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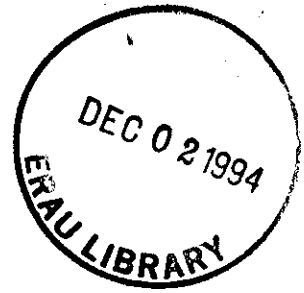
Summary Proceedings of the Joint Industry-FAA Conference on the Development and Use of PC-Based Aviation Training Devices



Kevin W. Williams, Editor

Civil Aeromedical Institute
Federal Aviation Administration
Oklahoma City, Oklahoma 73125

November 1994

Final Report

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16. Abstract

This report is a summarization of the proceedings of a joint industry - FAA conference on the development and use of PC-based aviation training devices (PCATDs) that was held June 16-17, 1994 in Oklahoma City, Oklahoma. Attendees to the conference included representatives from the PC development community, various universities conducting aviation training research, and the FAA. The primary purpose of the conference was to provide a forum of open dialog among interested PCATD parties, with the aim of finding common ground or areas of consensus, through which progress can be made in reducing or resolving any differences in viewpoint. Aside from the welcoming addresses by FAA representatives, the conference consisted of volunteered presentations by attendees, followed by open discussion of the points made by the presenter. A variety of topics were discussed and an attempt was made to let points and contentions be explored to the extent the group wished to pursue them. No attempt was made to provide a verbatim reproduction of the content of presentations and discussions. However, a concerted effort was made to capture the essence of each presenter's position, to accurately paraphrase major points, and to include brief summaries of group discussions through the insertion of editor's notes.

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FOREWORD

The growing number of Personal Computer-Based Aviation Training Devices (PCATDs) becoming available, coupled with steadily decreasing costs and increasing capability, have created an area of joint interest between the FAA, PCATD developers, users of such devices, particularly Part 141 training schools, and those conducting research in aviation training. Each of these groups has a particular interest in the development, marketing, purchase, use, and regulation of PCATDs; however, each group's interests may not be totally compatible with the interests of the others. As a result, a level of concern has developed in the PCATD community by those who feel that the FAA may not fully recognize the potential of these devices in providing effective aviation training.

Therefore, it was considered pertinent and timely for the FAA to host a joint FAA-Industry conference, with the objective of providing a forum for open dialog among interested PCATD parties. It is often helpful for groups with differing viewpoints to come together in neutral surroundings to discuss their perspectives, with the aim of finding common ground or areas of consensus, through which progress can be made in reducing or resolving any differences in viewpoint.

To that end, representatives of the various interest groups were invited to convene with representatives of the FAA to discuss problems and positions, obtain insights, and offer recommendations. Invitations were extended to any individual or company representative within the PCATD community who expressed an interest in attending. It was hoped that an open dialog among the parties would result in identifying one or more recommended approaches, which could be considered by the FAA in future actions concerning PCATDs. Similarly, ideas might be generated that would aid the PCATD development community in improving the level of recognition of their product by the aviation training community. By mounting such a collaborative effort, the cost-effective promise of PCATD technology could perhaps be more fully realized within the aviation training community, while maintaining high standards of training effectiveness and full consideration of aviation safety.

The conference was held at the Ramada Inn West, Oklahoma City, OK., on June 16-17, 1994. Twenty-six individuals attended with the following group representation:

PC Development Community	12
Research & Development	6
FAA	8

Aside from welcoming addresses by FAA representatives, the conference consisted of volunteered presentations by attendees who wished to address the group, followed by open discussion of the points made by the presenter. A variety of topics were discussed and an attempt was made to let points and contentions be explored to the extent the group wished to pursue them.

This document summarizes the proceedings of the conference. "Hard copy" versions of presentations which were made available by the presenters were included in their original form. In instances where a "hard copy" versions were not available, a concerted effort was made to capture the essence of each presenter's position, to accurately paraphrase major points and positions, and to include brief summaries of related group discussions. It was not possible to provide verbatim reproductions of the content of such presentations or the associated discussions.

"Editor's Notes" were included with some presentations to suggest an overall context for the remarks, to provide amplifying information, or to suggest a related point to improve continuity. Apologies are offered "before-the-fact" for instances in which our interpretation or emphasis might differ somewhat from that intended by a presenter or discussant.

R. E. Blanchard, Manager
Human Factors Research Laboratory - CAMI

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BACKGROUND

Qualification of PC Simulation

Lauren Basham
Flight Standards Service

During the last 10 years or more, FAA personnel have evaluated more than a dozen PC-based simulation devices in an effort to determine their permissible use under existing Federal Aviation Regulations. Although we are encouraged by the phenomenal advances in the technology represented, we have not been able to find the devices acceptable to the FAA Administrator that would authorize their use as generic ground training devices.

With the development and adoption of AC 120-45A, "Airplane Flight Training Device Qualification," in February 1992, the FAA established qualification levels for flight training devices, one through seven, with level one currently reserved. No similar qualification criteria has been established for lower level devices which, for whatever reason, may not be qualified as flight training devices. We believe it possible, however, that PC simulation devices, which are determined to have specific capabilities, could be assigned to level one or qualified as part-task training devices.

