STONE AGE TRAINING IN A SPACE AGE ENVIRONMENT

Lt Colonel Rowland H. Worrell, III
1013th Combat Crew Training Squadron
Air Force Space Command
Peterson AFB, Colorado 80914-5000

ABSTRACT

Air Force Space Command was established in September 1982 to conduct operational missions in space. The need to support those missions with well-trained personnel led to the creation of Undergraduate Space Training, an organization tasked with providing its graduates with a broad base of space fundamentals, and the 1013th Combat Crew Training Squadron, a unit which provides system specific operational crew training. The courses provided by both schools were designed using Instructional System Development technology and utilize a media mix which includes lecture, computer based training systems and simulation. This paper addresses the problems of developing training programs and acquiring simulation capability to support training personnel stationed at more than 30 sites worldwide with missions that vary from flying satellites to warning of missile attack. The paper also discusses the use of networked desk-top computers to provide space operations center simulation and explores the management decisions required to determine proper media mix. It compares training results of the previous on-the-job training programs with new, full fidelity simulation. The paper closes with comments concerning training programs and simulation as an integral part of new space system acquisitions.

INTRODUCTION

During the birth and evolution of Air Force Space Command (AFSPACECOM), various missions were drawn together from agencies throughout the Air Force. The training programs supporting these missions, however, were routinely nonstandardized and depended heavily upon on-the-job training (OJT). While the Department of Defense has long used OJT methods for upgrade training, the lack of standardization and inefficencies inherent in OJT programs become training shortfalls when OJT is used for initial qualification training (IQT). These deficiencies, added to the risk of having students training with on-line equipment used to operate critical national systems, have characterized AFSPACECOM training--an inferior system which remained stagnant as operational requirements increased in number, duration, and technical complexity. In other words, AFSPACECOM had been using a stone age training system in a space age operations environment.

Any training system, however deficient, could profit from a systematic scrub of requirements and formalization of instructor lesson plans and other course control documents. For several years the Air Force has employed an excellent course development process called Instructional Systems Development (ISD) which provides the tools for repairing defective courses and developing new formal training. The bigger problem, however, lies not in revising classroom presentations, but rather in getting training off the operational equipment. The solution to that problem is simulation.

But the acquisition of full fidelity simulation equipment often presents severe technical and managerial challenges because of the wide variety of missions within space operations, the uniqueness of the many operating systems, and the small number of students that train for each system annually. A computer based training system (CBTS) may be the answer to some of these challenges.

THE NEED

If a trainee crashes an aircraft, the unit may have lost one vehicle in a fleet of 200. But if a trainee sends a bad command which disables a satellite in a single vehicle constellation, the unit and the nation may have lost the whole fleet. The danger of having a trainee passing information over a command and control network upon which our national leaders depend cannot be overestimated. However, operational risk is not the sole rationale for establishing a formal, off-line training program.

The space operations career field has grown significantly over the past several years in assigned missions and number of personnel. From its embryonic size of 500 operators in 1981, the field will expand to over 1900 by 1990. This rapid growth will inevitably be accompanied by a corresponding decrease in operator experience levels. A solid training program offers the only defense against this shrinking experience base and provides the only means to offset the impact of rapid personnel changes.

