THE STRENGTHS, SUCCESSES AND LESSONS LEARNED IN THE USE OF COMPUTER-BASED TRAINING BY THE S-3A, F/A-18 AND F-14A NAVAL AVIATION TRAINING PROGRAMS

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ABSTRACT

The role of computer-based training (CBT) is growing in support of high-technology aircrew training systems. As the potential of CBT continues to grow, it is expected to play a more significant role in highly sophisticated training applications. The advantages of CBT are many. It is a medium for both cognitive and procedural training; it is currently the most flexible medium for maintaining concurrency with modern, rapidly changing aircraft and weapons systems; and it can be used as a vehicle to manage instruction. The self-paced capabilities of the medium ensure that students meet criterion levels of performance even when used within the context of lock-step programs.

CBT is being applied in three Navy aircrew training programs. It has been used in the S-3A and F/A-18 programs for several years and is currently being implemented to train F-14A aircrew. Future programs, including the F-14D, A-6F, E-2C and SH-60F, will also use CBT in aircrew training systems.

This paper will describe the strengths, successes and lessons learned in the use of CBT by the S-3A, F/A-18 and F-14A programs and how the use of CBT in these programs can serve as the building blocks for new CBT and training system development. The general conclusions of the authors is that a means to communicate these experiences will allow training systems managers and planners to build programs on a sound basis of experience. In this age of rapid technological advancements, training systems designs based on experience will offer the critical advantage.

INTRODUCTION

The emergence of digitally-based weapons systems has led to a requirement for training systems that are easily and conveniently updated in response to software changes in the aircraft computer systems. Computer-based Training (CBT) is meeting that requirement for both academic and hands-on part task training.

Traditional academic media, such as slide/tapes, workbooks and lectures, require a significant amount of time, money and manpower to keep current with the aircraft. For complex flight simulation including part task training, the cost is even higher. Since the CBT lessons operate from a program source code, a single change to the source updates a lesson. In the case of other academic media, all copies must be individually updated, dramatically increasing the manpower and cost to keep the courseware concurrent. In the case of part task trainers, extensive hardware and software upgrades must be accomplished. A typical CBT lesson can be updated in a matter of minutes, hours or days, while the modifications to other training media and devices takes weeks or months.

During the past few years, the Naval aviation community has attempted to capitalize on the advantages offered by CBT and has incorporated it into their training curricula. The S-3A training program was the first to be developed, followed by the F/A-18 program. The F-14A community is currently introducing CBT into their curriculum. There have been mixed responses to these programs.

PURPOSE OF THIS PAPER

The experiences gained through several years of CBT application in Naval aviation programs can be used to identify management perspectives for future programs. In support of this idea, the purpose of this paper is to briefly summarize some of the problems, successes and lessons learned in its various applications. It shows, by direct examples, how the strengths and weaknesses of one program have provided building blocks for the next program. It also shows how problems solved in one program could have been prevented in others if communications from one project to the next had been formalized.

The use of CBT in Naval aviation has now been extensive enough that a more comprehensive data base can be accumulated. The general conclusions and recommendations of the authors is that this data base should be used to develop a set of guidelines for management of the procurement, development, implementation and maintenance of CBT within aviation training programs. These guidelines should be a "living document" which would be updated at the conclusion of each new development effort. This way, as CBT technology advances, managers would have an up-to-date data base to use in planning decisions.

AIRCRAFT MISSIONS

The aircraft missions of the S-3A, F/A-18 and F-14A are briefly described below. The use of CBT in these programs is described in the next section.

The S-3A "Viking" is a four seat, twin engine, antisubmarine warfare (ASW) sonar aircraft. The primary mission of the S-3A is to locate and identify conventional and nuclear-powered submarines. The Viking carries a comprehensive range of sonobuoys in support of the mission as well as various types of bombs, torpedos and mines. The crew consists of a pilot, copilot, tactical operator and acoustic sensor operator. The training site for the Viking is located at Naval Air Station (NAS) North Island, California.

