procedures were used to analyze the influence of demographic factors on the dependent variable.

Analysis of the Effectiveness of the FDR

Two primary analysis efforts with respect to the FDR measures were made. First, a comparison of the FDR measures with CFI evaluations was accomplished. The best possible correspondence between the CFI scores and the FDR measures occurs in a segment of an ILS approach from glideslope intercept to decision height. This segment was chosen for evaluation. Second, the effect of the sampling rate on the accuracy of measurement was examined by comparing sampling rates of 1 Hz and 0.067 Hz (once every 15 seconds).

RESULTS

IPC Pass Rate by Group

A total of 45 of 106 subjects (42%) passed the IPC #1 flight in the airplane and 55 of 106 subjects (52%) passed the IPC#2 flight. Table 2 presents the number and percentage of pilots that passed/failed IPC #1 and IPC#2 for each of the four experimental groups. Chi-square tests were used to analyze the IPC#2 data to determine whether the treatment (assignment to group) had an effect on the pass/fail ratio for the IPC#2

Table 2. IPC pass rates for each experimental group.

Group	Group N	IPC #1 Pass N	IPC #1 Pass %	IPC #1 Fail N	IPC #1 Fail %	IPC #2 Pass N	IPC #2 Pass %	IPC #2 Fail N	IPC #2 Fail %
Aircraft	26	11	42	15	56	12	46	14	54
FTD	27	13	48	14	52	19	70	8	30
PCATD	27	11	41	16	59	16	59	11	41
Control	26	10	38	16	62	8	31	18	69
Total	106	45	42	61	58	55	52	51	48

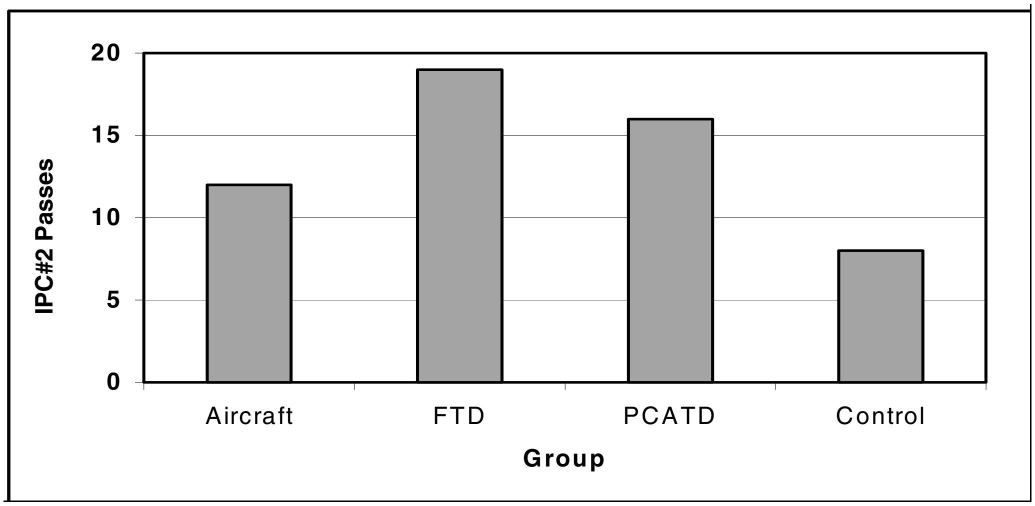

Figure 1. IPC#2 passes by experimental group.

flight. When all groups were compared, the treatment effect on the final IPC pass/fail ratios was statistically significant, χ^2 (3, $\underline{N}$=106) = 9.27, $\underline{p}$ < 0.05.

A series of planned-comparison tests were also performed between and among the experimental groups. The first test evaluated the effectiveness of PCATD for maintaining instrument proficiency by comparing the PCATD group with the control group. The PCATD group had a significantly higher proportion of IPC#2 passes than the control group, χ^2 (1, $\underline{N}$=53) = 4.34, $\underline{p}$ < 0.05. The next comparison was of the FTD and PCATD groups with the control group. Subjects who received recency of experience practice in either the FTD or in the PCATD resulted in a significantly higher IPC#2 pass rate than the control group, χ^2 (2, $\underline{N}$=80) = 8.18, $\underline{p}$ < 0.05. Neither the FTD nor the PCATD groups' IPC#2 pass rates were statistically different from the Aircraft group's, χ^2 (2, $\underline{N}$=80) = 2.52, $\underline{p}$ > 0.05, nor was the PCATD group statistically different from the FTD group, χ^2 (1, $\underline{N}$=54) = 0.73, $\underline{p}$ > 0.05. Figure 1 shows the differences between pass rates for the four groups for IPC #2.

Performance Changes from IPC#1 to IPC#2

An analysis of the change of performance that took place between the IPC#1 and IPC#2 flights was made in order to understand the benefit (or deficit) created by each of the training methods. Table 3 shows a comparison of the pass/fail rates for IPC #1 and IPC #2. Thirty-four of the subjects who passed IPC#1 also passed the IPC#2, and 40 of the subjects who failed IPC#1 subsequently failed IPC#2. This finding indicates that the performance on IPC#1 is the best predictor of performance on IPC#2 regardless of the type of recency of experience training during the six

Table 3. Comparison of the number of pass/fail for IPC#1and IPC#2.

		IPC#2 Pass	IPC#2 Fail	Total
IPC#1	Pass	34	11	45
	Fail	21	40	61
	Total	55	51	106

Table 4. IPC #1 and IPC #2 pass/fail rates by group.

	Pass IPC #1		Fail IPC #1		
	Pass IPC #2	**Fail IPC #2**	**Pass IPC #2**	**Fail IPC #2**	Total
Aircraft	7	4	5	10	26
FTD	11	2	8	6	27
PCATD	10	1	6	10	27
Control	6	4	2	14	26
Total	34	11	21	40	106

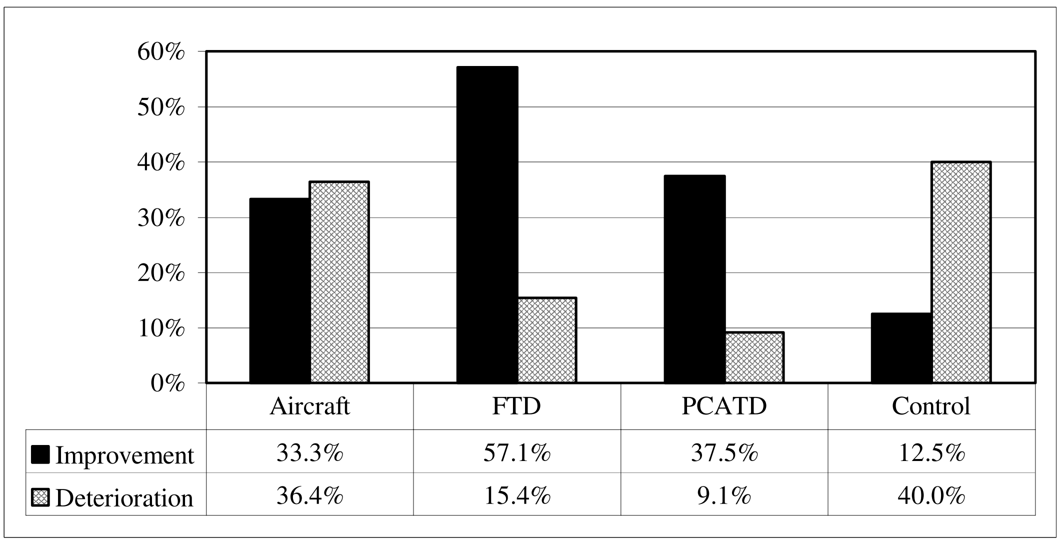

Figure 2. Skill improvement/ deterioration by group.

Table 6. Change in performance between IPC#1 and IPC#2 for individual maneuvers.

	Maneuvers					
Group:	**VOR**	**Hold**	**Turn**	**Uns. Att.**	**ILS**	**ATC**
Aircraft	3.57	3.60	0.09	0.33	1.00	0.66
FTD	1.29	3.60	0.11	0.00	0.09	1.00
PCATD	3.60	5.40*	2.00	1.80	5.40*	0.20
Control	0.69	0.29	1.33	0.67	0.00	0.20

*p<0.05.

months. Twenty-one subjects, who failed, IPC#1 subsequently passed IPC #2 and 11 of the subjects who passed IPC #1 subsequently failed IPC #2.

The IPC #1 and IPC #2 pass-fail rates by group are presented in Table 4. Analyses to determine the performance changes between IPC#1 and the IPC#2 for each experimental group were conducted and improvement and deterioration ratios are presented in Figure 2. Subjects who failed IPC#1 may benefit from practice in the aircraft, FTD, or PCATD during the six-month period and subsequently pass IPC#2 (the improvement ratio) and subjects who passed the IPC#1 may fail IPC#2 (the deterioration ratio). The improvement ratio for the airplane group showed that 33.3% of subjects who failed IPC#1 passed IPC#2, and the deterioration ratio shows that 36.4% of those who passed IPC#1 subsequently failed IPC#2. The McNemar test for intervening activity effects showed that the intervening six-month period of training in the aircraft was no more likely to improve performance than to deteriorate it, χ^2 (1, $\underline{N}$=26) = .11, $\underline{p}$ > 0.05. For the FTD group the improvement ratio indicated that 57.1% of the subjects who failed IPC#1 passed the IPC#2 and the deterioration ratio indicated that 15.4% of those who passed IPC 1, failed IPC#2. The McNemar test indicated that the improvement in performance for the FTD group approached significance, χ^2 (1, $\underline{N}$=27) = 3.60, $\underline{p}$ = 0.057. The PCATD group had an improvement ratio of 37.5% and a deterioration ratio of 9.1%; the improvement in performance approached significance, χ^2 (1, $\underline{N}$=27) = 3.57, $\underline{p}$ = 0.058. The improvement ratio for the control group was 12.5% and the deterioration ratio was 40%, but the trend was not significant, χ^2 (1, $\underline{N}$=26) = 0.67, $\underline{p}$ > 0.05.

IPC #1 Pass Rates by Prior Currency Status

Table 5 illustrates the number of subjects that passed/failed IPC#1 flight by prior currency status. Of the 106 subjects who completed IPC #1 in the airplane, 45 (42.5%) passed. Of the 32 pilots in currency status 1 (instrument current pilots), only 14 (44%) passed IPC#1 in the aircraft. In level 2 (those within the 12 months of currency) nine of 15 pilots (60%) passed the IPC#1 in the aircraft after competing recency of experience requirements in the FTD. For Level 3, 22 of 59 pilots (37%) passed IPC #1 in the aircraft. It is noteworthy that all 59 of these pilots received remedial training in the FTD and passed an IPC in the FTD before taking IPC #1 in the aircraft.

