DISTRIBUTED INTERACTIVE SIMULATION: THE ANSWER TO INTEROPERABLE TEST AND TRAINING INSTRUMENTATION

Captain Mark W. Kassan

ABSTRACT

This paper discusses Global Positioning System (GPS) Range Applications Joint Program Office (RAJPO) efforts to foster interoperability between airborne instrumentation, virtual simulators, and constructive simulations using Distributed Interactive Simulation (DIS). In the past, the testing and training communities developed separate airborne instrumentation systems primarily because available technology couldn't encompass both communities' requirements. As budgets get smaller, as requirements merge, and as technology advances, the separate systems can be used interoperably and possibly merged to meet common requirements. Using DIS to bridge the gap between the RAJPO test instrumentation system and the Air Combat Maneuvering Instrumentation (ACMI) training systems provides a defacto system-level interoperable interface while giving both communities the added benefits of interaction with the modeling and simulation world. The RAJPO leads the test community in using DIS. RAJPO instrumentation has already supported training exercises such as Roving Sands 95, Warfighter 95, and Combat Synthetic Test, Training, and Assessment Range (STTAR) and major tests such as the Joint Advanced Distributed Simulation (JADS) Joint Test and Evaluation (JT&E) program. Future efforts may include support of Warrior Flag 97 and upgrading the Nellis No-Drop Bomb Scoring Ranges. These exercises, combining the use of DIS and RAJPO instrumentation to date, demonstrate how a single airborne system can be used successfully to support both test and training requirements. The Air Combat Training System (ACTS) Program plans to build interoperability through DIS into existing and future ACMI systems. The RAJPO is committed to fostering interoperable airborne instrumentation systems as well as interfaces to virtual and constructive systems in the modeling and simulation world. This interoperability will provide a highly realistic combat training and test synthetic environment enhancing the military's ability to train its warfighters and test its advanced weapon systems.

KEY WORDS

Distributed Interactive Simulation, Global Positioning System, Air Combat Training Systems, Test Instrumentation, Time-Space-Position Information.

INTRODUCTION

The testing and training communities have developed different instrumentation systems to accomplish their mission requirements. Test requirements usually consist of a few aircraft instrumented over a small airspace with highly accurate multiple time-space-position information (TSPI) sources. In the past, the multiple TSPI sources may have included an optical tracker, several tracking radars and a high sample rate telemetry system on the unit being tested, which were later reduced and merged into a final highly precise data product. As a result of the shrinking defense budget, the military has moved towards making development tests more operationally representative. With the advent of GPS, this has become much easier. GPS gives test ranges the capability to include such things as flying over a larger airspace with more aircraft in more operationally-representative flight profiles with no loss of pertinent data on the item or items under test. The RAJPO GPS-based test instrumentation was designed to fulfill development test requirements. Training requirements, on the other hand, consist of many aircraft over a larger airspace with lower TSPI accuracy and lower telemetry rates. In addition, the training community requires real-time weapon simulations with real-time display and control in order to create a realistic combat environment. The ACTS Program Office multilateration-based ACMI system was designed to fulfill training requirements. Using advancing technology of graphic displays and computational processors, the RAJPO and ACTS systems took on similar subsystem functionalities. Both systems consist of an airborne instrumentation pod, a data link subsystem, a simulation/analysis subsystem and a display subsystem. See Figure 1 for a typical RAJPO instrumentation system and Figure 2 for a typical ACMI instrumentation system. Ongoing efforts are looking at ways to make the two systems common and interoperable, and in the future, may eventually evolve to a single test and training system.

This paper discusses fostering current test and training system interoperability by taking advantage of their subsystem similarities. These similarities provide a prime opportunity to use DIS to make both systems interoperable at the system-level as well as provide an interface to virtual and constructive simulations. For this paper, two or more systems are determined interoperable if they can provide data to and accept data from each other, can use the data so exchanged to enable them to operate effectively together.

