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Paper Session III-A - The Role of Simulation in Space Operations Training

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THE ROLE OF SIMULATION IN SPACE OPERATIONS TRAINING

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The mission of space operations has dramatically increased over the past decade. Increased responsibilities in the major areas of missile warning, space surveillance, satellite operations, and launch operations have driven the need for precise training of people working in these areas. To accomplish this training, the use of computer simulation is taking on a much larger and increasingly more important role.

The goal of any type of computer simulation is to emulate operational equipment and procedures. Exact duplication of the operational environment, equipment, and software to include known glitches is known as 100 percent fidelity and is a difficult goal to achieve. While such an effort is technically realizable, current and more realistic expectations are usually to achieve 80-95 percent of system fidelity. This is defined as high fidelity simulation.

Simulation has long been an important training tool in Air Force Space Command's missile warning and space surveillance mission areas. The maturity of these missions has driven the need for low fidelity computer simulation. Missile Warning simulators provide students with pre-recorded radar data used to train missile warning operations crews. Additionally, personnel assigned to space surveillance sites receive similar training using a low fidelity simulator known as the Granite Sentry Simulator system. Satellite operations training, however, requires a much higher fidelity simulation system.

The increased presence of Air Force Space Command in the new mission area of Satellite Operations has produced a strong demand for qualified operators capable of controlling a vast array of increasingly complex equipment. As more and more space systems are turned over to Air Force Space Command, duties formerly performed by civilian engineers employed by the systems' manufacturer have become the sole responsibility of "blue-suit" Air Force personnel. This growing demand has eliminated on-the-job training as a viable method of instructing new space operators while encouraging a centralized training concept.

Advances in computer technology have allowed instruction to be removed from the operational environment and transferred to organizations dedicated purely to training with space operations simulation. With today's technology, the training environment can emulate real-world facilities with amazing accuracy. Nowhere is this more true than in the area of satellite operations conducted by Air Force Space Command's 2d Space Wing.

The rewards of a high fidelity simulator in satellite operations are enormous. On-the-job training can be all but eliminated. As a training medium, on-the-job training is highly inefficient. Before centralized crew training, satellite operations personnel were given very little formal training. The bulk of the learning occurred after arrival at the assigned unit. Such a situation resulted in protracted classes and non-standardized training.

Using instructors who must double as operational crewmembers has drastically increased the amount of time it takes to train new personnel. In most cases this method doubles, if not triples, the number of calendar days required for instruction. Not only is the length of training increased, but a valuable crewmember, the instructor, cannot focus his entire attention on his primary task of performing operations.

As training programs developed, large amounts of training were done in the classroom; however, this instruction did not include any use of simulation. Students were handed paper copies of various satellite telemetry displays or state of health computer panels and queried on various anomalous conditions. Computer simulation eliminates these so-called "paper sims" and provides a hands-on learning environment which greatly enhances the students' retention of information and teaches real-time reaction to specific satellite operations.

While today's technology can allow near 100 percent fidelity, the software required to drive high fidelity simulations is still rather complex. In many cases, months and years of formal education is necessary to produce simulation designers who can develop simulator scenarios which can be used for student training. Ultimately, the goal of simulation designers and operators is to develop systems which are as user friendly as today's common word processing software. Such systems would allow novice computer operators to produce complex training scenarios with little or no effort and in a short time period.

Satellite operations training has started to mature to a point where it mirrors much of the instruction provided throughout the rest of the Air Force. Training in the 2d Space Wing is accomplished much like training in a typical flying or missile launch unit in that classes are held in a centralized location. The training is done under the auspices of the 1022 Combat Crew Training Squadron (CCTS). Computers and computer simulation play a major role in nine out of thirteen courses conducted with about 55-60 percent of each course using some form on hands-on simulator training.

The use of micro-computer technology as a training aid has increased at a rapid rate. Computer Based Training Systems (CBTS) have freed up valuable instructor time. The introduction of part-task trainers using off-the-shelf personal computers and custom software has allowed training of simple console operations to be removed from mainframe systems. Such actions free up valuable system time for more complex operations training.

The facilities employed by the 1022 CCTS are impressive, housing two stand-alone computer complexes dedicated solely to training future satellite operations personnel. The Mission Control Complex-Kernel (MCC-K) is a replica of an operational Satellite Control Squadron (SCS) located at Falcon AFB, CO. The system is driven by two IBM mainframe computers running actual operations software and using simulation databases. Six bays are available for conducting "team training" for groups of three students in each bay. These students are able to accomplish both operational training scenarios and required satellite control planning work. Each student works on a workstation identical to those used at the operational unit.