The F/A-18 "Hornet" is the most recent tactical aircraft to be introduced to the Fleet. The Hornet is a single seat, twin engine, digitially-based weapon system which employs air-to-air missiles, light attack bombs and an internal 20 mm gun in support of its mission. Its mission includes the air-to-air fighter role and the light attack air-to-ground bomber role. The primary training sites are located at NAS Lemoore, California and NAS Cecil Field, Florida.

The F-14A "Tomcat" is a two seat, twin engine, swing-wing aircraft. The Tomcat carries the long range Phoenix missiles, shorter range air-to-air missiles and an internal 20 mm gun. The F-14A missions encompass both the roles of Air Superiority in the defense of the Fleet and the Strike Groups and the lessor role of Tactical Air Reconnaissance Pod System (TARPS) missions. The crew consists of the pilot and radar intercept officer (RIO). The primary training sites are located at NAS Miramar, California and NAS Oceana, Virginia.

CBT IN NAVAL AVIATION TRAINING SYSTEMS

The introduction and implementation of CBT in each aircraft community was accomplished in different manners. In each program there were successes as well as problems.

S-3A

Computer-based training was first introduced into S-3A aircrew training over ten years ago. During the early to mid-seventies, CBT was believed to be the solution to many training problems including the answer to automating training systems. However, due to the novelty of CBT and lack of experience through application, problems arose in many programs and CBT did not meet expectations. This early introduction of CBT into Navy aircrew training represented one of the first applications of CBT in military training. An examination of the experiences gained in this early implementation reveals the bases of some of the general problems encountered in many programs.

The initial CBT courseware for S-3A training was developed under two successive contracting efforts and was retrofit into an already existing training program. The concept of using CBT for simulation exercises and part task training had not yet been introduced, thus the first lessons were academic in nature. The lessons were interactive in the sense that after the student read through textual material, he was required to answer questions on the material by selecting from alternatives. Further courseware development under a second contracting effort included the use of CBT for simulation exercises to download some training from an aircrew position trainer.

One of the first problems with courseware development during these early efforts arose when the second effort had to be performed off-site. Although the first contractor had worked on-site at the training squadron, due to a problem with available on-site computer resources, the second effort was performed off-site at the contractor's plant. This immediately posed problems with respect to the need of a close liaison with the training squadron.

The second contractor worked off-site, delivering lessons as they were developed to the training squadron. While this system worked to some degree, the contractor ended up spending much time traveling to the site and would have preferred to be resident during the courseware development.

During the development, problems with reviewing the Lesson Specifications and CBT lessons by squadron subject matter experts (SMEs) arose. The SMEs did not know how to review these lesson materials. Many of the changes the SMEs requested were due to differences in their instructional styles rather than technical problems. In addition, because Navy aviation officers have two jobs, flying and their squadron duties, many were too busy to review the lessons in a timely manner. Thus, the turnaround on the lessons was very long, in some cases causing the contractor difficulty in meeting milestones and delivery dates.

To solve these problems, the contractor took two actions. First, a SME training course was offered. This was a one day course offered at the training squadron. All SMEs reviewing lessons were required to take the course. Second, their reviews had to culminate in one of three results: a) lesson accepted as is; b) lesson accepted as changed; or c) lesson ignored. Lesson Specifications or CBT lessons which were ignored were considered accepted as is after 30 days. This approach encouraged SMEs to look at the lessons in a more timely manner and if they were acceptable no further action was required of them thus saving busy aviators valuable time.

Another problem arose with respect to an older courseware development language used for the first set of lessons. An update to the CBT operating system required many of these lessons to be recompiled to run. Although civil service programmers were in place to operate the CBT system, the definition of their job roles did not include maintaining and updating the courseware. As a result, many of the early lessons were no longer operable. In addition, changes to the aircraft and/or learning syllabus resulted in the need to update courseware. Over time, as the CBT courseware became outdated, the CBT system was utilized less often.