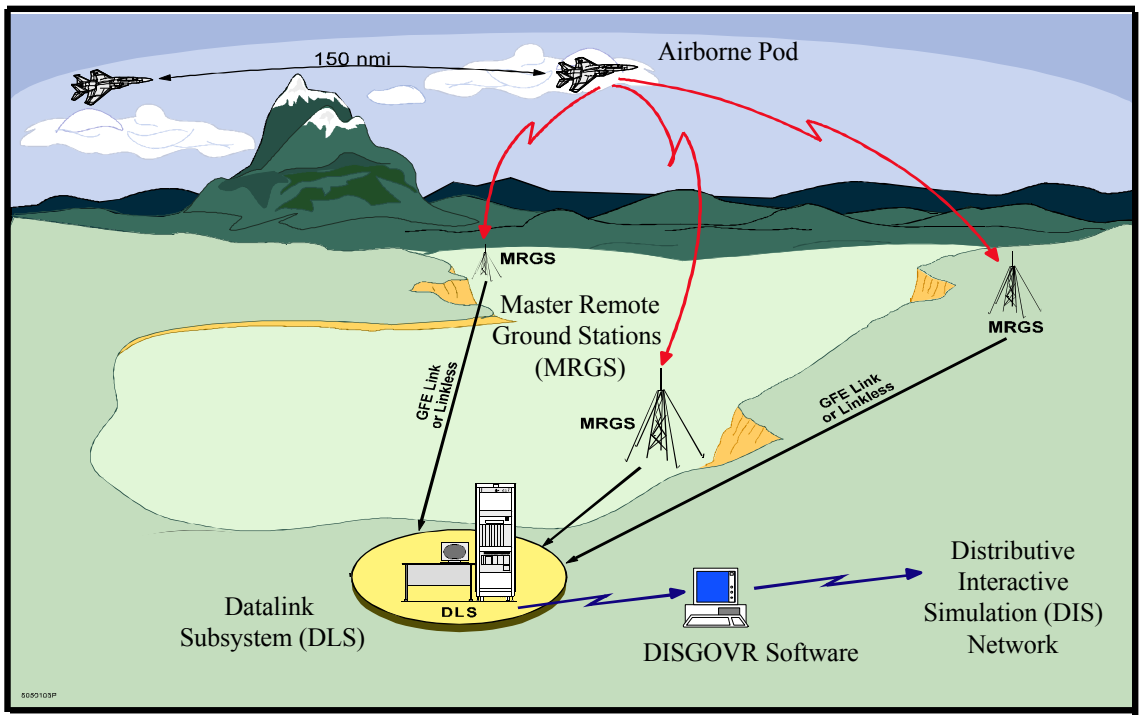

Figure 1: Typical RAJPO Instrumentation

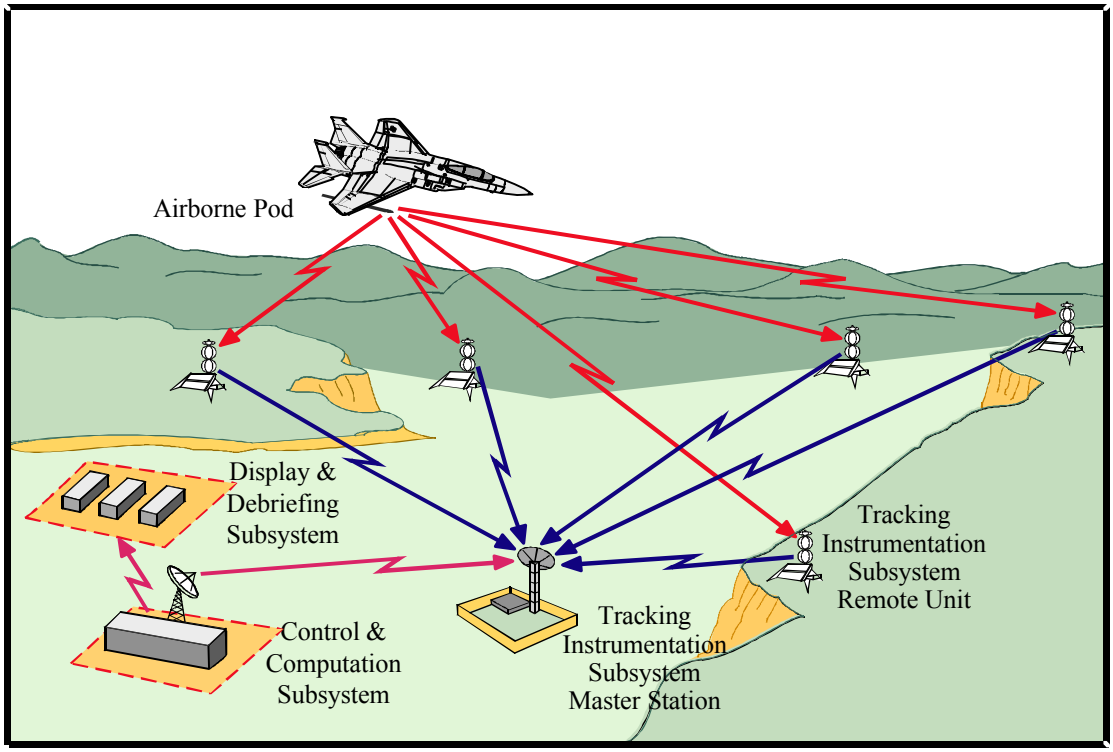

Figure 2: Typical ACMI Range Instrumentation

RAJPO DIS CAPABILITY

DIS is a standard that promotes the interaction and interoperability of virtual systems (human-in-the-loop simulators), constructive systems (wargames), and live systems (aircraft, ground vehicles, test and evaluation systems). It does this by defining the rules and protocols for networking through standard computer interfaces, and defining a time and space coherent synthetic representation of the real world. DIS has been especially useful in the modeling and simulation world for interconnecting diverse virtual and constructive simulation systems. Recent advances, GPS and advanced data link systems, have allowed the real-time interaction of live airborne and ground participants within the synthetic world. The RAJPO system added a DIS capability in 1994 as part of support for Roving Sands 95. This project was called DISGOVR (DIS GPS Optimal Virtual Range) and resulted in development of two software applications: the Live Entity Broker (LEB) and the Live Entity VisualizeR (LEVR).

The LEB software modifies the RAJPO TSPI telemetry stream and converts it to DIS entity state protocol data units (PDUs). The LEVR software is a three dimensional display system that monitors DIS PDUs out of LEB and other DIS PDU sources.

RAJPO DIS SUPPORT OF TRAINING EXERCISES

Roving Sands 95 was a multinational joint tactical operations exercise using military ranges in New Mexico, Texas, and South Colorado. Five F-15s and four F-16s were instrumented using RAJPO instrumentation pods and four AH-64 helicopters were instrumented using White Sands Missile Range's (WSMR) Truth Data Acquisition Recording and Display System (TDARDS) hardware. The DISGOVR software was used to convert the TSPI data from the two systems (RAJPO and TDARDS) and insert these aircraft into the synthetic battlefield representing the live exercise area. In addition, the battlefield was populated with simulated virtual air defense assets (Patriot, Hawk, and Avenger) and ground targets (SCUDs) that represented live assets. Several virtual man-in-the-loop cockpit simulators and constructive simulations from around the country participated in the synthetic battlefield.