On December 5, 1992, during a conference in Atlanta, Georgia, sponsored by the American Society for Mechanical Engineers, a way was outlined in which PC simulation could be used under Part 141 of the Federal Aviation Regulations (FARs), the regulation governing certificated pilot schools. The use outlined was as a "training aid" under section 141.55 in an FAA-approved Part 141 flight school curriculum. It is puzzling to us that we are unaware of a single application for such use since that date!

More than 40 years ago, as an instructor at the University of Illinois, Institute of Aviation, teaching a private pilot curriculum, I gave some 5 hours of instruction to students in a rather simple training device and then soloed them in from 2 to 5 hours in an Aeronca 7AC. This simple training device was constructed of wood and fabric and built to resemble an airplane, if we use the word "resemble" rather loosely. As I remember, the device had a short fuselage in which the pilot was seated between two stubby wings. There was a throttle quadrant and controls for aileron, elevator, and rudder. The instrument panel had an airspeed indicator, an altimeter, and a turn and bank indicator. It resembled the C3 Link, or the "blue canoe," for those of you who may remember, but it was really about as basic a training device or aid as you can imagine.

The instructors called these devices "air breathers" because they hissed and creaked while being "ham handled" through the specific sequence of flight maneuvers specified in the curriculum. These devices were considered effective for teaching a student about the attitude of an airplane in relation to control placement and the basic effect of power, or its absence. They were not, however, even remotely considered to be flight training devices.

There is no doubt in my mind that many of the PC simulation devices we see today are many times more capable than the devices just described. However, none have been qualified as flight training devices. We *believe it possible that the value of PC simulation devices is to be found in their ability to support training in aircraft systems knowledge and/or the procedural aspects of flight operations.*

After evaluating a number of PC simulation devices, and being aware of imminent changes being planned for the FAR, we realized that it was going to be very difficult to authorize the use of PC simulation for flight hour credit. This led us to propose a research study by Embry-Riddle. As some of you are probably aware, several of our aviation education institutions offering flight training curriculums employ a concept known as "training to a standard" under an exemption issued by the FAA. Under this concept, less emphasis is given to a required number of flight hours and more emphasis given to the knowledge and competency level of the trainee when he or she completes the FAA-approved curriculum requirements.

It should be emphasized that the Embry-Riddle research study was not to compare PC simulation with "flight training devices" which, under AC 120-45A, were intended to be used under circumstances in which flight hour credit is recognized. And most certainly, the study was not to evaluate specific systems, software, or the fidelity of controls and displays. Rather, the study was designed to compare state-of-the-art PC simulation with representative generic ground training devices, which at best, had been given nothing more than a subjective hands on evaluation in finding them acceptable for specific use under the FAR. Neither of these devices has been compared to a generic aircraft of any kind or description. The results of the Embry-Riddle research will be reported later during this conference.

With the positive findings of the research in mind, we knew that we would still need to determine baseline criteria with which to qualify individual PC simulation devices if these devices were to be authorized for use under the FAR. We are very grateful to Dr. Robert Blanchard, Civil Aeromedical Institute, and those assisting him for agreeing to accept the task of identifying an acceptable baseline for qualifying PC-based training devices for use in structured training curricula, or more specifically, to attempt to identify an evaluation criteria for our field inspectors to objectively authorize the use of PC-based devices in connection with structured training curriculums under the FAR.

It is only fair to say that regulatory initiatives and policy guidance documents, now under development by the FAA, will greatly affect the way PC simulation is used in the future. These initiatives and guidance include the following:

(1) Regulations under development such as part 142 of the FAR;
(2) Changes being considered for Parts 61 and 141 of the FAR;
(3) A revised AC 120-46A, "Use of Airplane Flight Training Devices," which addresses the inflight training and checking of airmen for qualification and certification; and
(4) The intended inclusion of an "inflight event matrix" in the revisions to existing practical test standards, showing the permissible use of flight training devices under the FAR.

Unfortunately, fiscal constraints now in place within the government make it very difficult for the FAA to ensure that funding will be available for any further research needed to support the authorized use of training devices within flight training curricula. We wish to assure you, however, that we in the Agency are not opposed to the use of PC simulation, but we must be able to justify any authorized use.

Again, we believe it possible that the value of PC simulation devices is to be found in their ability to support training in aircraft systems knowledge and/or the procedural aspects of flight operations. We intend to explore and capture that value to the extent possible. The results of your efforts while at this conference are critically important as a continuation of efforts to find a solution equally acceptable to all of us.

DEVELOPER PRESENTATIONS

NEED FOR FAA RECOGNITION OF PCATDs

Ken McLaughlin
Aviation Software

In order for the industry to achieve its true growth potential, there must be some sort of official recognition of PCATDs by the FAA. There is no real market for these devices until they are accepted for use in training by flight schools. There are currently a few progressive flight schools using PCATDs, but most will not use them because they are not supported by the FAA and the hours cannot be logged.

A current weakness in the market is in the development of controls. There needs to be more "good" control interfaces available to the consumer. We need to discuss what the focus of industry should be in the immediate future.

[Editor's Note: Many of the comments made following this presentation suggested that the focus of the industry should be directed toward the construction of "training devices" rather than "simulators." That is, the device should be assigned a more active role in the instructional process, instead of relying solely on the presence of an instructor to provide instructional guidance to the trainee. This role would consist of incorporating computer-based instructional systems design features into the devices that would assure that relevant task-related information is presented to the trainee under conditions known to facilitate learning which would result in better utilization of the capabilities available in personal computer technology.]