Change in Maneuver Performance Between IPC#1 and IPC#2

An analysis of the changes in maneuver performance that occurred between IPC#1 and IPC#2 was performed to determine if there were systematic changes in performance when considering the overall change in number of maneuvers passed. There were six maneuvers to be scored in both IPC#1 and IPC#2. An overall “maneuver change score” (+1, 0, -1) for each maneuver was determined for each subject; a positive score represents an improvement from IPC #1 to IPC #2, while a negative score represents a loss in skill from IPC #1 to IPC #2. The maneuver change scores for the six maneuvers were then summed for each subject. The subject’s overall performance change from IPC#1 to IPC#2 could range from –6 to 6. These scores were then standardized and analyzed using a single factor ANOVA to determine if there was a difference between experimental groups. The change in maneuver performance between IPC#1 and IPC#2 was not significant, $\underline{F}$ (3,105) = 1.1, $\underline{p}$ > 0.05.

Change in Individual Maneuver Performance Between IPC#1 and IPC#2

In order to compare maneuver performance among groups, the individual maneuver pass/fail judgment for one group was analyzed using the McNemar Chi-square test for intervening activity. Table 6 shows the results of this post-hoc analysis which indicates that a few maneuvers improved significantly between IPC#1 and IPC#2. The analysis shows that all three training groups (i.e., Aircraft, FTD or PCATD) showed improvement trend in performance on at least one of the six maneuvers over the period of six months. The improvement for the PCATD group was significant for the holding procedures and the ILS approach, χ^2 (1, $\underline{N}$=27) = 5.40, $\underline{p}$ < 0.05. No other maneuver improved significantly, but the following approached significance: the PCATD group on the VOR approach, χ^2 (1, $\underline{N}$=27) = 3.60, $\underline{p}$ = 0.06: the Aircraft group on the VOR approach, χ^2 (1, $\underline{N}$=26) = 3.57, $\underline{p}$ = 0.06 and holding procedures, χ^2 (1, $\underline{N}$=26) = 3.60, $\underline{p}$ = 0.06; and the FTD group on holding procedures, χ^2 (1, $\underline{N}$=27) = 3.60, $\underline{p}$ = 0.06. The Control group showed no significant change in individual maneuver performance.

Change in Maneuver Element Performance Between IPC#1 and IPC#2

During both IPC #1 and IPC #2, the CFI recorded additional detail about performance on each maneuver, including control and procedural performance.

An analysis of the change in performance at the maneuver element level was performed to determine if any of these elements contributed significantly to the overall maneuver pass/fail judgment. Several different elements for each maneuver received a pass/fail for both IPC#1 and IPC#2, so it was possible to compute on overall "maneuver element change score" for each subject. Maneuver elements fell into two categories; procedural and control. Therefore, two separate maneuver element change scores were computed. The procedural element change score consisted of those maneuver elements that were not directly related to aircraft control, but rather the execution of instrument procedures and Air Traffic Control (ATC) instructions. The control element change score consisted of those maneuvers concerned with how well the subject controlled the aircraft while executing the maneuvers. Only three of the six maneuvers scored had maneuver elements that were both procedural and control. The remaining three maneuvers consisted entirely of either procedural or control elements. Table 7 displays procedural and control elements of the three maneuvers used in the analysis.

Two tests were significant when the four experimental groups were compared for a change in performance on either procedural or control elements between IPC#1 and IPC#2. The hold maneuver improved significantly on procedural elements, $\underline{F}\,(3,105) = 2.63$, $\underline{p} = 0.05$. Post-hoc comparisons using Tukey's HSD test with a 90% confidence interval showed that both the FTD and Control group's performance on the maneuver elements changed were significantly different from the Airplane group's performance. The ILS approach also showed a significant change in performance on control elements, $\underline{F}\,(3,105) = 3.45$, $\underline{p} < 0.05$. Post-hoc analysis comparisons indicated that the PCATD group's performance on control elements for the ILS approach changed significantly (95% confidence interval) when compared to the Control group's performance on those elements.

Demographic Factors

The four demographic factors on which subjects varied were prior instrument currency status, age, flight time, and recent piloting experience. Flight time and recent experience variables contained several distinct data points, which were collapsed into single score (i.e., the flight time factor, and the recent experience factor) and then standardized. ANOVA results indicated no difference among the distributions of any of the four demographic factors between the four experimental groups: each of the four demographic variables failed to reach the $\underline{p}=0.05$ level of significance.

Analysis of Instructor Assignments

A factor that may have contributed to the overall IPC#2 rate was the failure to adequately randomize the assignments of the flight instructor to the IPC#2 flight. Substantial efforts were made to standardize each instructor on the experimental procedures and to keep instructors blind to the subject's group assignment. An analysis was made using the Friedman test for J matched groups was performed to determine if instructors had been assigned to an equal number of IPC#2 sessions within each experimental group. The result was non-significant, $\chi^2\,(3, \underline{N}=60) = 0.50$, $\underline{p} > 0.05$, indicating that any variability introduced by an individual instructor was evenly distributed among each of the experimental groups.

Delay to IPC#2

The period of time that elapsed between IPC#1 and IPC#2 was analyzed. Although the experimental design called for the IPC#2 flight to be completed six months from the IPC#1 flight, it was not always possible to complete IPC#2 on time. Inclement weather and subject illness were the two primary factors for delaying the IPC#2 flight. Since a delay in IPC#2 was a potential source of variability, an ANOVA was performed to determine if a significant difference existed between the groups. No significant difference in the number of days to IPC#2 was found between the experimental groups, $\underline{F}\,(3,105) = 1.04$, $\underline{p} > 0.10$. This result indicates that any influence of the delay between IPC#1 and IPC#2 on IPC#2 performance was equally distributed among all four experimental groups.

Influence of Partial Panel Approach on IPC#2 Pass/Fail Outcome

Since IPC#2 included an extra maneuver at the end of the flight, partial panel VOR approach, an analysis was performed to determine the effect of this maneuver on the overall pass/fail judgment for IPC#2. A Chi-square analysis was performed to determine if equal numbers of the four experimental groups passed the partial panel approach. The results showed no significant differences, $\chi^2\,(3, \underline{N}=106) = 0.63$, $\underline{p}>0.05$.

CFI Scores vs. FDR Measures

The evaluation of the FDR performance measures versus CFI scores was accomplished by collapsing all groups and both IPC #1 and #2 flights into two groups; those who passed and those who failed according to the CFI evaluation of a maneuver element. The sample maneuver (i.e., Decatur, IL [DEC] ILS 6, final approach) contained three elements scored by the CFI: (1) Course direction indicator (CDI) deflection (< ¾ scale deflection), (2) Glideslope (GS) deflection (< ¾ scale deflection), and (3) indicated airspeed (IAS) (± 10 K). The FDR recorded parameters relevant to this maneuver were: (1) IAS, (2) GS, and (3) CDI. For each of these parameters, five measures were derived: (1) Standard deviation (SD), (2) root mean square error (RMSE), (3) number of deviations outside tolerances (ND), (4) percent time outside tolerance (TD), and (5) mean time to exceed tolerance (MTE). The criteria used by the FDR measures were identical to those used by the CFIs.

In order to compare the CFI scores with the FDR measures, an analysis of variance (ANOVA) was performed for each measure and flight parameter. The null hypothesis was that the two groups (pass and fail) for both the CFI scores and the FDR measures would not be significantly different, that is, the pilots who passed would have come from the same population as those who failed the IPC flight. The alternative hypothesis was that the pass and fail groups came from different populations. The results of these analyses are presented in Table 8.

Table 8. Difference between the pass and fail groups by flight parameter and FDR data derived measure.

Measure	Group	n	Mean	SD	F	p
SD-IAS	Fail	26	5.01	2.02	8.77	0.004
(K)	Pass	136	3.95	1.59		
RMSE-IAS	Fail	26	4.69	2.14	4.30	0.04
(K)	Pass	136	3.94	1.58		
ND-IAS	Fail	25	1.72	1.97	1.67	0.198
	Pass	136	1.13	2.14		
TD-IAS	Fail	25	0.07	0.11	7.64	0.006
(s)	Pass	136	0.03	0.06		
MTE-IAS	Fail	25	91149.00	78753.00	2.14	0.146
(s)	Pass	136	73098.00	51853.00		
SD-GS	Fail	51	42.29	19.66	113.00	<0.001
(K)	Pass	113	20.52	10.30		
RMSE-GS	Fail	51	42.14	19.59	86.45	< 0.001
(K)	Pass	113	20.45	10.26		
ND-GS	Fail	50	1.54	2.08	31.69	< 0.001
	Pass	113	0.31	0.70		
TD-GS	Fail	50	0.09	0.12	42.39	< 0.001
(s)	Pass	113	0.01	0.03		
MTE-GS	Fail	49	76587.00	107559.00	1.41	0.237
(s)	Pass	113	62114.00	47988.00		
SD-CDI	Fail	26	40.17	12.96	48.92	< 0.001
(K)	Pass	137	22.94	11.24		
RMSE-CDI	Fail	26	40.03	12.92	48.89	< 0.001
(K)	Pass	137	22.86	11.20		
ND-CDI	Fail	26	1.04	0.87	48.27	< 0.001
	Pass	137	0.18	0.50		
TD-CDI	Fail	26	0.06	0.07	27.10	< 0.001
(s)	Pass	137	0.01	0.04		
MTE-CDI	Fail	26	63709.00	42930.00	0.26	0.609
(s)	Pass	137	58769.00	45469.00		

The SD of IAS revealed a significant difference between the pass and fail groups, $\underline{F}$ (1, 160) = 8.77, $\underline{p} < 0.005$. The pilots who failed the IPC flight exhibited higher variation in their airspeed control than the pilots who passed. The analysis of IAS RMSE yielded similar results. The pass and fail groups were significantly different, $\underline{F}$ (1, 160) = 4.3, $\underline{p} < 0.05$. The failed group exhibited larger RMSE values than the passed group. The number of deviations outside tolerances of IAS did not reveal differences between the groups. However, when examining the time pilots stayed outside tolerances, the groups differed significantly. The failed group spent less than 7% of the time outside the tolerance, and the pass group's spent 2.5% of the time outside the tolerance. The difference between the two groups was significant, $\underline{F}$ (1, 159) = 7.64, $\underline{p} < 0.01$. The time to exceed tolerance measure did not yield significant differences between the groups. This is probably because this measure is very difficult to be observed by the CFI, and would not be reflected in the subjective pass or fail judgment.

