A UNIQUE AIR FORCE C2 TRAINING SOLUTION FOR MODULAR CONTROL SYSTEMS

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ABSTRACT

A number of solutions have recently been proposed to provide effective training for the Air Force (AF) battle management crews responsible for tactical-level command and control (C2) in the in the Theater Air Control System (TACS) Modular Control Equipment (MCE). Some proposed solutions include intelligent tutors and stand-alone systems. Stand-alone systems currently do not provide training for the complete TACS MCE functionality.The most effective way to provide TACS training is to have the trainees employ the equipment they actually use, interfaced with other TACS entities, and all operating in a realistic synthetic battlespace. The immediate problem with the stimulation of the MCE to provide "in box training" concerns the difficulty and expense in integrating to the Military Standard (MIL STD) Naval Tactical Data System (NTDS). There are two alternatives to provide this type of MCE stimulation: (a) Reengineer a proprietary gateway to translate standardized simulation data to NTDS format, or (b) Use a remote radar port with an existing gateway to access the MCE. The first option, which proved costly, was prototyped and reported in other papers. The second option became available through the Joint Expeditionary Forces Experiment (JEFX) 2000, where Distributed Interactive Simulation (DIS) data from several simulations was integrated to real-world, next-generation C2 systems. Use of this existing translator from real-world experiments was then applied to solving the training deficiencies for TACS with emphasis on the MCE. This paper will report the success of a demonstration of that reusable interface and the future plans for this innovative approach to provide expanded MCE training

AUTHORS' BIOGRAPHIES

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INTRODUCTION TO THEATER AIR CONTROL SYSTEMS/ MODULAR CONTROL EQUIPMENT

The AN/TYQ-23 MCE provides the Air Force with a transportable TACS automated air C2 system for controlling and coordinating the employment of aircraft and air defense weapons. A complete description of the MCE may be found in the following references: Janes (1994), Litton (1995a, 1995b), and Defense Information Systems Association (DISA) (1997). The Air Force version of the MCE uses the AN/TPS-75, three-dimensional, long-range, high-power, air defense radar.

The basic system element of the MCE is the Operations Module (OM). A single OM is comprised of a six-meter enclosure and contains the C2 equipment, including a full range of tactical digital datalinks to perform the air defense function. System sensors and power supplies are external to the shelter. Figure 1 shows an operator inside the OM, and Figure 2 shows the MCE with two OMs.

Figure 1. Inside the Operations Module

Figure 2. Modular Control Equipment

Up to five OMs can be interconnected through the use of fiber optic cables to provide variable OM configurations at locations of up to 500 meters for tactical or terrain advantages. Typical configurations are four OMs for the Control and Reporting Center (CRC) and two OMs for a Control and Reporting Element (CRE) configuration. The local radars can be located up to two kilometers from the OM and are connected using fiber optic cable. Remote radars can be located at various distances and are only limited by the capability of the medium being used to transmit data to the OM.

Automatic target detection, acquisition, and tracking are accomplished by an automatic radar/Identify Friend or Foe (IFF) capability in the AN/TPS-75 radar system. The tracker software is installed in the Modern Tracking System (MTS) located in the radar shelter. The MCE surveillance tasks include the correlation of tracks reported from the MTS with other system tracks and with tracks received from digital data links from other sources. Automatic identification (friend, unknown, hostile) and classification (fighter, bomber, tanker) are also performed by the surveillance function. This function also performs automatic threat evaluation and classifies aircraft and air-to-surface missile tracks according to their potential threat to defended assets.

Within the OM, the weapons control function provides the capability to exercise positive control of fighter aircraft employed in tactical operations: air defense, counter-air, interdiction, close air support, reconnaissance, refueling, search and rescue, and missions other than war.

Inside each OM are four multicolor operator monitors for four C2 operators. These displays provide real-time information about the various tracks on the planned position indicator displays in regard to range and azimuth as well as IFF and jamming status. The display shows superimposed track symbols, map or overlay lines, and alphanumeric data. There is a monochrome auxiliary display presenting stored alphanumeric data to supplement the situational display. Touch sensitive screens allow the operator system control.