Another effort supported by the RAJPO DIS capability was Warfighter 95. Warfighter 95 was an Advanced Distributed Simulation (ADS) exercise merging constructive simulation, virtual simulators, and live fly aircraft to exercise battlestaffs, command and control elements, and shooters in the conduct of theater air defense missions. Warfighter 95 employed a Korean scenario. The DISGOVR software was used to map two live F-16 aircraft in real-time into the virtual battlefield. While LEB converted TSPI to DIS PDUs, it also translated the data to new coordinates that corresponded to the Korean peninsula. LEVR, which was fitted with a virtual Korean terrain database, visualized the live, virtual,

and constructive participants. Both Roving Sands 95 and Warfighter 95 were outstanding successes in using RAJPO and DIS to integrate live participants into a virtual battlefield.

Another effort conducted by the Army in early 1996 was called Combat Synthetic Test, Training, and Assessment Range (STTAR). Combat STTAR conducted a deep strike training mission at the National Training Center (NTC), Fort Irwin, CA. WSMR supported the effort using RAJPO instrumentation mounted on six AH-64A helicopters and an airborne telemetry relay via a C-12 fixed wing aircraft. The DISGOVR software was used by WSMR to convert the live aircraft data to DIS PDUs so that the training mission could be viewed by NTC, Ft Hood, and WSMR on their Virtual Reality Display System, thus enhancing virtual reality situational awareness. An objective of this successful effort was to enhance the operational environment to improve system testing while expanding the opportunity to train the warfighter. There are more examples of recent successes in interfacing live participants into a virtual world.