The above results were observed also on measures of glide slope tracking performance. Pilots who failed the maneuver exhibited significantly larger variability than those who passed, $\underline{F}$ (1, 162) = 113.00, $\underline{p} < 0.001$. A similar trend is evident also on the RMSE measure for GS. Pilots who failed had significantly higher RMS errors than those who passed, $\underline{F}$ (1, 162) = 86.45, $\underline{p} < 0.001$. Both the number of deviations outside the GS tolerance and the time outside the GS tolerance showed significant differences between the failed and passed groups, $\underline{F}$ (1, 161) = 31.69, $\underline{p} < 0.001$, and $\underline{F}$ (1, 161) = 42.39, $\underline{p} < 0.001$, respectively. Pilots who failed strayed more often outside the tolerance and spent more time there than pilots who passed the maneuver element. The mean time to exceed tolerance did not differ significantly between the groups.

The results were nearly identical for the localizer tracking performance (CDI). Pilots who passed this element of the ILS approach exhibited significantly smaller variance and RMSE scores in their tracking, F (1, 161) = 48.92, $p < 0.001$, and F (1, 161) = 42.89, $p < 0.001$, respectively. Similarly, both the number of deviations outside the CDI tolerance and the percent cumulative time outside tolerance were significantly smaller for the pilots who passed than for those who failed, F (1, 161) = 48.27, $p < 0.001$, and F (1, 161) = 27.1, $p < 0.001$, respectively. The groups did not differ in terms of time to exceed the tolerance. In summary, these results show a remarkably high correlation between the CFI scores and the performance measures derived from the FDR data.

The Effect of Sampling Rate on Measure Accuracy

In order to investigate the effect of sampling rate on the FDR measure accuracy, one IPC flight was arbitrarily selected and the data (originally collected at 1Hz) was manipulated to simulate a 0.067 Hz sampling rate. Because it was not possible to determine what the data might have been like if it had been collected at the lower rate, all possible outcomes were analyzed. Thus, the measurement value based on the 1 Hz sampling rate was compared to 15 other values, representing the 15 possible outcomes of a lower sampling rate (i.e., once every 15 seconds).

Figure 3 depicts altitude SD measures for each applicable maneuver. The solid white circle represents the measure based on 1 Hz sampling rate. Each black diamond shows a measure based on data sampled at 0.067 Hz, or once every 15 seconds. The 15 values represent all possible outcomes should the lower sampling rate be used.

Similar results were found for the other measures and flight parameters. Figure 4 shows the results for rate of climb RMSE. The use of the 0.067 sampling rate introduced a substantial degree of uncertainty to the measures and consequently reduced their reliability and usefulness. It is also noteworthy that the measures in Figures 3 and 4 are from segments that involved level flight. Maneuvers where the aircraft's state may change rapidly present further challenges to the FDR-derived measures .

Based on the analyses of each measure from each maneuver of the sample IPC flight data, if FDR data are used to derive measures on pilot performance, the highest possible sampling rate should be used. Any reduction in sampling rate degrades the quality and reliability of subsequent measures by potentially missing deviations or extreme values of the parameter recorded. The resulting measure may indicate better than true performance by missing extreme values, or worse that true performance by missing values that were within tolerances or close to criteria.

DISCUSSION

This study has clearly demonstrated the benefit of recency of experience training in maintaining instrument currency for instrument rated pilots. A comparison of the three training groups with the control group performance on the final instrument proficiency check indicated that the training groups performed significantly better than the control group. The study also indicated that PCATDs are effective in maintaining recency of experience for instrument rated pilots over a period of six months. The two

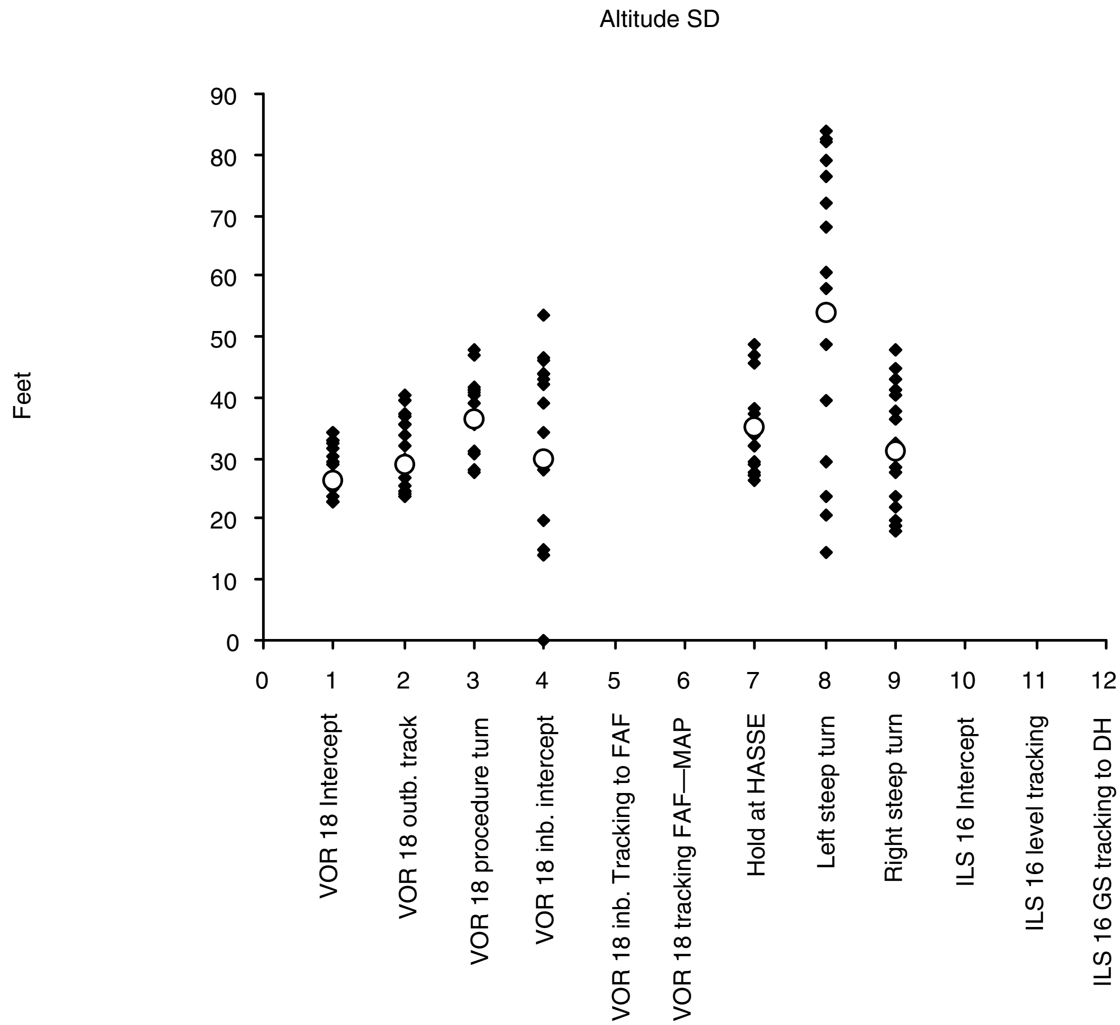

Figure 3. A comparison of altitude SD measures sampled at 1 Hz and 0.067 Hz for the 15 possible cases. Solid white circles represent the measure obtained from the 1Hz rate and black diamonds for each of possible outcomes using the 0067-sampling rate.

recency of experience practice sessions resulted in significantly better performance for the PCATD group on an IPC than the control group, which had no practice. Practice in either the PCATD or the FTD resulted in higher pass rates compared to no practice by the control group and practice in the PCATD and the FTD was found to be at least as effective as practice in the airplane. Finally, the performance of the PCATD group was statistically indistinguishable from the FTD group. These findings present compelling evidence that the FAA should permit the use of PCATDs to maintain recency of experience for instrument pilots.

A comparison of the pass/fail rates for IPC #1 and IPC #2 indicated that the performance on the baseline IPC was the best predictor of performance on the final IPC. Seventy-five percent of the subjects who passed IPC #1 also passed IPC #2 and 66 percent of the subjects who failed IPC #1 also failed IPC #2. Regardless of the intervening training during the six-month currency period 70 percent of the subjects either passed both tests or failed both tests. Thirty percent of the subjects passed IPC #1 and failed IPC #2 or failed IPC #1 and passed IPC #2. A comparison of improvement and deterioration ratios indicated a trend of improvement for the FTD group and PCATD group that approached statistical significance. The control group showed a trend for deterioration that was not significant. These results support the earlier finding of the benefit of the PCATD and FTD in maintaining instrument proficiency and suggest that improvement may be possible for some pilots when these devices are used.