CURRENT TRAINING SYSTEM DEFICIENCY

The MCE has an embedded training capability known as MC SIM (Litton, 1995b) that allows the OM to be put in a training mode where target tracks and raw video are simulated. An update to MC SIM added an external workstation that emulates the OM's operator control unit and provides an instructor remote control over the embedded simulation programs and scenario generation. This allows all four of the consoles in the OM to be dedicated to the training exercise. Without this update one of the OM consoles would be required to execute the embedded simulation and would be unavailable for operator training.

The MC SIM is difficult to use and inadequate for preparing operators for theater and full-mission duty (Chubb, 1997). The existing simulation and portrayal of the synthetic forces is not scalable and does not provide realistic autonomous behaviors. There are other disadvantages associated with MC SIM. *First*, it requires operators to run the simulation, and they are not proficient in console inputs, so they are not able to maintain the tempo required. *Second,* the Operational Training Officer (OTO) has no ability to insert events in the synthetic battlespace that were not already preprogrammed to occur. *Third,* "kills" and "drop track" commands do not occur as rapidly as their real-system counterparts, creating an unrealistic situation display. *Finally*, the existing training options and portrayal of synthetic forces is not easily or cost effectively interoperable with other distributed simulations.

When an MCE “Schoolhouse” was established in 1999, it was stood up with limited funding and an immediate training need. The existing training system described earlier is not sufficient to meet the requirements of the "Schoolhouse." Therefore, any technology or training strategy designed to assist the Schoolhouse in meeting their training requirements had to be low-cost, and available as soon as possible.

PAST RESEARCH AND PROTOTYPES

AFRL has been experimenting with stimulation of the actual MCE equipment over the past few years (George, Brooks, Conquest, & Bell, 1998; George, Brooks, Bell, Breitbach, Steffes, & Bruhl, 1999). Stimulation requires the use of actual operational equipment. In stimulation, an external synthetic battlespace provides target state, behavior, and environmental effects that would normally be represented by the radar and detection algorithms. Ideally, the operator should not perceive any difference between the real and stimulated systems. Stimulation has the advantage of easily supporting upgrades to the operational hardware, training at site, and providing a training environment that the operator is accustomed to.

This concept has been partially demonstrated with the stimulation of the MCE with Joint Semi-Automated Forces (JSAF). JSAF has been integrated to the MCE system via the Litton gateway providing tracks on the operator displays. The proprietary gateway used with the embedded training system allows simulated entities to be communicated and then displayed in the OM. The interface software in the Distributed Interactive Simulation (DIS)/MCE translator uses DIS 2.0.4 protocol to communicate with JSAF. Much of the interface software was reused from the AFRL Network Interface Unit software developed for the Distributed Mission Training (DMT) testbed and hosted on a Sun Sparc workstation. The radar system and tracking functions are simulated using entity state data from the computer generated forces (CGF). These tracks also have the simulated video from the Remote Interface Unit (RIU). The raw video functionality is from the existing embedded simulation system. The ability to display JSAF tracks was demonstrated in the summer of 1998.

The MCE stimulation program was further extended to the RoadRunner ‘98 DMT exercise that was conducted by AFRL in the summer of 1998. JSAF was hosted by AFRL at Mesa, AZ, and provided synthetic entity state information for the two remote sites to the 107^{th} Air Control Squadron (ACS) in Phoenix, Arizona, and the 133d ACS in Fort Dodge, IA.. This prototype evaluation indicated that the use of the proprietary gateway and reverse engineering the interfaces was not the best approach in regard to overall cost and in providing a full training capability. The use of existing interoperable simulation techniques and interfaces proved to be a more cost-effective and lower risk approach to provide an immediate "Schoolhouse" training solution.

