A New Interface for Air Force Modular Control Systems with Distributed Mission Training

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ABSTRACT

In order to accomplish training for Air Force (AF) battle management crews responsible for tactical level command and control (C2) in the Ground Theater Air Control System (GTACS), a translator called the Multi-Source Correlator Tracker (MSCT) Simulation System from the Solipsys Corporation was used to interface the Modular Control Equipment (MCE) with Distributed Mission Training/Operations (DMT/DMO). Although the Multi-Source Correlator Tracker (MSCT) has served as an interface for operational Modular Control Equipment (MCE) and DMT/DMO for several years for the 133 Test Squadron, stimulation of the operational MCE required a piece of operational equipment known as the Modern Tracking System (MTS). The MTS was a limited solution because there are only six MTS units in the Air Force (AF) inventory,

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and they are very costly to operate and maintain. The MTS was never fielded operationally and it remains an experimental system today. This paper will report on an MSCT that does not require an MTS, which is known as the Tactical Air Operations Module Interface (TAOMIF). In addition to providing the interface technology to bring operational equipment into DMT/DMO simulation exercises for enhanced initial, continuation, joint service, and coalition training, the TAOMIF technology provides the foundation for a potential system of the future for ground-based Air Control Squadrons (ACSs). The TAOMIF provides a proven DMT option for Air Control Squadrons (ACSs), but more importantly, it is complimentary to other DMO solutions ACC is considering in it's pursuit to enhance GTACS combat training at both the tactical and operational levels.

INTRODUCTION

Instructors and operators have proposed a number of solutions to provide effective training for the Modular Control Equipment (MCE) crews responsible for command and control (C2) in the ground Theater Air Control Systems (TACS). The most effective way to provide TACS training is to have the warfighters employ the equipment they actually use, connected to other TACS elements, and all operating in a realistic theater synthetic battlespace. There are several complimentary approaches being considered by Air Combat Command (ACC). The purpose of this paper is to highlight a joint development effort by the Warfighter Training Research Division of the Air Force Research Laboratory (AFRL/HEA) and the Iowa Air National Guard.

Stand-alone systems currently do not provide the level of fidelity required for trainees to comprehend the complete TACS MCE functionality. In order to accomplish such training for MCE operators, a translator called the Multi-Source Correlator Tracker (MSCT) Simulation System from the Solipsys Corporation was used to interface the MCE with Distributed Mission Training/Distributed Mission Operations (DMT/DMO). Although the MSCT has served as an interface for operational MCE and DMT for several years, an expensive, unreliable piece of operational equipment known as the Modern Tracking System (MTS) was required. This was a limited solution because there are only six MTS units fielded in the Air Force (AF) inventory. Therefore, the MTS remains an experimental capability that is being phased out and has no logistical support program. In order to make the interface available to as many Air Control Squadrons (ACSs) as possible for enhanced training, the MSCT has been upgraded to fulfill the functions of the MTS. This MSCT is known as the Tactical Air Operations Interface (TAOMIF).

THEATER AIR CONTROL SYSTEM/MODULAR CONTROL SYSTEM/MODULAR CONTROL EQUIPMENT

The AN/TYQ-23 MCE provides the AF 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 AF version of the MCE uses the AN/TPS-75, an early warning, surveillance 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 combat air operations. System sensors, power supplies, and environmental control 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. Automated 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 Modular Interface Group (MIG) located in the radar shelter. The MCE surveillance tasks include the correlation of tracks reported from the MIG with other system tracks and with tracks received from other sources. Automatic identification (friend, unknown, hostile) and classification (fighter, bomber, and tanker) are 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 Operator Console Units, each designed to support a C2 operator. These displays provide real-time information about the various tracks on finger-on-glass computer displays regarding 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 to interact with and change system capabilities as required.

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, including the items below.

- MC SIM requires operators to run the simulation and the external workstation is not user friendly. There is no formal training program for operating the workstation and if operators are not proficient on console inputs, they are not able to maintain the tempo required.
- The Operational Training Officer (OTO) has no ability to insert dynamic events in the synthetic battlespace to enhance the training scenarios.
- "Kills" and "drop track" commands do not occur as rapidly as their real-system counterparts, creating an unrealistic situation display.
- The existing training options and portrayal of synthetic forces is not easily or cost effectively interoperable with other distributed simulations.