PC-BASED INSTRUMENT TRAINING

Mallory Selfridge
Precision Training Software, Inc.

Three specific issues that need to be addressed in relation to PC-based instrument training are: 1) Part 61 instrument currency; 2) Part 61 instrument certification; and 3) Part 141 instrument certification. Suggestions for how PCATD technology should be used in relation to each of these issues is given below in the form of proposed changes to the FARs.

As for Part 61 instrument currency, no changes are recommended for the current regulations governing instrument currency (Editor's Note: However, see the discussion by Milford Derrick on the use of PCATDs for maintaining currency). No instrument pilot can be current if the only approaches he has shot in the last 6 months are on a PC.

For Part 61 instrument rating certification, current regulations are as follows:

§61.65 Instrument rating requirements

(e) Flight Experience. An applicant for an instrument rating must have at least the following flight time as a pilot: ...

(2) 40 hours of simulated or actual instrument time, of which not more than 20 hours may be instrument instruction by an authorized instructor in an instrument ground trainer acceptable to the Administrator.

(3) 15 hours of instrument flight instruction by an authorized flight instructor, including at least 5 hours in an airplane.

PC-based training can be integrated into this scheme through the use of a proficiency-based approach. This approach would require that there be 25 hours of dual instruction by a CFII in an aircraft, including 5 hours in category. In addition, in order to reach a proficiency criterion for the certificate, the student would receive additional study, possibly including:

1. dual instruction in an aircraft;
2. dual instruction on an approved ground trainer;
3. flight with a safety pilot;
4. textbook home study;

5. PC-simulation practice with a CFII or textbook;
6. PC-based tutor.

The proposed change to the FAR would be as follows:

§61.65 Instrument rating requirements

(e) Flight Experience. An applicant for an instrument rating must have at least the following flight time as a pilot: ...

(2) **25 hours of instrument flight instruction by an authorized flight instructor in an aircraft, including at least 5 hours in the category of aircraft for which the rating is to be issued.**

(3) <deleted>

This change would require more of an emphasis on the student achieving a certain level of proficiency before receiving a certificate or rating.

For Part 141 instrument training, current regulations are as follows:

Appendix C to Part 141 - Instrument Rating Course (Airplane)

3. Flight Training. The course must consist of at least 35 hours of instrument flight instruction given by an appropriately rated flight instructor, covering the operations listed in paragraphs (a) through (d) of this section. Instruction given by an authorized instructor in a pilot ground trainer which meets the requirements of §141.41(a)(1) may be credited for not more than 15 hours of the required flight instruction. Instruction in a pilot ground trainer that meets the requirements of §141.41(a)(2) may be credited for not more than 7.5 of the required 35 hours of flight time.

In order to integrate PC-based training into Part 141 training there needs to be a proficiency-based alternative to ground-trainer time. The proposed changes to the FAR would require 20 hours of dual instrument flight instruction in an aircraft and either (1) 15 hours of dual instrument flight instruction in a pilot ground trainer, or (2) completion of an approved ground-based instrument flight procedures course.

The proposed change to the FAR would be as follows:

Appendix C to Part 141 - Instrument Rating Course (Airplane)

3. Flight Training. ... Instruction given by an authorized instructor in a pilot ground trainer which meets the requirements of §141.41(a)(1), or **completion of an approved ground-based instrument flight procedures course** may be credited for not more than 15 hours of the required flight instruction. ...

A ground-based instrument flight procedures course would consist of a device which simulates instrument flight to a degree suitable for positive transfer of learning, and one of the following:

1. An appropriately rated flight or ground instructor, using a syllabus containing a course of instruction acceptable to the administrator.
2. An autonomous training system for the teaching of instrument flight procedures. This may include a workbook, recording, or self-contained teaching device, each of which must make provisions for recording of student performance and course completion.

PC-based learning devices can be an effective component of instrument flight training if combined with proficiency-based standards and required minimum dual instruction in aircraft.

[Editor's Note: The idea of a proficiency-based approach to training has been put forward by other people as well. Stan Roscoe stated the idea recently in this way: "Ideally, all aspects of the training curriculum could be taught to some criterion performance level on the ground. Competence in each block of training would be demonstrated after a brief transition in the airplane. Certification for each license and rating would be based on demonstrated competence with the minimum required flying hours greatly reduced. Credit for ground-based training would no longer be a formal issue." (Roscoe, 1991, p.868).]

Need for Broad PCATD Requirements

Alexander Bickel
Initiative Computing, Inc.

Be aware that technology development does not stop. Initiative Computing, Inc. is developing products that will be on the market in about two years. If the requirements that are created are specific only to current technology, those requirements will be outdated by the time they are released. Broad recommendations and requirements for PCATDs should be developed so that they are applicable to future, as well as present systems.

Even if you cannot log time on a PCATD, there is still some benefit to be gained from it in the form of increased flight safety.

The definition of a PCATD must be explored more fully. What is a PCATD? Is its intended purpose to convey information or provide an approximation to flight experience? [We] would argue for a broad definition of PCATDs to encompass any future innovations in the market.

It is important to note that the development and use of these devices will occur with or without the blessing of the FAA. Market forces will direct the development of PCATDs as much as, or perhaps more, than government regulations.