DESCRIPTION OF CD2 CONVERSION AND MCE INTERFACE

In order to stimulate the OM, the synthetic battlespace/CGF data must be translated into a format that OM Digital Data Bus (DDB) can use in its native format. This requires a translator from the DIS context to the OM format. Based on proven performance during JEFX, a reusable low-cost translator developed by the Solipsys Corporation and known as the Multi-Source Correlator Tracker (MSCT) Simulation System was investigated. The MSCT takes DIS data from interoperable simulations and converts to the Federal Aviation Administration (FAA) standard Common Digitized 2 (CD2) format, which can then be connected directly to the MCE OM. The simulator is personal computer (PC)-based and is a cost-effective approach to MCE stimulation using existing hardware and software assets. A proof-of-concept test of this solution was done at the 133d ACS (Iowa Air National Guard) in December 2000 and will be discussed in the next section.

JSAF was selected as the initial CGF, although any DIS-compatible CGF could have been used. For example, the Joint Interim Mission Model (JIMM) might have been used instead. JSAF was selected based on our past experience with this system, a very user-friendly scenario generation capability, and the availability of highly autonomous AF entities (the Air Synthetic Forces (AirSF) portion of JSAF) using the SOAR (Taking a State, applying an Operator And generating a Result) expert behaviors (Johnson, et al., 1994). These types of autonomous entities are desirable to reduce the workload on role players. Entities from AirSF perform their missions autonomously and integrate seamlessly to the virtual simulators. Once briefed, they plan and execute their missions in conjunction with the virtuals using appropriate doctrine and tactics.

Even though each entity is autonomous, it is not acting in isolation. Individual entities coordinate their actions using existing doctrine and Command, Control, Communications, Computers, and Intelligence (C^4I) systems. They use shared knowledge of doctrine, tactics, and mission objectives as well as explicit radio communication to achieve common goals. As the mission develops, entities may change roles dynamically as in the real world.

AirSF provides behaviors for most commonly flown air roles and missions including: air-to-air (Defensive Counter Air (DCA), Offensive Counter Air (OCA), and escort), air-to-ground (strike and Suppression of Enemy Air Defenses [SEAD]), control (Forward Air Control (FAC), Air Electronic Warfare (AEW), Ground Control Intercept (GCI), reconnaissance, and refueling. It can provide friendly, opponent, or neutral forces.

As illustrated in Figure 3, JSAF provides DIS entity, emission, and event Protocol Data Units (PDUs) to the translator.

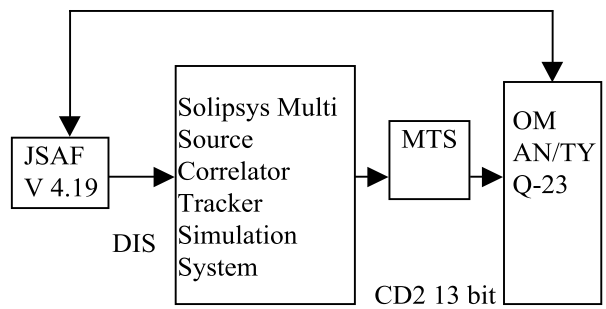

Figure 3. The Stimulation System Block Diagram

The translator interfaces directly to the MTS. The MTS operates with any radar as a stand-alone system, accomplishes sensor integration with command and control centers, and supports multi-radar integration activities. Designed for continuous, unattended operation, the MTS automatically initiates and tracks targets throughout the surveillance volume of the radar. It adapts automatically to accommodate changing environments. Both air and surface targets with velocities from zero to 40,000 knots (kts) can be tracked. The MTS initiates tracks in clear, cluttered, and high-density regions, with a full air picture established.