The initial CBT courseware was not well accepted by the squadron training personnel or replacement aircrew. This was probably due to a combination of factors. CBT was a new, untried instructional medium in aircrew training; there were problems of keeping CBT concurrent with the aircraft; CBT was retrofit into an already existing training curriculum. At some point during the program, alternate media such as workbooks were introduced

that allowed the students to obtain the same materials found in the CBT lessons. In addition, a very long and detailed CBT lesson was developed and used to describe to students how to interact with the computer system. All this combined to lower the acceptance of the CBT system.

Although this early implementation of CBT was somewhat problematic, the experiences gained and lessons learned helped build toward success in other programs and in a later reconfiguration of this one. Lessons learned included:

- Subject matter experts must be trained to properly review written lesson materials and on-line lessons.
- Timely review by busy subject matter experts is difficult to obtain. Procedures must be established to ensure reviews that meet courseware delivery schedules, but that require minimal intrusion into operational schedules. This problem has surfaced in other programs as well.
- Due to the very high turnover of subject matter experts, an agreement must be reached that prior approval by predecessors is not arbitrarily changed due to personal preference or factors other than technical accuracy.
- To ensure close communication between the squadron and the courseware developer, lessons whould be developed on-site whenever possible.
- Tasking must be assigned for the maintenance and update of lessons once they are developed. This tasking should include a liaison function with the squadron training department to ensure that weapons systems, tactics and training objectives modifications are anticipated by CBT staff whenever possible.
- A means to keep the CBT concurrent with the aircraft would eliminate the need for alternate media. Concise introductions to the use of CBT would result in CBT being more acceptable to the students and instructors.

F/A-18

The F/A-18 pilot training program commenced in August 1982. A detailed description of the program including the use of CBT is provided in Williams (1). The potential for extended applications to tactical training scenarios is discussed in Williams-Easter (2).

The F/A-18 CBT development benefited and capitalized on the experience gained in the S-3A community. As a result, this program encountered far fewer problems. The development of the entire F/A-18 training system adhered closely to MIL-T-29053B, the standard provided by the Navy for Instructional Systems Development (ISD) efforts. This standard provides guidelines for the development and implementation of all facets of a training system.

Ongoing modification and management of all of the training media, including CBT, was planned and provided for by a management structure in which the ISD officer was responsible for all lesson materials. The management of the F/A-18 training program was described in detail in Rondestvedt (3). The ISD Department, as a whole, includes squadron military personnel, government service training specialists and on-site contractor support. The ISD officer coordinates all activities in support of the training system. When potential deficiencies are identified, the Training Department determines whether a change is required and forwards a formal request to the ISD Department. Subsequently, ISD implements the lesson change, which goes back to the Training Department for final approval.

Initially, the courseware was developed at the contractor's plant. Subject matter reviews of the courseware was accomplished by squadron personnel traveling to the contractor's plant. Communication problems soon arose. The Navy requested the presence of on-site CBT development personnel to fine tune the lessons as they arrived from the plant. Presently, an on-site contractor performs all lesson development and updates.

Each of the CBT lessons in the F/A-18 program contains interactive portions and the interest level of the students in the lessons and their acceptance of CBT is very high (2). Each lesson is composed of several segments corresponding to one or two training objectives. Each segment presents a text to introduce and discuss the objective(s) and proceeds to an interactive section that requires actions on the part of the students. In addition to holding students' interest, the part task trainer application of CBT allows students to practice procedures that would formerly have been trained and practiced in either a flight simulator or the aircraft. Therefore, the use of CBT as a part task trainer reserves these more valuable and expensive resources for the training of more complicated skills. Transfer-of-training from the CBT procedural lessons to the aircraft is evidenced by the successful demonstration of these skills in subsequent simulator or aircraft training sorties.