Use of PCATDs for Currency Training

Milford Derrick
MDM Systems

Most, if not all, of the developers of PCATDs would like to see them certified for use in logging flight hours. That is the reason that they attended this meeting. The most important aspect of these training devices is that they can increase safety. Safety is of paramount importance; however, people who need simulators the most do not always have access to them. The private pilot, for the most part, has never seen a simulator. This is the role of the PCATD, but we need recognition by the FAA.

Focus should be on the use of these devices in currency training, in addition to their use in ab initio training. It would be reasonable to allow half of the time needed to maintain currency to be logged on a PCATD that was flown in the presence of a CFII. A lot of confidence is already placed on the CFII. A little more could be expended in allowing the CFII to watch someone performing instrument tasks on a PCATD and sign the person off on the basis of that performance. Flying is procedural. Procedures can be learned on a PC-based simulator just as well as in the airplane. This approach could enhance the safety of the entire process. Letting the CFIIs function in this manner would also allow PCATD developers to gain a foothold in the market.

USE OF PCATDS FOR PRIVATE PILOT TRAINING

Hugo Feugen
Bruce Artwick Organization, Ltd.

[The industry] sees the PC as a blank slate, which is capable of running very good aerodynamic models. We don't like the characterization of PC-based devices as low level. Perfect physical fidelity is not needed and is not cost effective. Fidelity should be addressed at the level of individual tasks/maneuvers.

[We] would like to see an effort to extend the devices past the instrument training environment to private pilot training as well. We seem to be victims of our pasts in this respect. The visual systems that are in current PCATDs are adequate for training in a variety of VFR tasks. Opening up training to the VFR sector would also greatly increase the number of people who could benefit from these devices.

People have the viewpoint that the general aviation community is not important to the FAA. An example of the attitude that the FAA has toward PCATDs is the following true story. A flight examiner at a flight school in Arizona was using a PCATD as a part of his training curriculum. He asked the local Flight Standards District Office (FSDO) inspector to review the device to make sure that there was no problem in its use. The FSDO inspector was positive about its use and wanted to OK it, but checked with people in Washington about it first. The Washington people said they would not approve the device for use as a ground-based training device.

[Editor's Note: At this point, a discussion was begun about the reasons that PCATDs are not approved for use within flight training. The main problem seemed to revolve around the fact that when application is made for use of these devices under FAR Part 141.55, it is for use of the device for hours equivalency as a flight training device. Approval of a PCATD as a flight training device which can be used to accrue flight hours is governed by qualification criteria under FAR Section 141.41 or as specified in AC 120-45A. The point was made that currently, there are no PCATDs that meet all of the requirements for certification as a flight training device and there is no indication that the devices provide an hour-for-hour training equivalency with the aircraft. Even when application is made for use of the device as a ground training device, there are difficulties in certifying them because the certification is based on the requirements set forth for flight training devices. It was noted further that, on the other hand, there is still a provision for the use of these devices within a flight training curriculum, as long as they are not used to accrue flight hours. They can be included as part of the curriculum "courseware" and used in the same manner as any other ground-based training device (video, manuals, etc.) Approval as courseware would not require that the device adhere to the guidelines specified in AC 120-45A.]

PCATD Approval: The Baby That Never Grew Up

E. Nobby Hall
Azure Soft Technology

There are letters dating back to 1969 requesting approval for the use of PCATDs in flight training. It is as though we have a baby that never grew up. PCATDs are a wonderful learning tool. It seems as though the FAA is constantly going through efforts to deny what we have. We have a superb practice tool. It doesn't totally resemble an airplane but does the basics of what is needed to learn to fly. We are trying to take the teaching process out of the most hostile environment in the world (the training airplane) and put it on the computer.

Most of the software publishers came to this conference hoping for some form of definitive statement from the FAA, and not just another agreement to look further into the problem. Ground Based Flight Training Devices have been subject to microscopic investigation for over 25 years, and we still cannot ascertain what is needed to obtain the FAA blessing.

Nobody in their right mind expects to receive enough certification to write total PCATD time in their log book - one hour for five would be nice in due time. A statement from the FAA stating that there is value in training on these products would help us, and incidentally, improve flight safety. There can be little doubt that PCATDs are an excellent teaching tool. At this stage, academia has surely looked at and researched its efficacy enough. There is enough evidence from the field that pilots at every stage of the learning spectrum benefit and feel more comfortable in the air after practice on the Elite.

There is no reason to examine learning transfer and the individual "cues" of each maneuver any longer. If you want to know how effective something is, ask the user. Azure, and probably other developers, would be delighted to pass on our data bases. The FAA could send out an inquiry letter to each known user.

It is understandable that the FAA has a very major function in controlling the use and misuse of flight training devices; however, is this not a case of examining the patient until he dies? The FAA needs to take the lead and acknowledge how useful PCATDs are as a training tool in the very near future. Our company believes we can play a major part in increasing flying safety in general aviation.

Don't (you the FAA) ask us what we (the developers) want. You are the regulation people. Tell us what you want and we will move. The average flight school is still frightened of PCATDs because they haven't been approved by the FAA. Please give the guidance and help that we need because we are throwing away one of the greatest tools we have. In the right hands, this tool can lower the hours needed to fly.

[Editor's Note: The Agency has recently initiated a research project to develop a systematic, task-based technique for identifying PCATD characteristics that can be expected to promote learning. See K. Williams' presentation for further details.]