A second complex located at the 1022 CCTS facility, is a downscaled model of an operational SCS. Known as the MCC-K Annex, this simulator, which runs on one IBM mainframe using operational software, is limited by the size and type of database. While equipment similar to the MCC-K is used, only one student bay exists. This limits the amount of students trained at one time. Both simulators operate with no outside connectivity to the operational environment.

Simulators are used in a variety of ways to train 2 SWG students. These methods range from the demonstration to students of various tasks, to scripted team training which simulates a satellite contact in a crew environment. Regardless of the method, tasks center around planning satellite contacts, conducting normal operations, and identification and resolution of satellite system problems, with the latter task being perhaps the most important of these three. Launch and early orbit training is accomplished by using an additional simulation system in conjunction with the MCC-K and Annex.

Simulator training is designed to compliment the type of instruction being accomplished. Students with follow-on assignments to the 1st Satellite Control Squadron (1 SCS) are trained in only two of the three crewmember positions. The other crew position is an upgrade at the 1 SCS and does not require training at 1022 CCTS. Because of this, simulator training favors demonstration/performance type activities with follow-on self-paced individual practice. Each student is assigned an individual database for training console operations, planning functions, and telemetry analysis in a segmented environment. This separate database allows the student to make and recover from mistakes without affecting other students. The Telemetry Simulation System (TSS) is used in conjunction with the MCC-K and Annex to perfrom launch and early orbit training for the Global Positioning System satellites.

Console operations acquaint students with the workstation they will encounter at their follow-on assignment. Lesson plans are automated to eliminate the need for the one-on-one student/instructor ratio required in a typical on-the-job training environment. It also allows each student to progress at his or her own pace. Planning exercises mandate the use of simulator assets. Students are walked through all planning functions. This is an area of instruction that is impossible to teach without actual hands-on experience. Telemetry analysis, the final major area of instruction, is greatly enhanced by the use of actual computer screens. This is a vast improvement over the previous procedure of using paper copies of operational telemetry screens.

The training concept employed by instructors teaching future 3d Satellite Control Squadron (3 SCS) crewmembers is drastically different from that of the 1 SCS. Students are trained as crews with each crew or team consisting of three people in two crew positions. This approach mandates different simulator training. Although the basic areas of console operations, planning, and telemetry analysis are still presented, the material is imbedded in the instruction of the process of satellite contact operations.

Simulator training for 3 SCS students is designed to mirror the operational environment they will encounter at their follow-on assignment. This instruction, termed team training, is as closely matched to real-time satellite contact operations as possible. Each scripted scenario includes simulated calls by the student to all supporting agencies associated with a normal support. Real world checklists are used and students are required to accomplish all the tasks expected in a real life support.

Future 3 SCS simulation systems for UHF Follow-On (UFO) and DSCS III launch and early orbit (LEO) training are in the development phase. The proposed UFO simulator has the potential to simulate the satellite to MCC link allowing training to include all aspects of normal operation including LEO. GT SIM will aid training by inserting a telemetry wavetrain into operational equipment allowing crews to train in their facility with high fidelity simulated satellite data.

Training of these students stresses the pressure of time-critical actions, adherence to a schedule, and interaction with external organizations. Very little of this simulator activity is self-paced. Such an environment teaches the discipline necessary for operations in a fast-paced control center. Launch and early orbit training puts an added strain on the simulator. The complex communications required during launch are difficult to simulate. A simulator which provides vehicle-like signals throughout all systems permits people to rehearse their launch roles. Future plans call for a generic system which will provide high fidelity simulation for any satellite. This will reduce the manpower requirements and cost of supporting the proliferation of stand-alone simulators now used.

Training for personnel to be assigned to the 2d Satellite Control Squadron (2 SCS) is the only instruction at the 1022 CCTS which lacks computer simulation. Students with future assignments to perform 2 SCS Global Positioning System Master Control Station (MCS) crew duty receive only academic training at the 1022 CCTS. This is due to a lack of hardware and software to support centralized off-site training of people assigned to a MCS six-person crew.

Due to the lack of a simulator at both the 1022 CCTS and 2 SCS, students must receive hands-on training using operational equipment. This is part of the OJT they receive after they arrive at the gaining unit. The drawbacks of this are numerous. While the number of training days required to complete training of a qualified operator may not change appreciably, the number of calendar days is greatly increased. On-the-job training is not provided in a dedicated environment. Training always takes a back seat to real world operations. Instead of consecutive training days, many situations arise where training may occur every second or third day. Instruction slows or stops during periods of peak activity or crew evaluations. Such situations are becoming increasingly common as 2 SCS operational requirements increase.