As part of a goal to provide maximum, easy accessibility to the F/A-18 courseware, the students' introduction to the CBT system consists of a short oral briefing to an entire class. Students receive the briefing while seated at the CBT terminals and are stepped through procedures to sign on, sign off, locate lessons, etc. After all students know the basics, they are stepped through the first segment of the first lesson. Since all the segments of the CBT lessons are structured in the same way, after the completion of the first segment students know how to use the CBT system. The process of introducing an entire class to the CBT system and training them to use it takes less than an hour.

Finally, a CBT Training Specialist, whose first task was to guide the implementation of CBT within the F/A-18 program, was assigned. In addition to directing all activities in the F/A-18 self-paced learning center, the Training Specialist also has the responsibility for coordinating all development and maintenance efforts of the contractor, the F/A-18 Training Squadron and the training device support detachment personnel. All procedures for student use, grade reporting, courseware standards and CBT system operation are established by the CBT Training Specialist.

In summary, the use of CBT in the F/A-18 training program was seen as extremely successful. However, this was to a great extent due to the experiences gained in the S-3A program. Most importantly, some of problems that had surfaced in the former program were able to be anticipated and avoided and, therefore, facilitated a smoother integration of CBT into the F/A-18 training system.

Some of the more important considerations in the implementation of the F/A-18 CBT system included:

- The CBT system, along with the entire training program, was implemented and then conducted according to an established guideline. In addition, this guideline continued to be closely followed. This provided structure for the program as a whole and helped to ensure the smooth integration of all of the individual media and training devices, including CBT.
- Assets required to keep the courseware concurrent with the aircraft and squadron training objectives are controlled by the ISD officer. The ISD Department makes modifications at the formal request of the Training Department.
- The presence of on-site lesson support ensures the concurrency of the CBT courseware with the aircraft and weapons systems, the compatibility of the courseware with releases of the CBT operating system and conformity with training squadron objectives. This helped to avoid the communication problems between the contractor and the squadron that tended to exist in the S-3A program.
- A short briefing was used to introduce a class to the CBT system. This concise, convenient introduction makes the CBT system more accessible to students. This is in contrast to longer, on-line introductory lesson which had been used in the S-3A program.
- A CBT Training Specialist was assigned to manage the implementation and use of CBT. This position provided a focal point for the use and management of the CBT system within the training program.

S-3A Update

In response to an identified need in the S-3A program to download training from a heavily used position simulator, an ambitious program of new courseware development was undertaken.

In this new implementation, the CBT lessons were designed exclusively as part task training segments for procedures to operate equipment in the S-3A aircraft. In contrast to earlier development in the S-3A and F/A-18 program, this large effort was conducted solely by government personnel; no contractors were involved. As in the F/A-18 program, a Training Specialist took a strong hand in coordinating and managing the effort.

In summary, as a result of both the initial implementation of CBT in the S-3A program and the F/A-18 program, this revision of the CBT system proved to be a very successful effort. Specific building blocks included:

- The demonstrated success of the previous use of CBT as a part task trainer led to the increased use of this application in the S-3A program.
- As in the F/A-18 program, a single focal point provided by the Training Specialist helped ensure success of the program.

F-14A

The F-14A CBT development is currently in the implementation phase of the initial development process. The ongoing status of this project offers the opportunity for a more detailed look at the development process. The F-14A CBT development, like the S-3A, is being retrofit into an already existing training curriculum. Thirty-five lessons were developed by the contractor using a team of contractor Subject Matter Experts (SMEs), Instructional Psychologists, Artists and a Programmer.

The F-14A Training Squadron based their CBT development on a different philosophy than did the F/A-18 Training Squadron. The F-14A Training Squadron chose to complement the existing training system by using CBT purely as a procedural part task trainer. The emphasis on the use of CBT in the F-14A program for simulation and part task training, capitalizes on the interactive capabilities of CBT. The CBT was viewed as an intermediate step before the students went to the simulators and aircraft. The F-14A Training Squadron expected students to obtain the basic aircraft systems information from the Naval Air Training and Operating Procedures Standardization (NATOPS) and lectures. In contrast, in the F/A-18 training system, the CBT covered the basic information as well as providing some simulation. The use of the NATOPS as an instructional medium was was not part of the formal syllabus although it remained the primary technical and operating procedures manual. For details on the CBT design used in the F-14A program, see Randel (4).