The current training configuration does not allow operational crews to participate in task-saturated events that fully exercise GTACS mission taskings. Participation in DMT/DMO exercises is key to meeting this warfighter requirement. A potential tool to achieve this goal is TAOMIF.

ENHANCED TRAINING OPPORTUNITIES

At this time, the ACS community is extremely anxious to obtain the interface to the Operations Module to provide up-to-date training scenarios to satisfy current initial and continuation training requirements. The Solipsys MSCT provides a quick, cost-effective solution that meets training needs in a fast changing C2 environment.

Other anticipated training advantages of this solution include the following:

- Joint Semi-Automated Forces (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 with other operational weapon systems
- Reduced training time is anticipated.
- JSAF does not require many "sim drivers," which will result in reduced manning for simulation training and a more focused training environment.
- 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 joint coalition training via DMT/DMO.

THE SOLIPYS MULTI-SOURCE CORRELATOR TRACKER INTERFACE

The Solipsys MSCT Radar Simulation System was used to integrate JSAF to the MCE, fully stimulating the OM. Photos of this equipment may be seen in Figures 3 and 4 on the next page.

Figure 3: Solipsys MSCT Radar Simulation System on Left and Litton MTS on Right.

Figure 4: Solipsys MSCT Radar Simulation System with Flat Panel Display/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:

Mutli Source Correlator Tracker

- 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
- Windows NT 4.0 Workstation Operating System

Source Integration Server

- Pentium 4.2 Gig Hertz Processor
- 4 – PTI-334 RS-232 Synchronous Interface Card (4 serial ports)
- 15” Active Matrix Rack Mount Flat Panel Display/Keyboard Drawer
- 256 MB RAM
- 18 MB Removable Hard Disk Drive
- Internal CD – ROM
- Internal 3.5” 1.44 MB Floppy Disk Drive
- Windows NT 4.0 Workstation Operating System

The MSCT Radar Simulation System (RSS) is configured to receive input from JSAF, which provides simulated synthetic battlespace. JSAF delivers Distributed Interactive Simulation (DIS) Protocol Data Units (PDUs) via User Datagram Protocol/Internet Protocol (UDP/IP) network packets. The MSCT RSS 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.

DESCRIPTION OF CD2 CONVERSION AND MCE INTERFACE

In order to stimulate the OM, the synthetic battlespace/computer generated force (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.

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 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, Jones, Koss, Laird, Lehman, Nielsen, Rosenbloom, Rubinoff, Schwamb, Tambe, van Lent, & Wray, 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, GTACS operators 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), Airborne Early Warning (AEW), Ground Control Intercept (GCI), reconnaissance, and refueling. Additionally, AirSF provides friendly, opponent, or neutral forces.

As illustrated in Figure 5 below, JSAF provides DIS entity, emission, and event PDUs to the translator. 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 can be tracked. The MTS initiates tracks in clear, cluttered, and high-density regions, with a full air picture established.

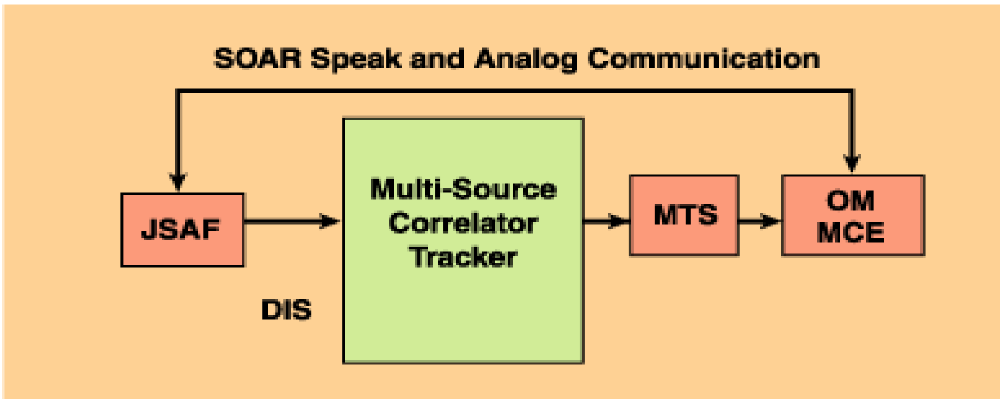

Figure 5: Stimulation System Block Diagram.