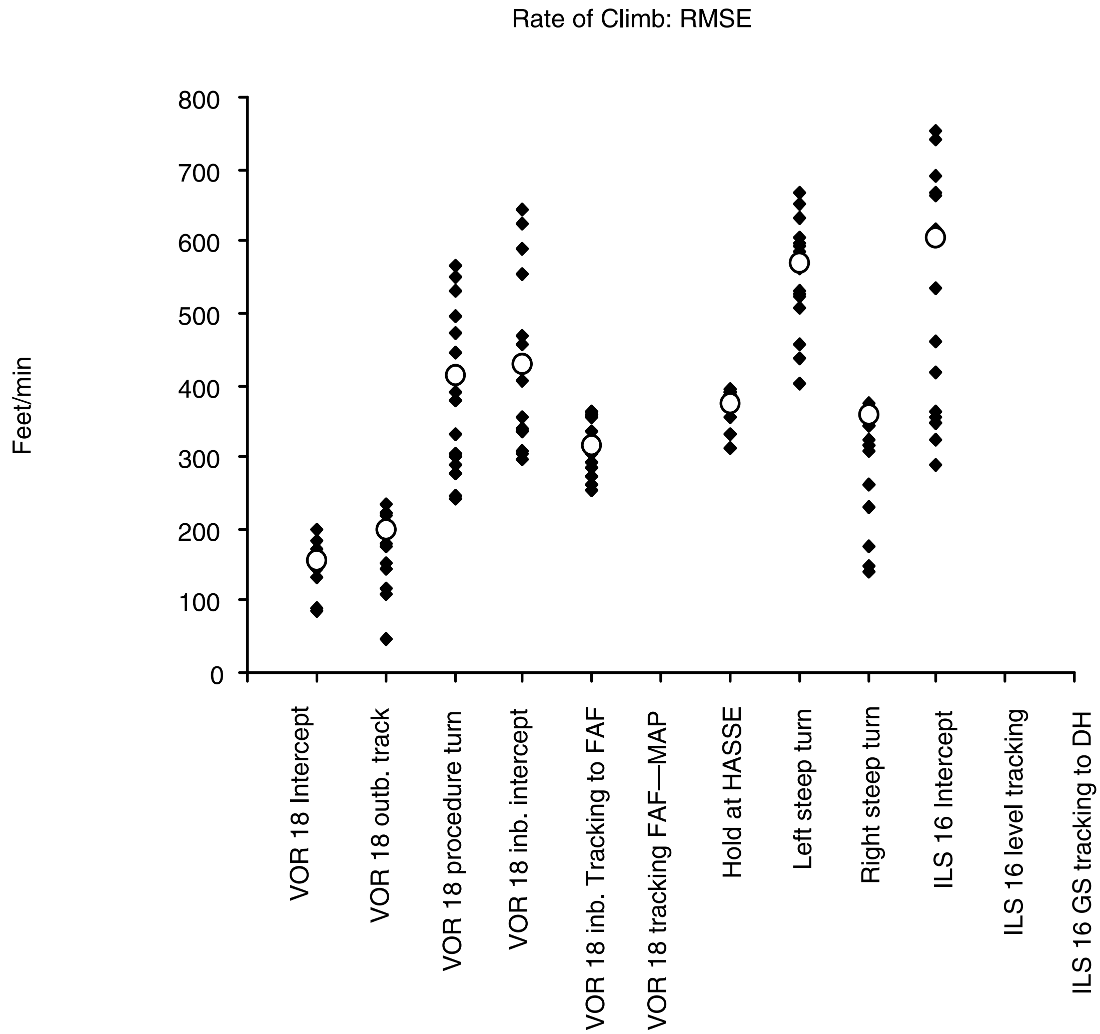

Figure 4 Rate of Climb RMSE measures based on full data (sampled at 1 Hz) and data sampled at 0.067 Hz for the 15 possible cases.

The study showed that only 42 percent of instrument current pilots passed the initial IPC in the airplane. Forty-four percent of subjects who were current (recency of experience level 1) passed IPC #1. Sixty percent of the subjects who met the recency of experience requirements in an FTD to regain their currency passed IPC #1. However, only 37 percent of the subjects who regained their currency by passing an IPC in the FTD passed the IPC in the aircraft. These findings raise questions concerning the relationship between instrument currency and instrument proficiency. While all subjects were instrument current, less than half of the subject population was able to demonstrate instrument proficiency in an IPC in the airplane. IPC #1 was performed before the most recent changes in Practical Test Standards (PTS). The new standards provide for a standardized PTS and add a partial panel non-precision approach such as a VOR approach that likely increases the difficulty of IPC flights. Some of the failures may be related to a lack of familiarity with the airplane, since few of the subjects had flown a Beech Sundowner prior to the study. In addition, most of those tested had not taken an IPC after the test was standardized to include required maneuvers. For example, the results indicated that many subjects had difficulty with the ILS approach. Current recency requirements require six approaches, but do not specify that any must be a precision approach. This suggests the need for the FAA to consider changing the recency of experience requirements for instrument currency. An alternative approach would be to require a periodic IPC to demonstrate instrument proficiency in addition to the current currency requirements.

As expected, the Control group's performance showed a trend of deterioration after a six-month absence of instrument practice. The finding supports the FAA regulations that require currency requirements to be met within a six-month period. The performance of the subjects who regained currency by passing an IPC in a FTD (recency of experience level 3) raises a different question. Only 37 percent of the subjects who pass an IPC in a FTD were able to subsequently pass the initial IPC in the airplane. This calls into doubt the effectiveness of a FTD as a viable platform to administer an IPC. It should be noted that all subjects in this category were more than one year out of currency. All retraining was done in an FTD. We recommend that the FAA sponsor a study specifically designed to test the effectiveness of both FTDs and PCATDs for administering the IPC. This study should include instrument pilots from all three currency groups.

Analysis of the individual maneuvers performed during IPC#2 showed that the PCATD was more effective than either the Aircraft or the FTD in terms of the number of maneuvers that were scored as passes by the checkpilot. One question concerns why the PCATD is more effective for individual maneuver performance when FTD group showed a larger improvement ratio for subject passes on IPC#2 than the PCATD group. This effect could result if a larger proportion of FTD subjects improved on enough maneuvers in order to pass IPC#2 after failing IPC#1, while a smaller proportion of PCATD subjects improved enough to pass IPC#2, but at the same time, showed improvement on more individual maneuvers than the FTD subjects. In this instance, the training effectiveness of the PCATD would be found to be higher than that of the FTD when considering individual maneuvers.

The effectiveness of the PCATD for training specific maneuver elements (i.e., altitude control, airspeed control, navigation procedures, etc.) was observed by comparing performance on subsets of maneuver elements between the experimental groups. A significant improvement for the FTD group on procedural elements on the hold relative to the Aircraft and Control group was found which is similar to the findings of Homan and Williams (1997) as well as Taylor and Stokes (1986), and Taylor (1985). The PCATD group showed a significant improvement on control elements for the ILS approach. This result appears to contradict the finding by Dennis and Harris (1998), that inferred that the PCATD was not effective for practicing psychomotor skills. However, it is well accepted that instrument flight tasks may require differing levels of psychomotor skills than the visual tasks such as those examined by Dennis and Harris (1998).

The effect of pilot experience as an explanation for observed variability in data has been reviewed by Taylor (1985) and Taylor and Stokes (1986). The subjects in the present study had a wide range of piloting experience which could potentially affect piloting performance. A biographical questionnaire was completed on each subject so that demographic data could be incorporated into the analysis. No significant difference for any demographic factors between groups were found, thus the effect of pilot experience was balanced across all groups.

The delay in completing the IPC#2 flight following the six-month period was evaluated as a potential source of variance in the IPC#2 results. Although a delay was experienced for some subjects from each experimental group, the results indicate that the differences between groups were not significant.

One last concern was that an extra maneuver flown in IPC#2 (partial-panel VOR approach) may have influenced the overall pass/fail judgments. The extra maneuver was added because of a change in regulations concerning the required IPC maneuvers. This change occurred after about 40% of the subjects had completed IPC#1. None of the subjects had completed IPC#2 at the point when the additional maneuver was added. In an effort to minimize the impact of an added maneuver, the extra approach was added to the end of the IPC flight so that no learning effect could contribute to the performance of the other maneuvers. Thirty-three subjects of 106 failed the partial-panel approach. Chi-square analysis showed that these failures were distributed equally among the four groups. Additional analysis of the maneuvers indicated that only 2 of the 33 partial-panel approach failures were only due to a failure of the partial-panel approach. The other 31 subjects also failed at least one additional maneuver. Therefore, the addition of partial panel approach to IPC#2 is unlikely to have changed the overall pass/fail outcome that was observed for each group.

RECOMMENDATIONS

Recommendations for Rulemaking

1. We recommend that the FAA permit the use of approved PCATD to meet recency of experience requirements.
2. We recommend that the FAA consider changing recency of experience requirements for instrument currency.

Recommendations for Further Research

1. We recommend that the FAA sponsor a study specifically designed to test the effectiveness of both FTDs and PCATDs for administering the IPC. The study should include instrument pilots from all three currency groups.
2. We recommend that the FAA sponsor a study to evaluate the flight data recorder measures for sensitivity in determining differences between pilots at different performance levels. Algorithms for additional measures should be developed based on the analyses of the IPC flight data. Factor analysis methods should be used to reduce the number of measures and to retain those of highest predictive power.
3. We recommend that the FAA sponsor a study to evaluate performance differences between pilots in the four experimental groups using FDR measures. The evaluation should be by both segment/maneuver and type of control (e.g., altitude, course tracking). This examination would potentially allow detection of very subtle differences in pilot performance that can conceivably be traced to the type of training device used in the experiment in contrast with the pass/fail performance assessment by the check pilots.

SUMMARY

This study has clearly demonstrated the benefit of recency of experience training in maintaining instrument currency for instrument rated pilots. A comparison of the three training groups with the control group performance on the final instrument proficiency check indicated that the training groups performed significantly better than the control group. The two recency of experience practice sessions resulted in significantly better performance for the PCATD group on an IPC than the control group, which had no practice. Practice in either the PCATD or the FTD resulted in higher pass rates compared to no practice by the control group and practice in the PCATD and the FTD was found to be at least as effective as practice in the airplane. Finally, the performance of the PCATD group was statistically indistinguishable from the FTD group. This finding presents compelling evidence that the FAA should permit the use of PCATDs to maintain recency of experience for instrument pilots.

A comparison of the pass/fail rates for IPC #1 and IPC #2 indicated that the performance on the baseline IPC was the best predictor of performance on the final IPC. Seventy-five percent of the subjects who passed IPC #1 also passed IPC #2 and 66 percent of the subjects who failed IPC #1 also failed IPC #2. Regardless of the intervening training during the six-month currency period 70 percent of the subjects either passed both tests or failed both tests.

Thirty percent of the subjects passed IPC #1 and failed IPC #2 or failed IPC #1 and passed IPC #2. A comparison of improvement and deterioration ratios indicated a trend of improvement for the FTD group and PCATD group which approached statistical significance. The control group showed a trend for deterioration which was not significant. These results support the earlier finding of the benefit of the PCATD and FTD in maintaining instrument proficiency and suggest that improvement may be possible for some pilots when these devices are used.

The study showed that only 42 percent of instrument current pilots passed the initial IPC in the airplane. This finding raises questions concerning the relationship between instrument currency and instrument proficiency. While all subjects were instrument current, less than half of the subject population was able to demonstrate instrument proficiency in an IPC in the airplane. The results indicated that many subjects had difficulty with the ILS approach. Current recency requirements require six approaches, but do not specify that any must be a precision approach. This suggests the need for the FAA to consider changing the recency of experience requirements for instrument currency. An alternative approach would be to require a periodic IPC to demonstrate instrument proficiency in addition to the current currency requirements.

As expected, the Control group's performance showed a trend of deterioration after a six-month absence of instrument practice. The finding supports the FAA regulations that require currency requirements to be met within a six-month period. Only 37 percent of the subjects who pass an IPC in a FTD were able to subsequently pass the initial IPC in the airplane. This calls into doubt the effectiveness of a FTD as a viable platform to administer an IPC. It should be noted that all subjects in this category were more than one year out of currency. All retraining was done in an FTD. We recommend that the FAA sponsor a study specifically designed to test the effectiveness of both FTDs and PCATDs for administering IPC. This study should include instrument pilots from all three currency groups.