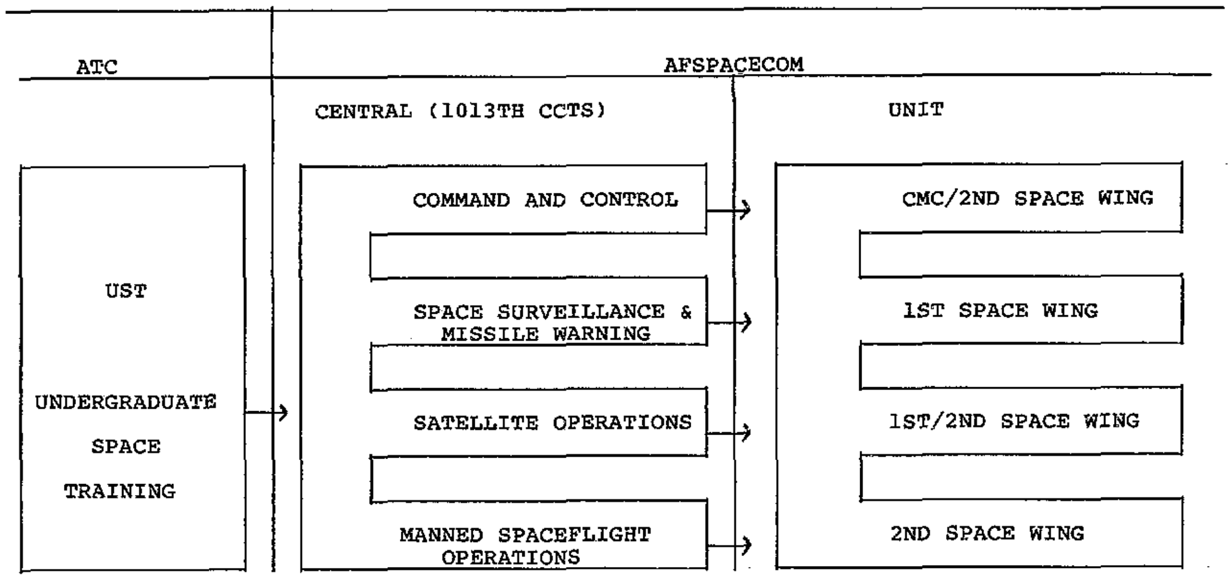

Figure 1. Concept for Space Operations Training

A TRAINING PLAN

The space operations career field includes four distinct areas: early warning, command and control, satellite operations, and manned spaceflight. In 1984 no existing organization or training system could capably handle the diverse set of training requirements attending these specialties. To correct the deficiency, AFSPACECOM and Air Training Command (ATC) conducted a joint review of space operations training requirements and established a training plan (Figure 1) which would not only meet current needs but also support the growth of the space operations career field. The plan called for a clear division of training responsibilities between ATC and AFSPACECOM.

Undergraduate Space Training (UST)

ATC assumed responsibility for developing a course of instruction which would provide a broad base of space knowledge to students preparing for a career in space operations, much the same as Undergraduate Pilot Training provides broad based, hands-on experience to pilot candidates. UST graduates could then enter any of the space operations specialties.

As developed, the school includes academics, computer based training (CBT), and generic simulation. The simulation not only teaches the skills needed for console operation but also emphasizes stress management to ensure students possess the characteristics required to work effectively in space operations centers. The simulation is generic in nature and does not require upgrade every time an operational system is upgraded. However, the operations skills trained and scenarios presented closely parallel the operational environment.

Crew Positional Training

AFSPACECOM's role in this new training concept is to provide crew positional training through a Combat Crew Training Squadron (CCTS). Following graduation from UST, new space operators come to the CCTS for system specific training. This training qualifies them to operate a crew position in a space operations center. The CCTS also provides a centralized schoolhouse to which space operators return for retraining prior to reassignment to new space systems or to upgrade to instructor status.

CCTS graduates are mission capable: they know the system, its checklists, malfunctions, and events but are not authorized to operate console positions unassisted by a certified operator. When graduates report to their unit of final assignment, they are assigned to operational crews. There they learn local site procedures and crew integration. Then, with their operational crew, they take the final check, qualify mission ready, and become certified operators authorized to work unassisted.

Like UST the CCTS uses academics, CBT and simulation in its training programs. Unlike UST the training is mission and position specific. CCTS instructors, therefore, must be fully qualified in the systems they teach, and all simulation must provide a large measure of fidelity with the actual equipment on which the students will later qualify. Additionally, whereas the basics which UST teaches rarely need updating, operational system changes and upgrades create a problem of currency for CCTS lesson plans, CBTS software, and simulation software and equipment. This challenge will be discussed as we visit each instructional medium individually.

The plan shown in Figure 1 is still in its infancy, but already there are significant reductions in on-site training times, and operators exhibit better system knowledge. The continued growth and success of this plan depend largely on quality courseware development and the continued acquisition and enlightened use of CBTS and simulation capabilities.