The F-14A development, like the F/A-18, followed the guidelines and standards established in MIL-T-29053B. However, a problem arose over what a Lesson Specification should constitute. The contractors delivered a standard specification but the Training Squadron was expecting something more along the lines of a storyboard. A compromise was established wherein the Lesson Specifications included many aspects normally found in the storyboard stage.

Another problem that arose early in the development process was that the Navy SMEs did not fully understand their responsibilities when reviewing preliminary materials for the CBT. The Training Officer, who served as the liaison between the SMEs and the contractor, would pass the Lesson Specifications along to the SME without specific instructions or guidelines on how to review the materials although these had been made available by the contractor. As a result, the Lesson Specifications would be reviewed for technical accuracy without thought as to how it would transfer to the interactive medium of CBT.

Lesson Specifications approved by the SMEs were subsequently storyboarded and programmed. When the SMEs would review the same lessons on-line, they requested changes to material they had previously approved. These changes often resulted in duplications of effort and could have been identified at the Lesson Specification phase.

An additional problem resulted from writing all the Lesson Specifications prior to any of the actual CBT development. Too much time elapsed between the start of an individual Lesson Specification and its draft acceptance on-line. Due to collateral duties, Navy reviews ranged from two weeks to over six months. Authors had to reread the NATOPS and relearn the details in order to write the storyboards.

Because of the extended length of time for complete development of each lesson, including the review process, there was little continuity of Navy SMEs. The SME that reviewed and accepted the initial draft Lesson Specification was seldom the SME that accepted the final CBT lesson, or in a number of cases, even the draft CBT lesson. In some extreme cases, each Navy review was conducted by a different SME, each requiring changes in style of lesson presentation rather than changes due to technical inaccuracies.

Finally, as is the case with all aircraft and weapon systems, modifications are made periodically. During the F-14A CBT development process, two modifications to the weapon system program tape were released. The second change occurred after many of the lessons had been accepted in draft form but prior to final acceptance. Therefore, many of the draft lessons that had been approved pending minor revisions suddenly required major rewrites prior to final acceptance. In addition, new lessons were still being storyboarded and programmed but because the other revisions also had to be made during the same time frame, less hours were available to devote to new lessonware development. Computer-based Training lends itself well to these types of updates and changes. However, the integration of such modifications should be carefully planned, when possible, to ensure it does not interfere with ongoing lesson development.

The courseware began being implemented in April, 1987. The first four classes were allowed to review the courseware on an optional basis. That is, slide/tapes continued to be required training materials while the CBT was on an "as time permits" basis. If the students desired to view the CBT, they could arrange to do so during their extra time.

During the implementation phase, only three computer stations were available for student use. The squadron has identified the need to buy a minimum of nine additional student stations and have the available funds. However, no contract vehicle currently exists through which the squadron can buy the hardware. As a result, although many of the students have used the CBT system diligently, others have not been able to use it because there were no terminals available during their free time.

One last point should be noted. Although not perceived as a problem at the outset of the F-14A development phase nor at the time of the S-3A development, the issue of retrofitting a new training medium into an already existing program requires special attention. The two CBT programs received more resistance and had more logistical problems than did the F/A-18 CBT program which was developed as a intregal part of the entire F/A-18 training curriculum. The contrast between the programs was especially apparent because of the overwhelming acceptance by all parties concerned in the F/A-18 program. The S-3A and F-14A CBT lessons appeared to be readily accepted by the students but the instructors were more reluctant about its instructional value.

In summary, the F-14A development built on previous development in the S-3A and F/A-18 programs.