The FAA should address the adequacy of the six-month instrument recency of experience requirements. Alternative method of performance measurement such as automated airborne performance measurement should be experimented with and compared to the current method which incorporates subjective evaluations. In using a flight data recorder, the highest possible sampling rate should be used. Finally, since we have established the effectiveness of a PCATD for meeting the instrument currency requirement, follow-on research should investigate the efficacy of PCATDs for administering IPC flights.

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APPENDIX A:
REPORTS AND PRESENTATIONS DURING THE CONTRACT

Semi-Annual Reports

1. Bradshaw, G., Taylor, H., Talleur, D., Emanuel, T., Hulin, C., Lendrum, L. & Vaughn, J. (1999). Determining the effectiveness of a personal computer aviation training device (PCATD) to meet recency of experience requirement. Semi-Annual Report, Jan. 8, 1999 – July 7, 1999.
2. Bradshaw, G., Taylor, H., Rantanen, E., Talleur, D., Emanuel, T., Hulin, C. & Lendrum, L. (2000). Determining the effectiveness of a personal computer aviation training device (PCATD) to meet recency of experience requirement. Semi-Annual Report, July 8, 1999 – Jan. 7, 2000.
3. Bradshaw, G., Taylor, H., Rantanen, E., Talleur, D., Emanuel, T., Lendrum, L., & Hulin, C. (2000) Determining the effectiveness of a personal computer aviation training device (PCATD) to meet recency of experience requirement. Semi-Annual Report, Jan. 8, 2000 – July 7, 2000.
4. Bradshaw, G., Taylor, H., Rantanen, E., Talleur, D., Emanuel, T., Lendrum, L., & Hulin, C. (2001) Determining the effectiveness of a personal computer aviation training device (PCATD) to meet recency of experience requirement. Semi-Annual Report, July 8, 2000 – Jan. 7, 2001.

Published Reports

1. Lendrum, L., Taylor, H.L., Talleur, D.A., Hulin, C.L., Bradshaw, G.L. & Emanuel, T.W., Jr. (1999). Airborne flight data recorders. Jensen, R. S., Cox, B., Callister, J. D., & Lavis R., editors. *Proceedings of the Tenth International Symposium of Aviation Psychology*. Volume 2, 1003 –1007. Columbus, OH: The Ohio State University.
2. Lendrum, L., Taylor, H.L., Talleur, D.A., Hulin, C.L., Bradshaw, G.L. & Emanuel, T.W., Jr. (2000). *PC data logger (a flight data recorder): Operation manual*. (Technical Report ARL-00-8/FAA-00-5). Savoy, IL: University of Illinois at Urbana-Champaign, Institute of Aviation, Aviation Research Lab.
3. Talleur, D.A., Taylor, H.L., Bradshaw, G.L., Emanuel, T.W., Jr., Hulin, C.L., Rantanen, E., & Lendrum, L. (2000). Effectiveness of personal computer aviation training devices to meet recency of experience requirement. University Aviation Association Fall Education Conference. Mesa, AZ (Abstract).
4. Talleur, D.A., Taylor, H.L., Bradshaw, G.L., Emanuel, T.W., Jr., Rantanen, E.M., Lendrum, L. & Hulin, C.L. Effectiveness of a personal computer aviation training device (PCATD) for maintaining instrument currency. *The Eleventh International Symposium on Aviation Psychology*. Columbus: The Ohio State University.
5. Taylor, H.L., Bradshaw, G.L., Talleur, D.A., Emanuel, T.W., Jr., Hulin, C.L., Lendrum, L. & Vaughan, J. (1999). Effectiveness of personal computers to meet recency of experience requirements. In R.S. Jensen, B. Cox., J.D. Callister & R. Lavis (Eds.), *Proceedings of the Tenth International Symposium on Aviation Psychology*, Volume 2, 1008 – 1013, Columbus, OH. The Ohio State University.
6. Taylor, H.L., Talleur, D.A., Bradshaw, G.L., Emanuel, T.W., Jr., Hulin, C.L., Rantanen, E.M., & Lendrum, L. (2000). *Evaluation of a personal computer aviation device to meet recency of experience requirements* (Technical Report ARL-00-9/FAA-00-6). Savoy, IL: University of Illinois at Urbana-Champaign, Institute of Aviation, Aviation Research Lab.

Presentations

1. Lendrum, L. Taylor, H.L., Talleur, D.A., Hulin, C.L., Bradshaw, G.L., and Emanuel, T.W., Jr. (1999). Airborne Flight Data Recorder, *Tenth International Symposium on Aviation Psychology*. Columbus, OH: The Ohio State University.
2. Talleur, D.A., Taylor, H.L., Bradshaw, G.L., Emanuel, T.W., Jr., Rantanen, E. M., Lendrum, L. & Hulin, C.L. Effectiveness of a personal computer aviation training device (PCATD) for maintaining instrument currency. *The Eleventh International Symposium on Aviation Psychology*. Columbus: The Ohio State University.
3. Taylor, H.L., Bradshaw, G.L., Talleur, D.A., Emanuel, T.W., Jr., Hulin, C.L., Lendrum, L. and Vaughan, J.A. (1999). Effectiveness of Personal Computers to Meet Recency of Experience Requirements. Tenth International Symposium on Aviation Psychology, Columbus, OH.
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5. Taylor, H.L. Evaluation of a Personal Computer Aviation Training Device to Meet Recency of Experience Requirements, 2000, NAFI/ERAU Symposium 2000, EAA Aviation Center, Oshkosh, WI, July 23, 2000.
6. Taylor, H.L. (2000). Effectiveness of Personal Computer Aviation Training Devices to Meet Recency of Experience Requirements. Research Roundtable, University Aviation Association, Fall Education Conference, October 28, 2000, Mesa, AZ.

APPENDIX B: BIOGRAPHICAL QUESTIONNAIRE

Flight Experience and Biographical Data Questionnaire

We expect that the pilots involved in this project will have widely varying flight experience. To help us interpret the results of our study, we need to have some background information about your flying experience, and so ask you to fill out this questionnaire and return it to us in the pre-paid envelope.

Your answers will help us classify the experience level of the participants in this experiment. All answers will be confidential: We will code your answers using only an arbitrary reference number assigned to each participant. The data will not be linked to your name in any way.

Please Print Your Responses

Name:__________________________ Date:____________ Ref # (   )

Age: ☐ Native Language: ☐
(language you learned to speak first)

Check the Flight Certificates and Rating you hold and indicate year earned (if available):

Year Earned:	Certificates/Ratings: (or Military Equivalent)
______	☐ Private Pilot Single Engine Land/Sea
______	☐ Private Pilot Multiengine Land/Sea
______	☐ Instrument Rating Single Engine
______	☐ Instrument Rating Multiengine
______	☐ Commercial Pilot Single Engine Land/Sea
______	☐ Commercial Pilot Multiengine Land/Sea
______	☐ Airline Transport Pilot Single Engine or Multiengine
______	☐ Certified Flight Instructor Single Engine
______	☐ Certified Flight Instructor Instrument Single Engine
______	☐ Multiengine Flight Instructor
______	☐ Multiengine Flight Instructor Instrument
______	☐ Military Flight Instructor (list qualifications below)
______	☐ Other Certificates or ratings:
______	_________________________
______	_________________________
______	_________________________

Please list any Type Ratings you have:

____

____

____

Please fill in the approximate amount of aircraft flight time you have: (This includes Helicopter Time)

1) Total Flight Time:

2) Total Simulated Instrument Time (Hood time) :

3) Total Actual Instrument Time (IMC conditions):

4) Total Ground Trainer/Simulator Time:

5) Total Personal Computer Aviation Training Device (PCATD) Time :

6) Total Dual Instruction Given (if you're a CFI) :

7) Total Dual Instruction Received:

8) Total Single Engine Airplane Time:

9) Total Multiengine Airplane Time :

10) Total Night Flight Time :

11) Total Cross Country Time :

12) Total Turbojet Time :

13) Total Turboprop Time :

14) What Type of Airplane Do You Usually Fly:
(Circle one choice from each column)

Engine:	Gear:	Horsepower:
1. Single	1. Fixed	1. Less than 200
2. Multi	2. Retractable	2. 200 or more

15) Total Recent Aircraft Flight Time:

Last 90 days	Last 6 months	Last 12 months

16) Instrument Currency:

a) Are you Instrument Current? Circle one: YES NO
b) If not, when were you last instrument current? (Date) ____________
c) How many Instrument Approaches have you flown in the last 6 months? _____
d) How many Holding Patterns have you flown in the last 6 months?_____
e) When did you last receive an Instrument Proficiency Check flight to renew your Instrument Currency? (Date) ____________

17) Do you have a current Flight Review (BFR)?
Circle one: YES NO

18) If you have military flight experience, please indicate types of aircraft flown here:

____________________	____________________	____________________
____________________	____________________	____________________
____________________	____________________	____________________
____________________	____________________	____________________

19) What is the main reason that you fly aircraft? Circle one:

a. For Fun
b. Commercially (Airlines, Charter, Corporate)
c. Military
d. Travel Related to my Job
e. Other (please fill in)_____________________

20) What type of flying do you normally engage in? Circle one:

a. local (within 50 miles of homebase airport)
b. Cross-Country of 50-200 miles
c. Cross-Country of 201-500 miles
d. Cross-Country of 1000 miles or greater
e. Other (please fill in)______________________

APPENDIX C: CURRENCY TRAINING SESSION

Currency Training Session:

Instructor______________________ **Date**___________ **Subject Number**___________

This form should be used to log the completion of the subject's required approaches/hold to meet the currency requirements of FAR part 61. Regardless of each subject's currency status, please have them perform six approaches, holding procedures and intercepting and tracking courses through the use of navigation systems. Please indicate the maneuvers flown to meet this requirement. Approaches may be flown with choice of procedure-turn or radar vectors. The subject may be pre-positioned for any or all of the approaches and hold. Assure that the subject is still eligible to achieve currency by simply doing six approaches and holding procedures. If they are not, you must start the session using the "Prescreening" form.