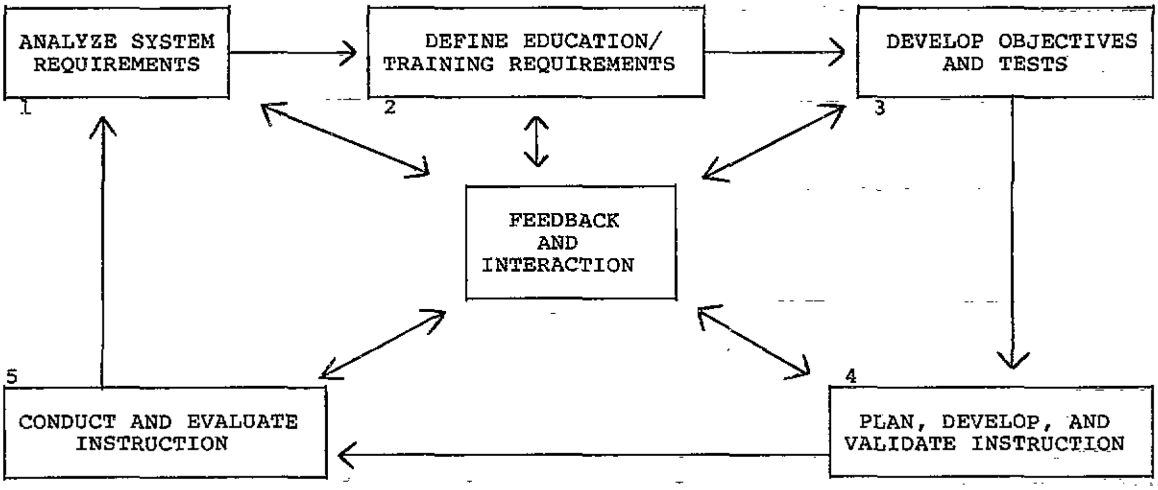

Figure 2. Air Force ISD Process

COURSEWARE DEVELOPMENT

Courseware development is a structured process which identifies training requirements and corresponding instructional methods. If the process is conducted properly and judicious course management decisions are made, then the product of these labors is a workable, cost-effective instructional system.

The Air Force subscribes to a process called Instructional Systems Development (ISD). It is nothing more than good management applied to training and the application of a systems approach to development and execution. All training components are logically interrelated. Each component has its own function, and each has an effect on other components. A change in academics affects the simulator, and adding new simulation equipment affects academics. The entire training system is an integrated whole.

The ISD process involves the five steps shown in Figure 2. The key to this process is that each step produces a predictable, quantifiable set of products. Each step utilizes the products of the previous step. The result is a chain of documentation into which changes can be readily infused.

Basically ISD uses actual job data from the field to formulate objectives and determine what needs to be trained. It then designs student centered courses which teach and test the objectives. Thus, student progress may be precisely measured against specific standards. This process, when combined with accurate, reliable feedback, results in an effective and efficient course of instruction.

MEDIA

The ISD process fails unless it accurately identifies the correct media by which each objective should be trained and reinforced. Classroom lecture, CBT and simulation are the primary tools used in instruction.

Classroom Lecture

With few exceptions, classroom lecture has been the backbone of Air Force academic instruction. The instructor is typically a subject matter expert and more often than not has operational experience in the system being taught. Assuming the lesson plans have been prepared in accordance with the ISD process, the lectures will be well structured, accurate and effective.

The advantages of the lecture medium include the ability of the instructor to enliven and personalize the class with his/her own operational experiences. It also allows the class to ask questions and receive an immediate response. As procedures change or new events take place, course material can be updated almost instantaneously. One instructor can teach a group of students simultaneously and typically requires no equipment other than a slide projector, overhead projector and chalkboard. Most importantly, the lecture medium provides an authentic, credible presence to motivate the class. In the space operator business, where assignments can be to the far extremes of the globe, motivation plays a significant role in how well students learn and subsequently how well they perform.

The few disadvantages of lecture include lack of opportunity for individualized instruction. Lecture is typically too slow for some and too fast for others. In addition, the instructor's ability and the attitude he conveys may be less than positive and present a potential liability to the class. Thus, ensuring quality control in the classroom becomes a more difficult task. Finally students are typically in the receive only mode and rarely afforded the chance to actively participate in the teaching process.

Full Fidelity Simulation

Conversely, full fidelity simulation is almost totally interactive. It puts students into a realistic semblance of the environment in which they will work. It usually pairs them one-on-one or two-on-one with an instructor. Lessons are precisely structured and the simulation is carefully controlled to ensure all students get the same information.

Despite the procedural diversity of space operations mission areas, all operators share the commonality of working from computer driven consoles which present radar or numerical data. Thus simulation is fairly easy to devise. By acquiring actual site consoles and a driver which will produce all site displays, targets and malfunctions, simulation becomes exact. Full fidelity simulation then provides the perfect environment in which to train and evaluate students. The obvious drawback, however, is that space operations consoles and computers to drive the simulation are expensive. System upgrades often require additional equipment be added to the system, thereby increasing the cost. Since many space operations sites are unique and replace only 10-15 operators per year, it becomes difficult to justify such an expense for each system. For those systems with low annual IQT requirements, a more cost effective method of training is required.

Computer Based Training Systems

CBT puts a student at a desk-top computer working self-paced through courseware displayed on the screen. Using an interactive process, the computer software will lead the student through the material, retraining wherever the student displays a lack of understanding. Instructors remain available to answer student questions. Recent studies indicate CBT is more efficient than the lecture method, and students consistently demonstrate better retention.

Using sophisticated software graphics or video disks, operator consoles can be simulated on the CBTS screen with an impressive degree of visual fidelity. Graphically displayed console switches can be "operated" by light pen or keyboard, producing true-to-life equipment reactions. Additionally, CBTS consoles can be networked to interact and provide full ops crew integration. CBTS simulation may not provide the realistic "feel" of sitting at a full size operations console, but it has the capability to simulate many different systems by simply changing the software. Obviously, the cost savings of buying software instead of consoles and computers is tremendous.