The MSCT will not only feed live track data into the OM, but will also translate DIS data into the format required by the OM. Thus, trainers can use the reusable low-cost MSCT to stimulate the OM with a wide range of scenarios. It is anticipated this capability will help fulfill the Air Force's distributed mission training (DMT) vision to integrate live, virtual, and constructive simulations.

TAOMIF: NON-MTS INTERFACE

Under contract to AFRL/HEA, the Solipsys Corporation developed a new interface to MSCT that allows MSCT to talk directly to the OM. This entire effort was conducted in full collaboration with the 133 Test Squadron in Ft Dodge, IA. The objective of this effort was to develop the capability to directly stimulate an Tactical Air Operations Module (TAOM) using an MSCT – without an MTS. This technology is known as TAOMIF, and is illustrated in Figure 6 below.

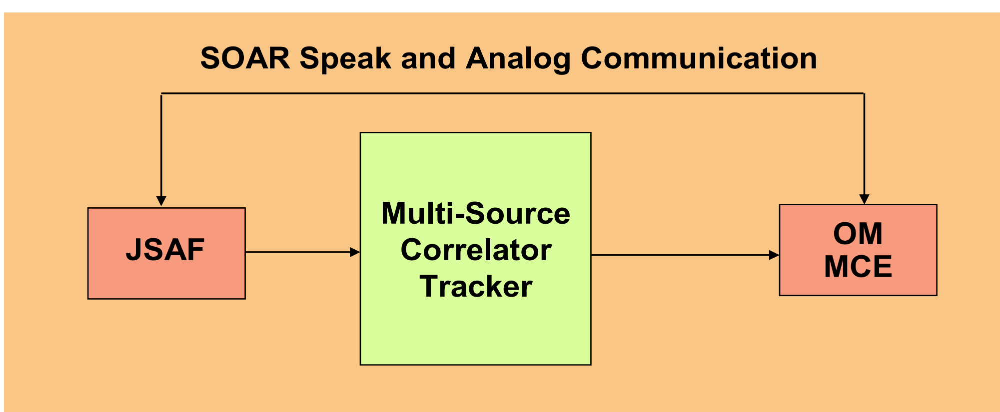

Figure 6: MSCT Direct Connect.

The TAOMIF makes it possible for the MSCT to be used in all ACSs, including those squadrons without an MTS. In addition, substantial cost savings should be realized through the elimination of the requirement for an MTS.

The TAOMIF MSCT permits the MSCT to talk directly to the OM via the remote radar 2 channel. This is a synchronous serial channel normally run at 16 kps, but capable of 32 kps. The MSCT can be configured at runtime to use the TAOMIF MSCT.

TAOMIF HARDWARE

The FAA radar data if directed to a Source Integration Server (SIS) that accepts the CD-2 13 bit data on PTI-334 cards, converts the data into a TCP/IP format and then is sent to the MSCT. The TAOMIF runs on a MSCT 280R Sun server equipped with a synchronous serial RS232 port. Other computers with different synchronous serial connections could be used, but would require minor adjustments to the code. The MSCT computer is connected to a synchronous Condition Diphase modem via a standard RS-232 cable, and does not require a null-modem cable. At this time, a GA-MDA-21 condition diphase modem from DRS Corporation is being used. The modem is connected to remote radar 2 port on the TAOM via field wire. The transmitter of the modem should be connected to the receiver of the TAOM and vice-versa as shown in Figure 7 below.