ACADEMIC PRESENTATIONS

An Overview of an Experiment Examining the Use of Personal Computer-Based Training Devices in Teaching Instrument Flying

Steven Hampton, Thomas Kirton, and David W. Biers
Embry Riddle Aeronautical University
William F. Moroney
University of Dayton

The flight performance of aviation students trained on PC-Based Training Devices (TDs), using "Elite" and "IFT" software packages, was compared to the flight performance of students trained in an FAA-approved generic training device (Frasca 141). Seventy-nine students enrolled in an instrument flight training course were trained on one of the three TDs and then flew in a Mooney 20J. Instructors/evaluators used a form, based on criteria specified in FAA's Practical Test Standards (PTS) for an instrument rating, to evaluate student performance on six maneuvers and two categories of general flight skills. Records were also maintained on the number of trials, hours to proficiency, and the number of trials per task. The student's performance was evaluated by course instructors and independent "stage check pilots" during both the ground-based and in-flight portion of the course.

For those maneuvers evaluated, no significant difference in either the number of trials or hours to instrument flight proficiency in the aircraft was noted among those students taught using any of the TDs. However, differences in student performance were noted in the number of trials/hours to proficiency in the TDs. Compared to students trained on the Frasca, students trained on the PC-Based TDs required:

1. significantly fewer trials, hours, and trials per task, to reach the overall Practical Test Standards in the TDs and,
2. significantly fewer trials to reach proficiency in the following maneuvers: precision approach, non-precision approach, timed turn to magnetic compass heading and general flight skills (partial panel).

In addition, based on a very conservative estimate, at least $400 less was expended to train each student to criterion on the PC-Based TD. With respect to cost effectiveness, the PC-Based TDs and associated hardware cost approximately 8% of the approved TD. Furthermore, students can be trained for approximately $18.50 less per hour on the PC-Based TDs than on the currently-approved TD.

Thus, the considerably lower-cost PC-Based TDs provide training comparable to that currently provided in more expensive TDs. The authors confidently recommend: a) the use of PC-Based instrument flight training devices to the FAA and, b) that steps be initiated to qualify them as Flight Training Devices, which can be used to accrue Instrument Rating credit.

[Editor's Note: From the perspective of exploratory research, the results of this study are encouraging, given that the approved training device has in fact been in use by Part 141 training schools for many years, and is considered to be an effective training tool. These results suggest that an investment would be warranted to conduct a study with a control group trained only in an aircraft to determine empirically the training transfer effectiveness of a representative PCATD.]

The Need for a Systematic Examination of PCATD Requirements

Henry Taylor
University of Illinois, Institute of Aviation

As long as there is a flight hour requirement in flight training then there will exist an effort to qualify PCATD training for hours equivalency. PCATDs should not be evaluated on their physical fidelity, but on whether or not they are effective teaching devices. The issue is one of training effectiveness.

Principles need to be developed for how these devices can be used within a training curriculum. An evaluation methodology should be created that is as objective as possible. Performance measures must be identified. Instructional variables should be included in the evaluation of these devices.

I would argue for a systematic approach to research as a first step. Systematically gather data that will allow the eventual certification of these devices for hours equivalency.

Use of the PCATD for Part-Task Training

Randy Chambers
Wichita State University

Very effective training can be achieved by breaking a task into parts. The approach used in air force training was to take the most difficult part of a task and practice it over and over. The task would then be restructured. This approach led to a reduction in training time. This approach was also used for astronaut training. Task component training is extremely important. The beauty of it is that you can evaluate, measure, and train for the most difficult parts of the task.

Identification of the most difficult parts of the task can be accomplished by measuring how quickly each part reaches a certain performance criterion. A second method is through subjective judgments on the part of students receiving the training.

Question from the audience - Has there been a list of necessary tasks developed for obtaining a private, commercial, or instrument rating? Recommend that the FAA develop a list of these tasks, present them to the flight schools, and leave them alone to teach without trying to direct them as to what methods are used and what equipment is needed.

[Editor's Note: The FAA is in the process of developing a task data base which, ultimately, will be organized by rating or certificate. The initial task set for the instrument rating should be available by September, 1994. (See Williams' presentation). The Practical Test Standards presents a list of necessary tasks for obtaining a particular certificate or rating. The FAA exerts very little control over the manner in which training objectives are met (probably too little control). The task data base being developed should allow the identification of those parts of the task where training on a PCATD should be more effective.

As far as part-task training is concerned, the answer to the question of whether it is more effective or efficient than whole-task training is dependent on the circumstances. Some early work by Naylor and Briggs (1963) suggest that there are two characteristics to the task that must be considered in deciding whether part-task or whole-task training would be more effective. The first is the task "organization," which refers to the demands imposed on the trainee due to the interrelationships existing among the various subtasks. The second is the

task "complexity," which refers to the demands in information-processing and/or memory storage capacities of each separate subtask when treated independently of the others. Naylor and Briggs suggest two principles for selecting part-task or whole-task training.

Principle 1. For tasks with high organization (i.e., highly interrelated), as subtask complexity is increased, whole-task training should become relatively more effective than part-task training.

Principle 2. For tasks with low organization (i.e., sub-tasks are independent), as subtask complexity is increased, part-task training should become more effective than whole-task training.