Communication back to role players at the JSAF monitors is accomplished using normal communications channels from the OM. Currently the 133d ACS is exploring the possibility of interfacing SoarSpeak, which would provide voice control of synthetic, SOAR-based entities. SoarSpeak uses natural voice recognition and speech generation to direct and interact with synthetic, constructive entities controlled by the AirSF air behavior system. This capability allows such synthetic entities to maintain autonomy, flexibility, and realism. Rather than requiring a system operator to manually intervene to change an entity's behavior, SoarSpeak allows OM operators and relatively untrained role players to retask aircraft via voice directives, which will provide a realistic training capability.

RESULTS OF DECEMBER 2000 DEMONSTRATION

The Solipsys MSCT Radar Simulation System was delivered to the 133d ACS on 18 December 2000. This system was used to integrate JSAF to the MCE, fully stimulating the OM. Completed integration and testing was completed on 20 December 2000, illustrating the ease of integration. Photos of this equipment may be seen in Figures 4 and 5 below.

Figure 4. Solipsys MSCT Radar Simulation System on left and Litton MTS on right

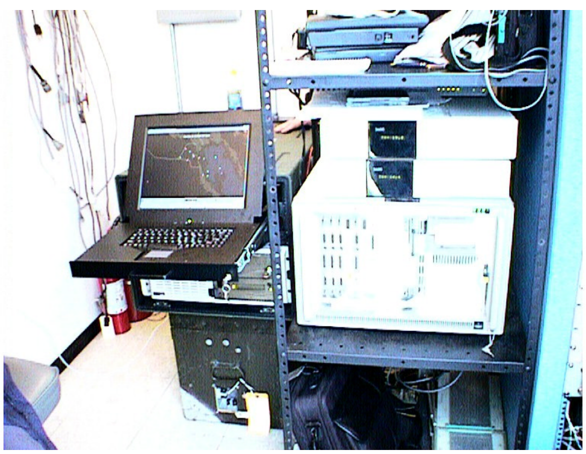

Figure 5. Solipsys MSCT Radar Simulation System with Flat Panel Dispay/Keyboard Drawer opened

The MSCT Radar Simulation System consists of a collection of hardware and software programs that provide the impetus to stimulate external systems with radar data in the CD2 13-bit format. The software was pre-installed by Solipsys Corporation prior to shipping. The hardware platform provided by Solipsys Corporation with this delivery included a rack-mounted computer with the following specifications:

- Dual Pentium III 750 Mega hertz (MHz) Processors
- 512 Mega-byte (MB) Random Access Memory (RAM)
- 18 MB Removable Hard Disk Drive
- Viper II Video Card with 32 MB Memory
- 15” Active Matrix Rack Mount Flat Panel Display/Keyboard Drawer
- Internal Compact Disk (CD)-Read Only Memory (ROM)
- Internal 3.5” 1.44 MB Floppy Disk Drive
- PTI-334 RS-232 Synchronous Interface Card (4 serial ports)
- Windows NT 4.0 Workstation Operating System

The MSCT Radar Simulation System is configured to receive input from JSAF, which provides simulated synthetic battlespace. JSAF delivers DIS PDUs via User Datagram Protocol/Internet Protocol (UDP/IP) network packets. The MSCT Radar Simulation System successfully received all simulated entities and events, which were provided to the Solipsys Tactical Display Framework (TDF) for display. In addition, air assets within the coverage area of a user-defined simulated radar were then passed to the Litton MTS system for further processing.

The MSCT Radar Simulation System is used to output simulated radar data to the Litton MTS system. The MSCT Radar Simulation System outputs CD2 13-bit formatted messages via an RS-232 synchronous serial port. Due to the limited documentation for the internal workings of the Litton MTS system, several key elements to this interface had to be addressed on-site in a reverse engineering manner. To illustrate, it was discovered that each byte must be inverted prior to transmission to the Litton MTS system. The configuration and integration was completed successfully, with the Litton MTS system displaying plots and initiating tracks based on the MSCT Radar Simulation System output

The demonstration showed that several hundred simulation entities could be displayed in the OM. The operators received a week training in JSAF operation and scenario generation capabilities. This was sufficient for the operators to execute various missions and scenarios. The displayed tracks represented both high autonomous entities based on AirSF behaviors as well as lower fidelity models based on standard ModSAF task frames. The demonstration further illustrated the ease of using reusable assets that promote interoperability and standardized interfaces. The gateway also provides the opportunity to interface virtual devices such as a four ship from the AFRL

Warfighter Training Research Center manned simulation facility in Mesa, AZ.. This innovative concept and solution fits well into the Air Force's Distributed Mission Training (DMT) vision that ultimately will integrate live, virtual and constructive simulations.