Date that subject was last current ______________ (Assure that they are still within one year of currency for this session)

Approaches:

1)____________________________________

2)____________________________________

3)____________________________________

4)____________________________________

5)____________________________________

6)____________________________________

Acceptable Approaches:

CMI: VOR 22R, VOR 4L, VOR18,
ILS 32L, LC BC 14R
C16: VOR-A, VOR-B
2K0: VOR-A
2I5: VOR 27

Hold:

1)____________________________________

Acceptable Holds:

OCTOE, EMTEE, LODGE,
BEMEN, FRAKA

Time flown in the Frasca to complete the above training ________

APPENDIX D: PRESCREENING SESSION

<u>Frasca Prescreening Session</u>

Subject Number_________________

Instructor__________________________

Date___________

(A) The scenario below will be followed in order to assess the participant's instrument proficiency. It is possible that a participant will complete the assigned maneuvers successfully within 30-40 minutes. In this case, if you believe the participant will be able to pass an IPC in the Frasca without future sessions, instruct them to perform the remaining maneuvers **(B)** that will result in completing an IPC. Section (B) must be completed in order to give an IPC sign-off. Otherwise, if you believe the participant needs additional training, use section **(C)**.

<u>Maneuver:</u>	**<u>Completed Satisfactorily</u>:**
Takeoff & Climb to 3000 ft	________
Straight & Level	________
Standard Rate turns	________
Pattern B Climb and Descents Profile (see attached)	________
ILS 32L Approach Via Radar Vectors	________

If the above maneuvers were performed satisfactorily, assign the participant to complete, at a minimum, the maneuvers in Section (B) to your satisfaction in order to receive an IPC sign-off. You may ask the participant to perform other maneuvers or repeat maneuvers if you feel this will lead to the IPC sign-off. If the subject needs extra training to achieve proficiency, continue instructing the participant using section **(C)** to bring their performance up to a satisfactory level.

Section (B)

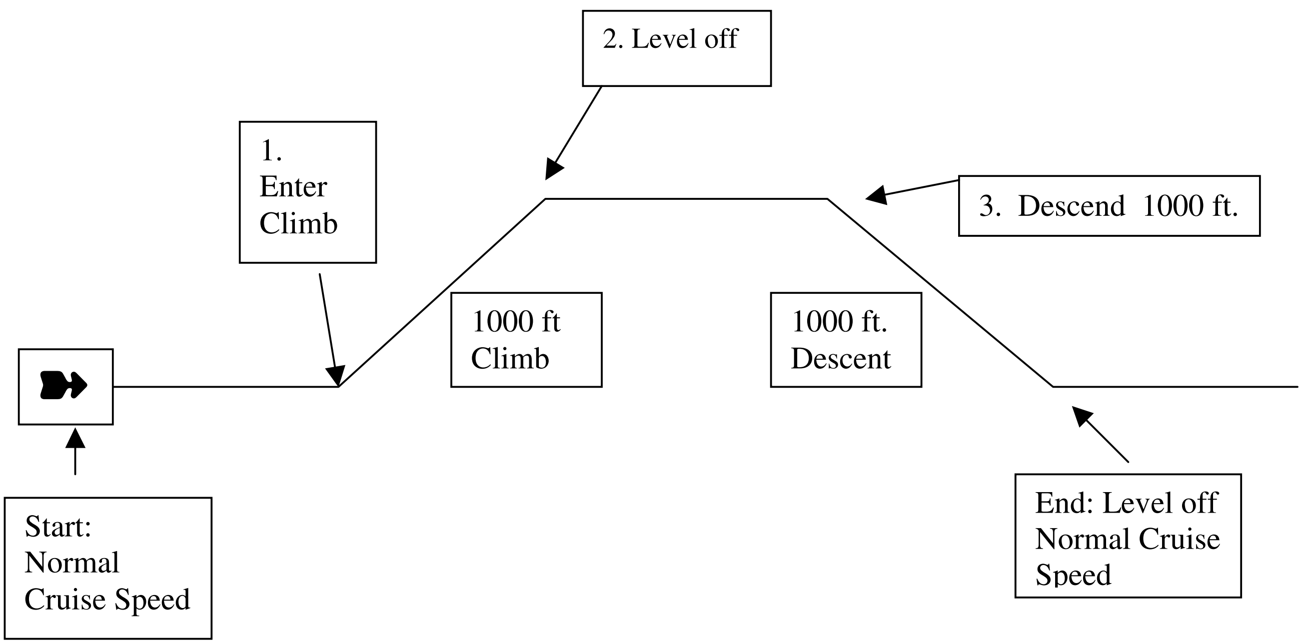
<u>Maneuver:</u>	**<u>Completed Satisfactorily</u>:**
VOR approach via PT	________
Hold at an Intersection	________
Partial Panel VOR approach	________
Recovery from Unusual Attitudes	________

<u>Statement of Currency at Completion of Prescreening Session:</u>

This participant has successfully completed an IPC (and has received a logbook endorsement) and is ready for the Oral and Aircraft Orientation: **YES** **NO**

Flight Time spent during Prescreening Session: ______
Flight Time spent during Proficiency Training Session(s): 1)_____2)_____3)_____

Pattern B



Section (C) Proficiency Training:

Subject______________________ Instructor__________________ Date_________

(C) This section is for participants who do not complete section **(A)** and **(B)** satisfactorily in the allotted time. The maneuvers below are recommended at this stage to prepare the participant to pass an IPC in the Frasca.

Maneuver:	**Completed Satisfactorily:**
For Review of Basic Attitude Skills:	
Pattern A (see attached)	_______
For Review of Procedural Skills:	
Partial Panel MTO VOR 6	_______
MTO VOR 24 via Procedure Turn	_______
MTO ILS 29 via Radar Vectors	_______
Hold at ARCOL intersection	_______
Partial Panel DNV VOR 21	_______
DNV VOR 3 via Procedure Turn	_______
DNV ILS 21 via Radar Vectors	_______
Hold at BUBLE intersection	_______

If participant is not ready to pass an IPC in the Frasca within the two-hour block of time, have them schedule another two-hour Proficiency Training session. Please list below any specific trouble area so that the next instructor will know what you've done and what areas to reemphasize.

APPENDIX E: ORAL/FAMILIARIZATION SESSION

Oral Discussion/ Aircraft Familiarization Session

Instructor______________________Date___________Subject Number________

Task:	Completed:
Participant has completed Oral Discussion	______
Participant has received an Aircraft Familiarization	______
Participant has received briefing on IPC flight Profile	______

Suggested Aircraft Familiarization Schedule:

A) Explanation of Controls and Throttle
B) General Instrument Layout
C) Radio Rack Layout and Operation
D) Location and Operation of Emergency Equipment
E) Fuel Management
F) Use of Safety Belts and Harness

APPENDIX F: ORAL/FAMILIARIZATION SESSION PROFILE BRIEFING

IPC #1 Flight Profile:

The following flight profile will be flown on the IPC #1 flight. There will be minimal time to review the profile during the session in which it is scheduled to be flown. Feel free to review the attached charts in preparing yourself for this flight. The flight will be executed in the exact order listed below.

Profile:

1) Depart CMI (Champaign's Willard Airport) VFR or with a clearance to fly to VFR conditions

2) A short amount of time will be spent going over the basic performance characteristics of the aircraft; you need not prepare yourself for this part.

3) An IFR clearance will be obtained to do the following:

   a) VOR 18 at DEC (Decatur) via the CMI 253 radial to TRACS Intersection. This approach will be flown via Procedure Turn.

   b) Modified Missed Approach procedure to HASSE Intersection. You will be asked to hold there for 3 turns in the hold.

   c) Steep Turns and Unusual Attitude recovery will be performed.

   d) ILS 6 at DEC via Radar Vectors

   e) Miss and return to CMI via Radar Vectors to within 2 miles of CMI. At that point the Instructor will take over and finish the flight.

APPENDIX G: IPC#1 SCORE CARD

IPC 1

Instructor______________________ Date___________Subject Number________

Data logger File Name:__________________

VFR Flight Familiarization Schedule:

It is reasonable to assume that most of the participants do not have experience flying the Sundowner. The following schedule of maneuvers is designed to provide some operating experience with the performance profiles of the aircraft. This portion of the 1st IPC flight should be carried out prior to any instrument work. It is recommended that this training be kept to a maximum of 15-20 minutes. Verbal or physical intervention is allowed during the VFR training. All maneuvers during the VFR training are to be performed in VFR conditions without a hood.

On taxi out:	**Completed:**
Instrument Check during taxi	______

Maneuvers:	**Completed:**
Takeoff	______
Cruise Climb	______
Level -off	______
Straight & Level	______
After reaching practice area:	
180° Std. Rate Turns	______
A/S Climb and Descent	______
Rate Climb and Descent	______
A/S and Rate Descent (Precision Profile)	______
A/S and Rate Descent (Non-Prec. Profile)	______

Once the above is completed, have the participant obtain an IFR clearance to proceed with the scheduled IPC flight.

Continue to next page to begin IPC scoring

Instructor_____________________ **Date**___________ **Subject Number**________ **IPC 1**

VOR Approach (DEC VOR 18)
Please test the VOR approach first during the flight of this flight. Check "yes" or "no" to indicate whether the subject's performance met the criteria.

Task	Yes	No
Tune, Ident VOR	_____	_____
Set Proper Course	_____	_____
Before Final Approach Segment:		
Altitude ±100 ft	_____	_____
Heading ±10°	_____	_____
Less Than Full-Scale CDI Deflection	_____	_____
Executes Proper Procedure Turn	_____	_____
Identifies FAF	_____	_____
Starts Time	_____	_____
On Final Approach:		
Less Than 3/4 Scale CDI Deflection	_____	_____
Airspeed +10 kts	_____	_____
Maintains MDA +100/-0 ft	_____	_____
Properly Identifies MAP	_____	_____
Meets Practical Test Standards	_____	_____

Marking Instructions:

Mark data at the beginning and end of each segment listed below:

1) Start of outbound tracking from TRACS through start of Procedure Turn
2) Start of Procedure turn through intercepting FAC inbound
3) Tracking inbound until arrival at TRACS
4) TRACS inbound to MAP

Instructor____________________ Date__________ Subject Number________ IPC 1

Holding Procedures (HASSE)
Please test the holding pattern second during the flight. Check "yes" or "no" to indicate whether the subject's performance met the criteria.