Flight tasks could be characterized as high in organization and low in complexity (i.e., individual subtasks are not very complex, but all subtasks are highly interrelated, which makes the entire task difficult). If this characterization is correct (and Naylor and Briggs principles are useful), it would suggest that there would not be much difference between part- and whole-task training methods.]

Development of the Basic Flight Instruction Tutoring System (BFITS)

Jefferson Koonce
University of Central Florida

The Basic Flight Instruction Tutoring System (BFITS) is a microcomputer-based flight trainer designed to teach both the declarative and procedural knowledge needed for basic flight maneuvers, while monitoring, tracking, and recording the student's behavior as he/she works with the tutor. BFITS provides a criterion task for (a) the validation of experimental psychological tests under consideration for pilot selection, and (b) the evaluation of the effects of drugs and environmental factors on pilot performance. BFITS consists of an instructional module, a flight simulator, and a performance evaluator, which will work together to involve the student in tasks requiring both cognitive and psychomotor skills. The instructional module teaches the declarative knowledge of basic flight using text, graphics, and animation. The flight simulator provides the student with practice in flying a simulated airplane. It is used in conjunction with a number of easily changed flight scenarios that direct the student's current task and provide performance evaluation criteria and hint messages. The performance evaluator tracks student progress and allows the student to view a graphical display of his/her performance as measured against the evaluation criteria. Flights can be played back for review also.

GOVERNMENT PRESENTATIONS

Development of Qualification Guidelines for Personal Computer-Based Aviation Training Devices

Kevin W. Williams
FAA Civil Aeromedical Institute

There is a need for FAA involvement with PCATDs due to the rapidly growing number of requests for approval of these devices within flight training curricula. The technical capabilities of these devices are constantly expanding. The FAA has a role in PCATD use to: 1) support the transfer of this technology into the aviation training environment; 2) ensure the safety of the flying community as it is related to these devices; and 3) provide guidance to PCATD developers and users on their development and use.

There is a lack of evidence supporting the training transfer effectiveness of PCATDs. Problems that exist in the studies that have been performed include: 1) a lack of a control group that performs training only in the aircraft so that data can be used to gauge the transfer effectiveness of the PCATD; 2) a limited set of training tasks, so that transfer effectiveness is shown for only a small portion of the tasks that are involved in flying the aircraft; and 3) no manipulation of variables that will provide a way to identify those characteristics of a training device that contribute to transfer effectiveness.

The development of qualification guidelines for PCATDs will be based on an analysis of criterion-referenced flight tasks. The focus of the analysis will be on what is learned and on how learning occurs. The development of the guidelines seeks an optimal tradeoff between cost and transfer of training.

The analysis is based on a recognition that learning occurs in stages. Initial-stage learning of a task involves the learning of task objectives, overall task outline, location of displays and controls, and the relationship between different controls and displays within the context of the task. Second-stage learning involves establishing correct patterns of behavior and learning to coordinate movements and anticipate actions in the same manner as the actual flight tasks. Final-stage learning involves the development of smooth, automated movements. Performance of the task at this stage takes place relatively automatically without the requirement of conscious control on the part of the performer.

The support of lower-stage learning does not require as high a level of physical fidelity as the support of higher-stage learning. Because it does not require as high a level of physical fidelity, support of lower-stage learning is less expensive than support of higher-stage learning. It is our view that PCATDs can be made more cost effective if more emphasis is placed on the support of lower-stage learning. The PCATD should have a more active role in ensuring that task objectives and outlines are presented to the trainee, that feedback regarding performance of a specific task is given, and that the trainee establishes the correct patterns of behavior and learns to coordinate movements and anticipate actions in the same manner as the actual flight tasks.

Based on these objectives, the focus of guideline development will center around three issues: 1) the PCATD should promote positive transfer - specifically, it should support as much stage one and two learning of a task as possible; 2) the PCATD should avoid negative transfer when compromising physical fidelity so as to introduce invalid expectations regarding the flight task to the trainee; and 3) the PCATD, in the emphasis of lower-stage learning, should incorporate instructional systems design approaches that have been shown to maximize the amount of useful information presented to the trainee and ensure that the information has been assimilated by the trainee.

The near-term goals for guideline development will be to produce an initial set of guidelines based on the instrument rating. The guidelines will be organized into a PCATD Qualification Tool (PQT) that will be used by FSDO inspectors to approve Part 141 flight school curricula that incorporate PCATDs as part of their ground-based training aids. At this point, there will be no attempt to develop an hours equiva-

lency scheme for PCATDs nor try to define them as flight training devices, as outlined in AC 120-45A. In a sense, the FAA is assuming the role of consumer advocate in trying to define those characteristics that will maximize the cost-effectiveness of the devices.

The expected benefits of this approach are that it will:

- Incorporate PCATDs into the formal flight training process
- Allow market forces to determine the best and most cost effective training devices
- Allow a more selective use of PCATDs; in a sense, create smart buyers
- Lead to more effective and efficient flight training programs

The development of a prototype set of guidelines for devices used for the instrument rating is expected to be completed by September 1994. A field evaluation of the guidelines is scheduled to be completed during 1995.

Plans are to expand the use of the guidelines to include other certificates and ratings, including the private pilot certificate and commercial rating, and to expand their use to include Part 141 schools, the PCATD development community, and individuals desiring to purchase and use PCATD technology. The guidelines will be packaged in the form of a computerized evaluation program and distributed on floppy disk. They will also be written in the form of an advisory circular for general distribution.