- As in the revised S-3A program, the emphasis was to use the CBT system for part task training of procedures in a totally interactive mode.
- Using the philosophy of the F/A-18 program, a short oral briefing, followed by a brief on-line lesson is used to introduce students to CBT. Total orientation time is under one-half hour.
- From the problems encountered in the S-3A and initially in the F/A-18 programs, it was seen as mandatory to place the CBT development team on-site.
- Although problems arose (as discussed below), as in the F/A-18 program, the military specifications provided standard guidelines for lesson development and courseware management.

Because the F-14A development effort is in progress at the writing of this article, several problems are currently being addressed. These have been discussed in detail above and include:

- Contractors and squadron personnel had different expectations of what the deliverables required. A Military Specification (MIL-SPEC) outlining the format of CBT-associated deliverables should be developed.
- SMEs accepted Lesson Specifications without having sufficient knowledge of CBT. The contractor should have more direct access to SMEs to instruct them on review procedures, provide guidelines for acceptance of materials and to place emphasis on the importance of the paper reviews prior to the on-line reviews.
- Too much time elasped between the initiation of the Lesson Specifications and the completion of draft lessons. Timely review periods should be scheduled and the schedules should be observed. This would help to ensure continuity of SMEs reviewing the deliverables.
- Student reactions, as well as most instructor reactions, to the F-14A CBT has been extremely positive. However, in a few cases negative reactions were encountered. This was perhaps due to these instructors being satisfied with the existing training program and reluctant to change it. CBT should be part of the complete training system when new aircraft are introduced into

the Fleet such as the F-14D or when major modifications to existing aircraft are made, as is the case with the F-14A+. If CBT is to be retrofit into existing training, there should be careful consideration and planning so as to ensure the CBT is well integrated into the training syllabus at the time of implementation.

- The hardware requirements were not met by implementation of the courseware into the syllabus. The money and contracting vehicle for all pertinent purchases required for CBT development and implementation should be identified and ensured prior to the start of any CBT development effort.

CONCLUSIONS AND RECOMMENDATIONS

The Navy has implemented CBT in three different aviation training programs. In each case different conditions existed. In the initial S-3A program, on-site and off-site contractors developed courseware that was retrofit into an already existing program. In the F/A-18 program, CBT was acquired as part of the entire training system procurement. In the revised S-3A program, the courseware was developed entirely by government personnel. Finally, in the current F-14A effort, an on-site contractor is developing courseware to be retrofit into the training curriculum.

Despite the different conditions in which CBT has been implemented, it has been shown that lessons learned in one program provide the building blocks for successive programs. With the impending procurement of several new aviation systems, it would be most advantageous to develop a general set of guidelines which specifically address issues surrounding Computer-based Training in such programs. This set of guidelines should be kept up-to-date so that each development effort can benefit from previous lessons learned.

While some of the lessons learned in the CBT development efforts were communicated and served as building blocks, others were not. For example, the problems of SME reviews pervaded all three programs. In each case, the problem was managed or resolved. A communication vehicle which formally documents such problems and how they were resolved may have helped to avoid these problems in subsequent programs.

The authors suggest that the general set of guidelines being proposed be established as a "living document." This document would be updated by each contractor during or at the conclusion of each CBT development program. These updates or reports on lessons learned would be an identified task in the Statement of Work for every CBT contract. This document, including general guidelines and lessons learned, would be available both to those under contract and, perhaps more importantly, to those preparing proposals. The availability of such a document at the time of proposal preparation would help to ensure much more accurate cost and planning estimates.

A management perspective that looks ahead and anticipates problems must be developed. Prior to the implementation of the three CBT programs discussed in this paper, this would not have been possible. It would have been impossible to anticipate the various types of problems that occurred. However, the accumulated experience with CBT could provide a comprehensive data base to support the development of a set of guidelines for procurement, development, implementation and maintenance of Computer-based Training.

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