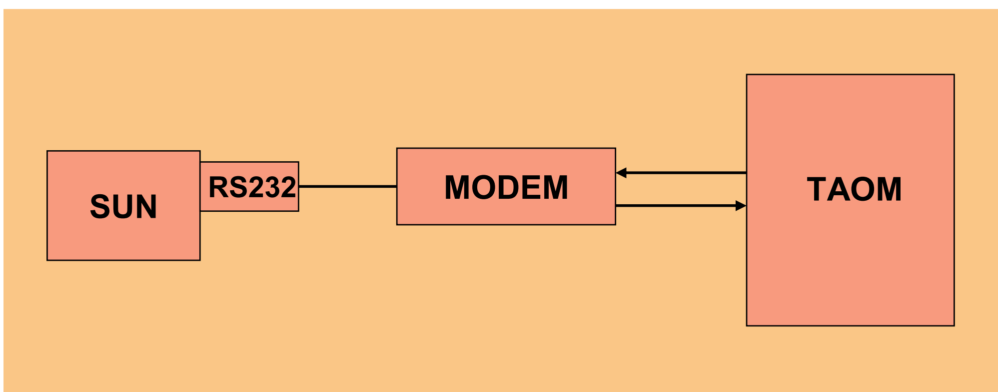

Figure 7: MSCT Hardware Connection.

Figure 8: TAOMIF View 1.

Figure 9: TAOMIF View 2.

TAOMIF SOFTWARE

The TAOMIF software has many configurations that will aid the Mission crew to complete their mission.

- Filter Speed Filter
- Choose 1-7 FAA radars at a time
- Install sector inhibit
- Radar/JU Registration
- Plot Smoothing
- Track Quality & Reporting Responsibility
- Position Message Receipt
- All amplifying data

Additional information and full specifications on the TAOMIF software may be found in a publication by the Solipsys Corporation (2002).

LIMITATIONS

- A32kps modem is recommended because the 16kps modem channel can only carry a limited amount of data and saturates at around 500 tracks.
- A radar registration process is required when multiple sources feed a TAOM. The TOAMIF software completes radar registration between FAA and the TPS-75. The TAOMIF software correlates and injects numerous FAA radars into the AN/TYQ-23 remote radar port. The TPS-75 can simultaneously be connected to the AN/TYQ-23 via field wire or by fiber-optic.
- The TAOMIF only runs on a Sun computer equipped with a synchronous serial RS-232 port. Although other computers can be used, minor adjustments to the code are required.

FUTURE DIRECTION

We can now send the simulated training scenario into the operational OM, and that training scenario can be sent to other OMs in different geographical locations via T-1 connectivity. The next step is to develop a performance measurement system and conduct training research to determine the effects of training on operator performance. This type of training can easily be expanded to meet joint service and coalition training requirements. Future MCE operational equipment may be able to incorporate this technology to provide enhanced operational and training capabilities.

CONCLUSIONS

The TAOMIF offers a cost-effective stimulation system to provide a training environment for the Modular Control System. It's use in several DMT/DMO exercises have demonstrated it's potential to provide a low-cost, enhanced training capability for the MCE operators. It immediately provides on-demand training for initial and continuation MCE training requirements in the setting and environment that the operators demand. Furthermore, the architecture and interface to the OM reflects the current Concept of Operations for Air Control Squadrons in the utilization of deployed radars to reduce the overall footprint of the Control and Reporting Center in a theater of operation. The design leverages on interoperability standards that allow for full training scenarios of live, virtual, and constructive operation in theater environments. The concept allows for expandability and scalability using hybrid systems to meet expanding C2 training requirements.

TAOMIF strengths are that it works and provides a low-cost, easily operated DMT/DMO capability for ACSs. Additionally, it leverages the operational capability of MSCT to merge multiple radar feeds into a single correlated radar display. This new capability is already supporting Operation NOBLE EAGLE. The weakness of TAOMIF is found in having to connect through the remote radar interface unit (RIU) port. This architecture has inherent limitation in the areas of display, bandwidth, and random loss. These limitations could easily be overcome by combining TAOMIF with complimentary local radar port solutions, currently under ACC consideration. A combined solution would afford ACSs even greater training and operational capability.

ABOUT THE AUTHORS

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