In addition, only normal operations can be presented. Anomalies with the satellite or ground system cannot be trained This situation forces instructors to use a less effective system of "paper sims" to train satellite anomalous conditions. Such anomalies are hard to detect in this static environment because students lack the ability to cross check other information to insure their evaluation of a problem is correct. Students are forced to explain their response to a problem and do not benefit from the experience of hands-on resolution.

The technology to conduct 2 SCS simulation does exist. A part-task trainer is in the development stage and a high-fidelity crew simulator is in the planning stage. The part-task trainer is a PC based system with hardware and software providing detailed simulation of an actual crew workstation. With a flexible architecture, the part-task trainer is capable of simulating any mission scenario as viewed from a single crew position. Designed as an initial crew trainer, student databases are maintained and scenario scripts are organized into lessons. Tutoring prompts, in the form of pop-up windows, can be inserted into a scenario to guide the trainee, pause for short quizzes, or highlight important system responses. In addition to moving initial training beyond academics, the part-task trainer will serve as a near term solution to removing some training from the 2 SCS operational equipment. The high-fidelity crew simulator, Crew Training and Software Maintenance Facility (CTSMF), will be similar to the MCC-K and Annex. The system will use a mainframe

IBM computer to allow stand-alone simulation independent of operational equipment. As operational requirements increase and the availability of training time on the operational system decreases, dedicated simulator systems will become invaluable.

The 1000 Satellite Operations Group (SOG) has what is perhaps the highest fidelity and most user friendly simulator in use by 2 SWG at this time. Computer simulation is conducted on a stand alone 32 bit Data General system which is used to export information to operational equipment at Defense Meteorological Satellite Program (DMSP) sites at Fairchild AFB, Washington and Offutt AFB, Nebraska. This full fidelity system was constructed partially with spacecraft components which makes for a dynamic system which responds to operator inputs without instructor intervention. The system is user friendly in that training scenarios are constructed using windowed software with mouse selection. Unlike other simulators, the 1000 SOG system is capable of emulating launch and early orbit activities.

Simulation of satellite vehicles is not the only use for computer simulators. The satellite ground system is an integral part of the overall control process. Instruction for students assigned to the Resource Control Center uses computer simulation to mirror the Air Force Satellite Control Network. Ground system anomalies can be presented to students to support academic instruction and problem resolution.

The process of making mistakes during training is an integral part of the learning process. Simulators allow students to see the effects of an improper response to an operation without any degradation to the equipment or system they are using. Instruction on real world equipment does not allow this luxury with equipment that is valued in the billion dollar range and a satellite at the end of the communications link.

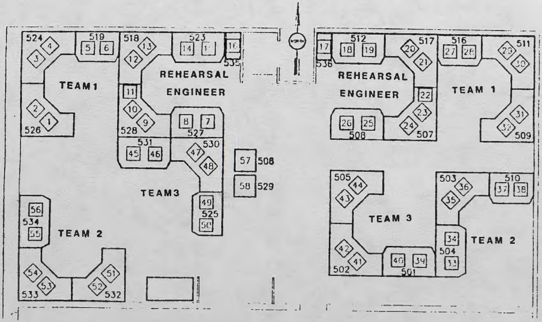
The benefits of centralized simulator usage as an instructional tool can not be understated. The saving in training days alone has been dramatic. Purely OJT training for Satellite Control Squadron crews requires approximately 425 calendar days to complete. The typical course at the 1022 CCTS averages 120 calendar days. Because assets are dedicated only to training and not a combination of operations and training, instruction can be done more efficiently. Continuity of training can be preserved as classes can be planned and conducted on a daily basis.

Computer simulation allows a student to be trained to a level which he or she can transition to operational status with very little additional unit level training. This is exactly the opposite from students who do not benefit from simulator training. These students have demonstrated that they are slow at performing tasks and at a risk to operations until their proficiency is improved through months of operational duties.

non-threatening environment and can benefit from poorly timed or inaccurate decisions.

Finally, simulator training allows dedicated instruction. In an operational environment real world operations must take priority over training. In a simulated environment the continuity of training is preserved. Constant interruptions on real world equipment mandates increased training time because many tasks must be retrained after extended breaks in training.

It is becoming increasingly obvious that the future of space operations training lies with computer simulation. The savings in money and manpower alone dictate this medium of instruction as the most efficient possible. As technology improves, simulation can, and will, be driven to the personal computer level in many cases. The overall effect will be more efficiently trained crewmembers who will be ready to assume crew duties as soon as they arrive at the unit.



MCC-K TERMINAL ROOM