CBT, however, is not without its shortfalls. CBT is still a relatively new field, and courseware development and simulation software design tend to be labor intensive. The industry statistics for courseware production show 200 to 500 development hours for every hour of courseware produced. Simulation software is even more labor intensive. Also, authoring languages still tend to be non-user friendly. In many systems extensive programming skills are required to make even simple program changes. In view of the propensity for change that current space operations systems display, it is imperative that the CBTS be reprogrammable by a line instructor with only minimal programming skills.

THE MANAGEMENT CHALLENGE

Within the ISD process the first real management decision comes in determining the appropriate mix of lecture, CBT and simulation. Additionally, a management decision must be made concerning full fidelity simulation versus CBTS simulation. Both decisions must look at three factors: effectiveness, efficiency and cost.

For training to be considered effective, the student must reach specified levels of proficiency. Training effectiveness increases as students attain consistently higher proficiency levels. Efficiency of training deals with the amount of time required to attain a given proficiency level. Cost deals with dollars spent to acquire and maintain the training program. It includes both equipment and instructor expenses.

Together these factors define the overall goal of improved training productivity--better trained people in less time for less money.

As previously discussed, advanced technology--CBT and simulation--should increase efficiency and effectiveness. However, CBT systems and simulators require capital investments which cannot be ignored. Thus, a cost/benefit analysis must become a part of any course design effort and focus upon life cycle costs, changeability of the operations system, and the ease with which training media can respond to those changes. The decision process must evaluate whether the payback from increased efficiency will be greater than the cost of making it efficient.

NEW SYSTEM ACQUISITION

Each new system acquisition includes a training program for the initial cadre of operators. And although the Air Force pays for that training, rarely is it adequate for a continuing training program. To offset that deficiency and ensure new space systems acquisitions are delivered with a quality training program, a training office has been established within AFSPACECOM's Directorate of Plans. To assist them, the CCTS has developed a standard for courseware development, and a standard for CBT use is being coauthored by AFSPACECOM, ATC, and Air Force Systems Command.

RESULTS TO DATE

AFSPACECOM's CCTS started classes in January 1986 and graduated 682 students from seventeen different courses in its first year. Although many of these courses are still in the development/validation phase of ISD, the results are promising. Courses which were developed using lecture only have resulted in an average reduction of 35% in on-site training time. Courses utilizing lecture and CBT have experienced up to 45% reduction, and courses which include simulation have resulted in reductions of over 50% in unit training time. The training courses which incorporate full fidelity simulation have shown better results than those using CBTS for simulation, but only on the order of 10 to 15%.

Note, however, that these efficiencies have not been without corresponding increases in costs. While each hour of lecture required an average of only 31.7 hours of development time, each hour of CBT courseware required 292 hours and each hour of CBT simulation took 480 hours to develop. Finally, while constructing system tapes for full fidelity simulators took only 10-15 hours, the cost of equipment was prohibitively high at $1 to $5 million per simulator.

CONCLUSIONS

Although the space operator training courses are still young, several conclusions can be drawn.

An OJT program is too inflexible, unstandardized, and dangerous to be used for initial qualification training. It just cannot keep pace with a career field as technically complex and rapidly expanding as space operations.

Although any formalized academic program will shorten training time in the field, the greatest benefits are realized from a program which includes simulation that exposes students to the operational environment in which they will work.

Despite the fact that a live instructor tends to motivate better than a desk-top computer and can rapidly and inexpensively modify lesson plans, well-designed CBT courseware provides student paced efficiencies which classroom lecture cannot duplicate. However, courseware development typically requires computer programming skills and is still a labor intensive process. Full fidelity simulation yields the best training results. But for those systems with a low annual student load, CBTS simulation may be a more cost effective alternative.

Each operational system must be carefully reviewed to identify training requirements. Management must then analyze the need and predict course life cycle costs as a decision factor in acquiring an economical training system.

The challenge to industry is to develop user friendly CBTS authoring languages which can be used by both programmers and instructors.

As DoD budgets tighten, training is historically one of the first places to feel the pinch. But subjugating training is much like the Fram Filter Man saying, "Pay me now or pay me later." Only by smart, aggressive management can the Air Force acquire the cost effective training systems which will build a mature space operations training program...a program that will not only meet the demands of today, but also provide well-trained men and and women to meet the challenges of tomorrow.

ABOUT THE AUTHOR

Lieutenant Colonel Worrell is the Commander of Air Force Space Command's 1013th Combat Crew Training Squadron. He activated the squadron in December 1985 and has directed its growth from 12 to over 120 instructors and support personnel. He holds a Bachelors Degree from the Air Force Academy in Astronautical Engineering and a Masters Degree from the University of Colorado in Aerospace Engineering. He qualified as a Shuttle Landing Supervisory Officer and worked Shuttle missions as part of NASA's Flight Control team. In addition Lt Col Worrell spent fourteen years instructing and evaluating in numerous Air Force aircraft systems including the F-111D.