Holding Pattern Entry

Measure	Desired	Yes	No
Tune and Ident Proper Navaids		_____	_____
Recognizes Arrival at Holding Fix		_____	_____
Initiates Prompt Entry		_____	_____
Uses Recommended Entry Procedure		_____	_____
Properly Reports Entry		_____	_____
From Initial Arrival at Holding Fix to Crossing Fix on 1st Inbound Leg			
Airspeed	$\pm$10 kts	_____	_____
Altitude	$\pm$100 ft	_____	_____
On Inbound Leg			
Maintains Desired Course	$\pm 10^{o}$	_____	_____
Applies Proper Timing		_____	_____

First Full Holding Pattern

Measure	Desired	Yes	No
On Outbound Leg:			
Maintains appropriate Wind Correction		_____	_____
Applies Proper Timing		_____	_____
On Inbound Leg:			
Maintains Desired Course	$\pm 10^{o}$	_____	_____
Throughout Pattern:			
Airspeed	$\pm$10 kts	_____	_____
Altitude	$\pm$100 ft	_____	_____

Second Full Holding Pattern

Measure	Desired	Yes	No
On Outbound Leg:			
Maintains appropriate Wind Correction		_____	_____
Applies Proper Timing		_____	_____
On Inbound Leg:			
Maintains Desired Course	$\pm 10^{o}$	_____	_____
Throughout Pattern:			
Airspeed	$\pm$10 kts	_____	_____
Altitude	$\pm$100 ft	_____	_____
Meets Practical Test Standards		_____	_____

Marking Instructions:
Mark arrival at HASSE and end of holds just prior to starting Steep Turns

Instructor_____________________ Date___________ Subject Number________ IPC 1

Steep Turns
Please test steep turns third during the flight; one 360° turn to the left and one 360° turn to the right. Check "yes" or "no" to indicate whether the performance met the criteria.

Measure	Desired	Yes	No
Left 360° Steep Turn			
At 90° Heading Change			
Altitude	±100 ft	______	______
Airspeed	±10 kts	______	______
Bank Angle	±5°	______	______
At 180° Heading Change			
Altitude	±100 ft	______	______
Airspeed	±10 kts	______	______
Bank Angle	±5°	______	______
At 270° Heading Change			
Altitude	±100 ft	______	______
Airspeed	±10 kts	______	______
Bank Angle	±5°	______	______
Rollout at Starting Heading			
Heading	±10°	______	______
Altitude	±100 ft	______	______
Airspeed	±10 kts	______	______
Right 360° Steep Turn			
At 90° Heading Change			
Altitude	±100 ft	______	______
Airspeed	±10 kts	______	______
Bank Angle	±5°	______	______
At 180° Heading Change			
Altitude	±100 ft	______	______
Airspeed	±10 kts	______	______
Bank Angle	±5°	______	______
At 270° Heading Change			
Altitude	±100 ft	______	______
Airspeed	±10 kts	______	______
Bank Angle	±5°	______	______
Rollout at Starting Heading			
Heading	±10°	______	______
Altitude	±100 ft	______	______
Airspeed	±10 kts	______	______
Meets Practical Test Standards		______	______

Marking Instructions:
Mark beginning of Steep Turns and end just prior to unusual attitude recovery

Instructor_____________________ **Date**___________ **Subject Number**________ **IPC 1**

Unusual Attitude Recovery

Please test one unusual attitude recovery immediately after the steep turns. Check "yes" or "no to indicate whether the subject's performance met the criteria.

Task	Yes	No
Applies appropriate **Bank, Pitch** and **Power** in a timely fashion during recovery.	_____	_____

Marking Instructions:

Mark Beginning and end of maneuver

ILS Approach (DEC ILS 6)

Please test the ILS approach last during the flight. Check "yes" or "no" to indicate whether the subject's performance met the criteria.

Task	Yes	No
Tune, Ident Localizer	_____	_____
Before Final Approach Segment:		
Altitude $\pm$100 ft	_____	_____
Heading $\pm 10^{o}$	_____	_____
Less Than Full-Scale CDI Deflection	_____	_____
Properly Intercepts Glide Slope	_____	_____
Starts Time	_____	_____
On Final Approach:		
Less Than 3/4 Scale CDI Deflection	_____	_____
Less Than 3/4 Scale Glide Slope Deflection	_____	_____
Airspeed $\pm$10 kts	_____	_____
Properly Identifies MAP	_____	_____
Meets Practical Test Standards	_____	_____

Marking Instructions:

1) Interception of FAC until reaching ELWIN
2) ELWIN until DH

ATC Procedures/ Communications

Please monitor the subject's ATC procedures and communications throughout the flight. Check "yes" or "no to indicate whether the subject's performance met the criteria.

Task	Yes	No
Subject used appropriate ATC procedures and Communications during the flight	_____	_____

Would you give this participant an IPC sign-off based on the performance of the above maneuvers?

YES **NO** (Circle one)

Please indicate the Hobbs time logged on this flight _______

APPENDIX H: IPC CHECK PILOT STANDARDIZATION DOCUMENT

IPC Check Pilot Standardization: IPC signoff guidelines

Below are some basic guidelines to assist you in making a decision to give a subject an IPC signoff. These rules are not meant to supercede PTS guidelines, but rather supplement them since we are not strictly required to follow PTS standards in determining whether a pilot should be singed off:

General- Overall Performance

1) Most scored maneuvers have tasks that specify fairly concrete parameters (such as +/- 100 ft, etc.) These task elements should be scored objectively in the sense that the subject's performance either falls within the stated limits or it does not. No subjective decision or rational should be applied to these scores.

2) At the end of each maneuver you are asked to indicate whether the maneuver, on the whole, meets PTS standards. Remember that this judgement allows for the standards to be exceeded as long a) as they are not consistently exceeded and b) a prompt and correct action is taken by the subject to recover from the error.

3) The last "scoring" item is if you feel the subject's performance deserves an IPC signoff. This is the most subjective decision that you will make during the session. Remember to make your decision by referencing what is safe, legally allowable, and accepted practice in terms of performance. Also use the guidelines below to help determine how closely the PTS should be followed when making an IPC signoff decision.

4) In terms of overall performance, there are a few areas that are immediately disqualifying:

a) failure to realize a missed approach is needed (due to full scale deflection of CDI inside of FAF, etc.)

b) inability to communicate on the radios; however, a subject may miss a few radio calls due to unfamiliarity with the call sign. You may prompt them that they've missed a call. At that point they should be able to handle the call without assistance. Incorrect readbacks to ATC followed by correct action on the pilot's part should not immediately disqualify them. Making these types of errors **consistently** is grounds for disqualification. Non-compliance with an ATC clearance or request will be disqualifying if the error would clearly lead to a possible violation or put flight safety at risk.

c) consistent busting of altitudes, MDA, or leveloff is disqualifying; however, infrequent deviations from PTS is allowed in all areas as long as timely corrections are made.

d) failure to identify the MAP within safe limits: this means within the context of the approach being flown and surrounding terrain or obstructions.

5) A statement from the pilot indicating reasons for doing a maneuver, or part of a maneuver, in a manner different from what we normally expect is acceptable as long as there is no legal or safety issue. Do not confuse technique with ability to perform a maneuver safely within legal limits.

6) Leeway should be given if unusual environmental circumstance exist: i.e., turbulence, high winds, windshear. It should be clear that most pilots will not venture into certain weather conditions while solo. However, with us onboard, they may agree to fly in conditions that are beyond their ability. Every effort should be made to determine if the pilot is comfortable with the weather conditions. In general if you are doubtful about the "average" pilot's ability to handle the current weather, you should have the session rescheduled. If you would not do a training flight with an AVI 130 in the current conditions, you should seriously consider whether you want to do it with our subjects.

VOR Approach

1) Pilot must perform some sort of procedure turn (PT) on the barbed PT side of the FAC.
2) Pilot must make a decent from FAF to MDA in order to arrive at the MDA by the time they reach the MAP. Being higher than necessary crossing FAF is not immediately disqualifying unless they fail to descend **safely.** They must be in control of whatever descent they perform.
3) Timing from FAF to MAP is not required if they are using an alternate means to identify MAP.
4) Deviations below MDA exceeding 20 ft (but not to exceed 50 ft) are allowed as long as prompt action is taken by the pilot to return to MDA.
5) Deviations above MDA are allowed and not limited to a specific altitude; however, if they exceed 100 ft they should have a reason for doing so.
6) Deviations beyond ¾ scale CDI deflection are allowed at anytime along the FAC as long as the error is infrequent and the pilot sees the need, and applies, a correction appropriate to the deviation.

Holding Pattern

Note: The altitude at which we hold is usually part of a block altitude clearance. The pilot may be unfamiliar with this, so you should tell them what altitude they are expected to maintain.

1) Pilot must stay in protected airspace at all times. Remember that this is a large area around the holding fix.
2) Pilot must be able to enter the hold in some manner consistent with staying in protected airspace. Remember that the standard holding entry procedures are recommended and are not regulatory.
3) Pilot may identify the fix either by DME or crossing radials as charted.
4) Pilot should know where they are at relative to the holding fix at all times.
5) Accurate timing is not a requirement as along as a complete lack of timing does not lead to disorientation in the pattern or would lead to busting protected airspace.
6) Corrections to return to the inbound course (if off -course) so as to be within full scale CDI deflection prior to crossing over the holding fix is required. However, the pilot should not consistently need to correct from full scale deflection on each inbound leg.
7) Altitude deviations from PTS are allowed as long as they are infrequent and the pilot makes corrections to return to the desired altitude.

Steep Turn

1) Deviations from altitude and airspeed are allowed but prompt correction should be made if an error does occur.
2) Pilot must be able to rollout from turn and be restabilized in straight and level flight within 10-15 sec.
3) Pilot must be in control of the aircraft with no serious doubt about the outcome of the maneuver.

Unusual Attitude

1) Deviation from the standard recovery procedure (order) is allowed as long as the pilot is in control of the aircraft and a return to steady state is accomplished in a timely manner.

ILS Approach

1) Pilot should be able to intercept course from ATC vector and become established inbound prior to reaching FAF.
2) Once established, full scale deflection is allowed outside of the FAF only if the pilot realizes the error and is in the process of correcting.
3) Proper glideslope interception is at the Initial Approach Altitude (IAA) as charted, however, the pilot may intercept the glideslope form any altitude above IAA and track it to the FAF.
4) If the glideslope is full scale at FAF the maneuver is failed and the pilot should indicate the need to execute a missed approach.

5) During Final descent on the glideslope, the pilot needs to stay within full scale deflection at all times while tracking both the localizer and glideslope. Consistent deviations to ¾ scale (or beyond) is disqualifying.
6) The pilot needs to recognize the need to look up and then execute a miss upon reaching the DH.
7) Timing is not a requirement for the ILS

VOR Partial Panel Approach (IPC#2 only)

1) Pilot should be able to fly approach partial panel from established inbound on the FAC within 10 miles all the way to MAP or until you need to take over for the landing.
2) Pilot must make a decent from FAF to MDA in order to arrive at the MDA by the time they reach the MAP. Being higher than necessary crossing FAF is not immediately disqualifying unless they fail to descend **safely.** They must be in control of whatever descent they perform.
3) Timing from FAF to MAP is not required if they are using an alternate means to identify MAP.
4) Deviations below MDA exceeding 20 ft (but not to exceed 50 ft) are allowed as long as prompt action is taken by the pilot to return to MDA.
5) Deviations above MDA are allowed and not limited to a specific altitude; however, if they exceed 100 ft they should have a reason for doing so.
6) Deviations beyond ¾ scale CDI deflection are allowed at anytime along the FAC as long as the error is infrequent and the pilot sees the need, and applies, a correction appropriate to the deviation.