Issues in Using Off-the-shelf PC-based Flight Simulation for Research and Training: Historical Perspective, Current Solutions and Emerging Technologies

Dennis Beringer
FAA Civil Aeromedical Institute

Until recently, flight simulation had historically been an expensive proposition, particularly if any out-the-window views of the world were desired. Advances in computer technology have increased the power of personal computers to the point where they are now capable of supporting moderate-fidelity flight simulations of both the internal cockpit environment and the visual contact world. A modular off-the-shelf flight simulation that has been adapted, with minimal effort, for conducting general-aviation research in our laboratory. This simulation uses widely available personal computers based on the 80486 processor (50 MHz variety) to generate a comparatively rich simulated flight environment, including variable flight instrumentation, forward, 45 degree left, and 90 degree left views of the outside world, and a map display. Control inputs are provided by high-fidelity analog controls (damped and self-centering yoke, high performance throttle quadrant, gear, flap, and trim controls; navigation radio frequency select, etc.). The simulation is based upon two commercially available flight simulation software packages, one designed as an instrument flight trainer and the other as a "game"-type flight simulation. The instrument package provides cockpit displays, control input processing, continuous collection of 16 variables, and feeds 6 degree-of-freedom data to the second package that produces the out-the-window view. This latter package is used to produce all outside views, one per processor/display combination. The forward view is projected to obtain accommodation distances exceeding 3 meters. All interprocessor communications are serial. The advantages of this approach are: (1) low cost hardware, in many cases already available on site, (2) low cost software, (3) modularity of both hardware and software, allowing upgrade of any of the components as is deemed appropriate or necessary and allowing easy expansion of simulation by adding components, and (4) simple communications protocol. The low cost and ease of assembly/integration allow multiple "standardized" systems to be distributed for cooperative interlaboratory studies. The approach appears to have great utility for both research and training. Preliminary experimental results from our laboratory validate the utility of the system for research.

Training Devices and the Flight Standards District Office (FSDO) Inspector

Robert Dippi
FAA, FSDO Inspector, Oklahoma City, OK

The FSDO inspector's job is not to make policy. He is, however, guided by policy made at the headquarters level. By the very nature of his job, the FSDO inspector is the interface between the FAA, the pilot, and the flight instructor.

Under Part 61, flight training is the sole responsibility of the individual flight instructor. Each flight instructor has the latitude to develop his or her own curriculum, training schedule, etc., and to modify it to meet the needs of the individual flight student. Flight training under FAR Part 61 (as opposed to FAR Part 141) is unstructured.

Currently, the average number of hours spent in completion of training for a private pilot certificate is between 60 and 65 hours. Any type of training aid that would reduce this average time would be beneficial to the flight student. The ability of a PCATD to enable students to obtain their pilot certificates in less than this "average" amount of time would be a good marketing tool. Remember, however, that we are not talking about substitution of flying time, but rather, gaining required knowledge and skill in less than "average" training time through the use of innovative training aids/courseware.

Under Part 141, the FAA must ensure that the individual flight school meets minimum criteria for facilities, personnel, equipment, etc., and their curriculum must be approved. This is the job of the FSDO inspector. A FAR Part 141 "approved" flying school is a structured training environment, as opposed to FAR Part 61.

Any device that will help achieve the objectives of the curriculum is acceptable, no matter what it is based on. Supporting the objectives in an individual lesson is the goal. The FSDO inspector will look over the curriculum and the syllabus, and determine whether or not they meet the criteria. He or she has the latitude to approve or disapprove the curriculum. When a PCATD is included in the curriculum as courseware, not as a flight training device or simulator, but as courseware, then the FSDO inspector must approve the curriculum, based on an assessment of the capabilities of that device to support the curriculum. If anyone submits courseware that will benefit the student by increasing the learning, it is acceptable and encouraged. We cannot suggest courseware, but we can encourage innovative courseware. A training device used as courseware or as a training aid has to support an individual curriculum. The FAA will approve the curriculum, not the device.

Comment from Larry Basham - Part 141.55 allows an operator to incorporate a training aid into a training curriculum - and requires that the curriculum be approved. We do not approve a training aid separately under Part 141. No one, to my knowledge, has submitted a PCATD for use as a training aid within a Part 141 course curriculum.

We are trying to broaden the development and use of PCATDs to the level of an instructional device. PCATD development is moving toward incorporating the features of instructional devices. We need to develop a methodology for qualifying these devices for use within an aviation curriculum (as training aids). We have 92 district offices. It would be beneficial to the FAA to have some form of baseline or standard criteria for approving curricula that included the use of a PCATD as courseware within those curricula. (See K. Williams' presentation).

PCATD Certification and the Need for Data

Ed Cook
FAA, National Simulation Program

The absence of data is the major obstacle to the certification of PCATDs for flight hour equivalency. Currently, for a device to be qualified, we must be able to say that the performance of that device is sufficiently close to the performance of the aircraft. PC simulation is vastly more capable than some currently certified training devices, but that doesn't mean that there are not hurdles to clear before PCATDs will be certified for flight hours.