FUTURE DIRECTION OF THE TRAINING SOLUTION

At this time, the MCE Schoolhouse personnel are extremely anxious to obtain this capability because they feel confident that it will be valuable in helping them to meet their training requirements. The system that was demonstration in December of 2000 provides the capability for training immediately. This solution provides a quick cost effective solution that the Schoolhouse needs today. Other anticipated training advantages of this solution include the following:

- JSAF and DMT provide higher fidelity of training
  - JSAF aircraft perform realistic maneuvers and have automatic kill removal
  - JSAF allows rapid generation and archival of training scenarios to meet instructional objectives
  - Manned cockpits in DMT provide practice in communication with actual pilots
  - DMT allows all data to be recorded and played back for debrief
  - DMT provides the opportunity to train as part of the combat team in the Joint Synthetic Battlespace
- Reduced training time is anticipated
- JSAF does not require many "sim drivers," which will result in reduced manning for simulation training.
- Training from your home unit via DMT results in Temporary Duty (TDY) cost savings and reduced scheduling conflicts
- Creates potential to expand to include Joint Service Training Exercises (JSTEs) and training with additional C2 platforms via DMT.

Unfortunately, when the next version of MCE software is installed, the MCE will no longer have an MTS. This means that the current interface discussed here will no longer work. The authors are currently working with Solipsys on a low-cost interface without the requirement of an MTS. When this non-MTS interface is complete, it will be possible to interface all Department of Defense MCE equipment together and with DMT. For this reason, Aerospace Command and Control and Intelligence, Surveillance, and Reconnaissance Center (AC2ISRC) and Electronic Systems Command (ESC) personnel have recently expressed interest in making the interface part of the GTACS Modernization Program.

Personnel at the 133d ACS are planning Systems Training Exercises in the very near future using the MSCT. AFRL and the 133d ACS are hoping to participate in major simulation exercises such as Desert Pivot and Blue Flag using the MSCT, and are exploring the possibility of conducting a Joint Service Training Exercise (JSTE) in this manner. Although the interface technology is available, the manner in which these tools can be used for maximum training effectiveness has not been determined. Therefore, training research will be required to determine optimum use of these training tools.

A final key point is that the interface allows for "plug and play" capability of any other DIS simulations. An ongoing evaluation of various CGF's by AFRL indicate that any one CGF does not entirely meet all requirements for C2 training. For example JSAF is weak on link simulations for other sensor interfaces and higher level command structures. A new concept of distributed hybrid systems of CGF's is being explored (Dion et. al. (2000)) that allow various simulations to fuse together providing the strong points of each to meet training requirements. For example a training solution might use JSAF for entity level simulations and the National Aerospace Model (NASM) be used for higher level command and links to other sensor and intelligence assets. Hybrid systems allow for cost effective training systems using existing assets as much as possible rather than developing new simulations.

CONCLUSIONS

Reuse of existing interface hardware and software that is fully interoperable has provided a cost-effective stimulation system to provide a training environment for the Modular Control System. The demonstration showed an effective solution that provides a "Schoolhouse" capability for the MCE operators. It immediately provides on-demand training for the majority of C2 training requirements in the setting and environment that the operator is most familiar. The design leverages on interoperability standards that allow for full training scenarios of live, virtual, and constructive operation in a Joint Synthetic Battlespace which is part of the DMT vision. The concept allows for expandability and scalability using hybrid systems to meet all expanding C2 training requirements.

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