APPENDIX I: RECENCY OF EXPERIENCE SESSION #1

Recency of Experience Session #1

Instructor______________________ **Date**___________ **Subject Number**________

The following maneuvers should be flown during Recency of Experience Session #1. Do all maneuvers in the order listed. If circumstances beyond your control should arise and you need to deviate from the order or perform a maneuver other than those listed below, please make a note on this form.

Maneuver:	Completed:
DEC LOC BC 24 via UNITI transition	________
DEC VOR 36 via Radar Vectors	________
Miss to a Hold at MAROA Intersection	________
DEC VOR 18 via Holding pattern	________
Return via Radar Vectors to CMI	________

(Let subject fly with hood on)
(Instructor is to fly instrument approach if wx is IMC, otherwise, Instructor is to take over within two miles of CMI for landing.)

(If this training is completed in the Frasca or the PCATD, it is permissible to discontinue the flight within 2 mile of CMI VORTAC.)

Hobbs time flown to complete this session _________

APPENDIX J: RECENCY OF EXPERIENCE SESSION #2

Recency of Experience Session #2

Instructor_____________________ Date___________ Subject Number________

The following maneuvers should be flown during Recency of Experience Session #1. Do all maneuvers in the order listed. If circumstances beyond your control should arise and you need to deviate from the order or perform a maneuver other than those listed below, please make a note on this form.

Maneuver:	**Completed:**
DEC VOR 18 via Radar Vectors	________
Miss to a Hold at DEC VOR	________
DEC ILS 6 via Radar Vectors	________
Partial Panel DEC VOR 36 via Procedure Turn	________
Return via Radar Vectors to CMI	________

(Let subject fly with hood on)
(Instructor is to fly instrument approach if wx is IMC, otherwise, Instructor is to take over within two miles of CMI for landing.)

(If this training is completed in the Frasca or the PCATD, it is permissible to discontinue the flight within 2 mile of CMI VORTAC.)

Hobbs time flown to complete this session _________

APPENDIX K: IPC#2 SCORE CARD

IPC 2

Instructor_____________________ Date___________ Subject Number________

Data logger File Name:_______________

On taxi out:	**Completed:**
Instrument Check during taxi	______

VOR Approach (DEC VOR 18)
Please test the VOR approach first during the flight of this flight. Check "yes" or "no" to indicate whether the subject's performance met the criteria.

Task Yes	No	
Tune, Ident VOR	_____	_____
Set Proper Course	_____	_____
Before Final Approach Segment:		
Altitude $\pm$100 ft	_____	_____
Heading $\pm 10^{\circ}$	_____	_____
Less Than Full-Scale CDI Deflection	_____	_____
Executes Proper Procedure Turn	_____	_____
Identifies FAF	_____	_____
Starts Time	_____	_____
On Final Approach:		
Less Than 3/4 Scale CDI Deflection	_____	_____
Airspeed $\pm$10 kts	_____	_____
Maintains MDA +100/-0 ft	_____	_____
Properly Identifies MAP	_____	_____
Meets Practical Test Standards	_____	_____

Marking Instructions:

Mark data at the beginning and end of each segment listed below:

1) Start of outbound tracking from TRACS up to start of Procedure Turn
2) Start of Procedure turn through intercepting FAC inbound
3) Tracking inbound until arrival at TRACS
4) TRACS inbound to MAP

Instructor_____________________ **Date**___________ **Subject Number**_______ **IPC 2**

Holding Procedures (HASSE)
Please test the holding pattern second during the flight. Check “yes” or “no” to indicate whether the subject’s performance met the criteria.

Holding Pattern Entry

Measure	Desired	Yes	No
Tune and Ident Proper Navaids		_____	_____
Recognizes Arrival at Holding Fix		_____	_____
Initiates Prompt Entry		_____	_____
Uses Recommended Entry Procedure		_____	_____
Properly Reports Entry		_____	_____
From Initial Arrival at Holding Fix to Crossing Fix on 1st Inbound Leg			
Airspeed	$\pm$10 kts	_____	_____
Altitude	$\pm$100 ft	_____	_____
On Inbound Leg			
Maintains Desired Course	$\pm 10^{\circ}$	_____	_____
Applies Proper Timing		_____	_____

First Full Holding Pattern

Measure	Desired	Yes	No
On Outbound Leg:			
Maintains appropriate Wind Correction		_____	_____
Applies Proper Timing		_____	_____
On Inbound Leg:			
Maintains Desired Course	$\pm 10^{\circ}$	_____	_____
Throughout Pattern:			
Airspeed	$\pm$10 kts	_____	_____
Altitude	$\pm$100 ft	_____	_____

Second Full Holding Pattern

Measure	Desired	Yes	No
On Outbound Leg:			
Maintains appropriate Wind Correction		_____	_____
Applies Proper Timing		_____	_____
On Inbound Leg:			
Maintains Desired Course	$\pm 10^{\circ}$	_____	_____
Throughout Pattern:			
Airspeed	$\pm$10 kts	_____	_____
Altitude	$\pm$100 ft	_____	_____

Meets Practical Test Standards _____ _____

Marking Instructions:

5) Mark arrival at HASSE. Stop marking just prior to starting Steep Turns

Instructor______________________ Date____________ Subject Number_______ IPC 2

Steep Turns

Please test steep turns third during the flight; one 360^{o} turn to the left and one 360^{o} turn to the right. Check "yes" or "no" to indicate whether the performance met the criteria.

Measure		Desired	Yes	No
Left 360^{o} Steep Turn				
At 90^{o} Heading Change				
	Altitude	$\pm$100 ft	______	______
	Airspeed	$\pm$10 kts	______	______
	Bank Angle	$\pm 5^{o}$	______	______
At 180^{o} Heading Change				
	Altitude	$\pm$100 ft	______	______
	Airspeed	$\pm$10 kts	______	______
	Bank Angle	$\pm 5^{o}$	______	______
At 270^{o} Heading Change				
	Altitude	$\pm$100 ft	______	______
	Airspeed	$\pm$10 kts	______	______
	Bank Angle	$\pm 5^{o}$	______	______
Rollout at Starting Heading				
	Heading	$\pm 10^{o}$	______	______
	Altitude	$\pm$100 ft	______	______
	Airspeed	$\pm$10 kts	______	______
Right 360^{o} Steep Turn				
At 90^{o} Heading Change				
	Altitude	$\pm$100 ft	______	______
	Airspeed	$\pm$10 kts	______	______
	Bank Angle	$\pm 5^{o}$	______	______
At 180^{o} Heading Change				
	Altitude	$\pm$100 ft	______	______
	Airspeed	$\pm$10 kts	______	______
	Bank Angle	$\pm 5^{o}$	______	______
At 270^{o} Heading Change				
	Altitude	$\pm$100 ft	______	______
	Airspeed	$\pm$10 kts	______	______
	Bank Angle	$\pm 5^{o}$	______	______
Rollout at Starting Heading				
	Heading	$\pm 10^{o}$	______	______
	Altitude	$\pm$100 ft	______	______
	Airspeed	$\pm$10 kts	______	______

Meets Practical Test Standards ______ ______

Marking Instructions:

6) Mark beginning of Steep Turns. Stop marking just prior to unusual attitude recovery

Instructor_____________________ Date___________ Subject Number_______ IPC 2

Unusual Attitude Recovery

Please test one unusual attitude recovery immediately after the steep turns. Check “yes” or “no to indicate whether the subject’s performance met the criteria.

Task	Yes	No
Applies appropriate **Bank, Pitch** and **Power** in a timely fashion during recovery.	_____	_____

Marking Instructions:

7) Mark Beginning. Stop mark at end of maneuver

ILS Approach (DEC ILS 6)

Please test the ILS approach last during the flight. Check “yes” or “no” to indicate whether the subject’s performance met the criteria.

Task	Yes	No
Tune, Ident Localizer	_____	_____
Before Final Approach Segment:		
Altitude $\pm$100 ft	_____	_____
Heading $\pm 10^{\circ}$	_____	_____
Less Than Full-Scale CDI Deflection	_____	_____
Properly Intercepts Glide Slope	_____	_____
Starts Time	_____	_____
On Final Approach:		
Less Than ¾ Scale CDI Deflection	_____	_____
Less Than ¾ Scale Glide Slope Deflection	_____	_____
Airspeed $\pm$10 kts	_____	_____
Properly Identifies MAP	_____	_____
Meets Practical Test Standards	_____	_____

Marking Instructions:

8) Mark Interception of FAC until reaching ELWIN

9) Mark passing ELWIN. Stop mark at DH

Instructor_____________________ Date___________ Subject Number_______ IPC 2

Partial Panel VOR Approach via Radar Vectors (Name of Approach _______________)
Please test a partial panel VOR approach during return to CMI. Check “yes” or “no” to indicate whether the subject’s performance met the criteria.

Task	Yes	No
Tune, Ident VOR	_____	_____
Set Proper Course	_____	_____
Before Final Approach Segment:		
Altitude ±100 ft	_____	_____
Heading ±10°	_____	_____
Less Than Full-Scale CDI Deflection	_____	_____
Identifies FAF (If applicable)	_____	_____
Starts Time (If applicable)	_____	_____
On Final Approach:		
Less Than ¾ Scale CDI Deflection	_____	_____
Airspeed ±10 kts	_____	_____
Maintains MDA +100/-0 ft	_____	_____
Properly Identifies MAP	_____	_____
Meets Practical Test Standards	_____	_____

Marking Instructions:

Mark data at the beginning and end of each segment listed below:
10) Mark Start of tracking final approach course inbound until FAF or Final descent
11) Mark Final approach course inbound of FAF or during final descent (if applicable)
12) Mark when level at MDA until descent for Landing. Stop mark anytime after landing.

ATC Procedures/ Communications
Please monitor the subject’s ATC procedures and communications throughout the flight. Check “yes” or “no to indicate whether the subject’s performance met the criteria.

Task	Yes	No
Subject used appropriate ATC procedures and Communications during the flight	_____	_____

Would you give this participant an IPC sign-off based on the performance of the above maneuvers? (Using old PTS requirements) **YES** **NO** (Circle one)
Please indicate the Hobbs time logged on this flight ___________

Did you give an IPC signoff (based on current PTS requirements) **YES** **NO** (circle one)