One of the things that needs to be done currently is to revise AC 120-45A. You (the developers) are encouraged to provide your input to that process. In addition, AC 120-46A is being developed. Efforts are now underway to establish a new FAR part to describe the technical criteria for simulation devices and to revise the Practical Test Standards. There are also requirements to modify Parts 61, 91, 120, 135, etc., in short, a major overhaul of the regulatory process is being considered. This overhaul deals with the general aviation industry and is open to the industry.

There is a perceived notion by the industry that the FAA is not interested in PC-based simulations. In fact, they are encouraged.

It is the position of the National Simulator Program (NSP) Staff, that research must be initiated to provide a factual basis from which decisions may be made regarding the technical requirements for simulation devices, as well as how these devices may be incorporated into pilot/flight crew member flight training and testing programs.

Our recommendation is that a short-term research program be designed and implemented that would yield information in a useful time frame. By this, we mean that within 18 to 24 months information may be obtained with which decisions might be made about many of the questions that are continual in nature and impact directly on the way in which simulation is, and may be used, to meet the needs of pilot/flight crew member flight training and testing - for both certification and qualification. This program would include a requirement for monthly updates and "mid-course corrections" when necessary.

Such a program would also include preliminary information regarding a determination of a long-term research program on simulation. The application of this long-term research would be both beneficial and necessary to the FAA.

We also believe that such a research program should have a hierarchy of accomplishments. The most basic questions should be asked and answered before the more sophisticated questions are addressed. Since simulation requires visual, sound, and motion systems as part of an airplane flight simulator, we believe that it would only be appropriate to address these systems, as systems, first. The supposition here is that when involved in pilot training or testing, these systems are to produce the same cues in the simulated environment as would be present in the aircraft when performing the same maneuver or procedure in the same portion of the flight envelope. It has been presumed that the presence of these cues assures that the behavior learned in the simulator will transfer directly into the aircraft.

A key element that has been missing in the understanding of flight simulation is a determination of what specific criteria are necessary to have a cueing system that accurately provides appropriate cues for a specific task or situation. The questions that arise in discussions on this issue that are in need of answers are noted below. It is our firm opinion that these questions should be dealt with in their entirety. To select certain of these questions and ignore others would result in a less-than-comprehensive position.

1. What is a "cue?" How and where is it measured? What are the appropriate metrics for cue measurement? Is a cue constant, or is it specific to an aircraft or to an individual?
2. Can we separate motion, visual, and sound cues one from the other, then measure and reproduce them in the simulated environment successfully?
3. What visual, sound, and/or motion cues are used (required?) by the flight crewmember to accomplish a particular maneuver or procedure? Can we

develop a list of required cues against a list of required maneuvers/procedures for varying training and/or checking goals?

4. Are these cues, and their relative importance, different between airplanes and helicopters? If so, how are they different?
5. What are the aspects of these cues and how do we take them into consideration when developing technical requirements for simulators? -or- How are these cues best replicated in the simulated environment? -or, more technically- What should be the appropriate phasing of acceleration cues with the visual system, sound system, and cockpit instrumentation cues?
6. What maneuvers and procedures that are appropriate for airman certification are supported in what levels of simulation devices? What maneuvers and procedures that are appropriate for airman qualification are supported in what levels of simulation devices? What experience, if any, of the applicant may play a role in this determination?
7. How closely do the cues presented in the simulator need to be to those experienced in the aircraft to assure that accurate behavior transfer from simulator to aircraft will occur? Is there an "experience factor" to be considered here?
8. Is there or should there be a difference between the simulator's capability to provide cueing for: the instructor demonstrating a maneuver; the student trying the maneuver; the student practicing the maneuver; the student demonstrating proficiency on the maneuver to his/her instructor; and the student's being evaluated on the maneuver for a license?
9. Has there been any research accomplished in this area previously? If so, what does the literature indicate?
10. What kind of test or data gathering efforts would be required to obtain answers to these questions?
11. Is this list of questions exhaustive? In what order should these (and any other germane) questions be asked and answered?
12. What, if any, long term research program would be beneficial (needed?) to ensure adequate/accurate incorporation of technological advances made in simulation and simulation application?

Action Steps

In closing the conference, the audience was asked to suggest action steps that should be addressed in a timely fashion by one or more of the PCATD interest groups.

The following actions were suggested:

- Develop and distribute an FAA position statement on the values of PCATD technology in aviation training.
- Develop a quarterly newsletter jointly between FAA and the PCATD community that highlights developments, approval actions, etc.
- FAA should sponsor a program of research and development within the realm of PCATD to address the following issues:
  a) Transfer of training (aircraft only; generic training device; PCATD)
  b) Determine specific characteristics of PCATDs that tend to contribute relatively more to transfer of training.
- Consider separating type and circumstances of use of PCATDs between ab initio pilot training and use by experienced pilots for proficiency training and skills maintenance. PCATDs may be of more value when used for regaining proficiency on already-learned skills than when they are used for initial skills acquisition in ab initio training.

[Editor's Note: As an action outcome, two weeks following the conclusion of this conference, a draft edition of a new advisory circular (AC) was in preparation covering the use of PCATDs within Part 141 flight school curricula. The AC includes a statement of support for the use of these devices in integrated ground and flight training curricula approved under Part 141. In another action, a grant was recently awarded to the University of Illinois Institute of Aviation to conduct additional research to determine the transfer of training effectiveness of PCATDs. The results of this study should aid in the application of the guidelines and help support future decisions regarding the approved used of PCATDs.]

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APPENDIX A

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