PRESENT TEST COMMUNITY DIS EFFORTS

While we have mentioned examples of using test instrumentation and DIS for meeting primarily training requirements, developmental and operational testing using DIS has not been fully addressed. A special organization, the JADS Joint Test Force, was created to investigate the utility of ADS for test and evaluation. They will conduct actual tests using ADS to examine and quantify its utility. Some of these tests involve support from the RAJPO and DISGOVR. One of the tests, involves linking a live shooter aircraft with a hardware-in-the-loop simulation of an AMRAAM against a live target aircraft. RAJPO equipment will be mounted on the two live aircraft and converted to DIS PDUs for integration with the AMRAAM simulation for viewing both at Eglin AFB and Kirtland AFB. This type of test may be effective and affordable for early integration testing and help testers plan their limited live missile tests more effectively. Though the testing hasn't occurred yet, we believe DIS will be proven as a useful tool for increasing the effectiveness of modeling and simulation for test purposes.

FUTURE AIR FORCE EMPHASIS ON MODELING AND SIMULATION

Ongoing RAJPO efforts, with cooperation from the ACTS community, are to permit use of existing ACMI training and RAJPO test instrumentation systems on the same range using DIS. This is in line with two separate efforts to integrate test and training. The first is the Air Force's New Vector Initiative for Modeling and Simulation (M&S). The Chief of Staff and the Secretary of the Air Force directed emphasis be placed on M&S. This is based on the realization that M&S is essential to the Air Force to organize, train, and equip its forces. A key concept mentioned is the integration of live participants, human-in-the-loop

virtual simulators, and constructive simulations that can interact within a common synthetic battlefield across distributed networks for both testing and training purposes.

The second is a recent Range Commanders Council initiative to integrate test and training instrumentation. This initiative attempts to leverage current investments in airborne instrumentation systems by identifying interfaces that allow common display of TSPI from each system. The ultimate goal is a common test and training instrumentation system. The Range Commanders Council is composed of high-ranking representatives from the Major Range and Test Facility Bases (MRTFB) of the Army, Navy, and Air Force.

DIS BENEFITS

Other approaches being looked at for accomplishing the integration of test and training include airborne pod commonality and direct interfaces on a range-by-range basis. Both are longer term and higher cost alternatives compared to developing a DIS interface. The RAJPO is working with the ACTS program to establish a DIS capability for their current display subsystem and their existing and future simulation subsystems. This ACMI DIS capability will allow interoperability with RAJPO instrumentation and many other operational virtual training and test simulators and simulations. DIS interoperable and compatible test and training instrumentation systems have the following benefits:

a. DIS is an established DoD and industry standard (IEEE 1278) and future systems will be DIS compliant. The other services are all moving towards making their systems DIS compatible. The Air Force needs to support DIS interoperability for its systems and other systems throughout the DoD. This ability will significantly enhance the ability to conduct joint training and meet joint testing objectives.

b. View, real-time or archived, DoD exercises (simulation-based or live-based) geographically anywhere a DIS compliant terminal is located. The ACTS display systems are installed in many operational squadrons. DIS compatible terminals would provide a relatively low cost method for squadrons to view ongoing or archived exercises, including those of other squadrons and/or other DIS compliant systems. In addition, air crew would be able to conduct after-action reviews at their home station immediately after conducting a mission at a remote site. After a training mission, the air crew could playback the mission through a local display terminal while the mission is still fresh in their minds. It would be immediate because their home station would have recorded the information as the mission occurred at the remote site.

c. Tie together ranges anywhere a DIS training or test system exists for real-time testing/training. Associated ranges for a common exercise can interact together via DIS and not leave their home station. These ranges could also synthetically expand to

any number of different live or virtual participants. For instance, an Army range can tie in tanks and soldiers with a Navy range that has aircraft, whose weapon systems interact through DIS. These ranges can be geographically located side-by-side or a continent apart.

d. Accommodate additional simulations (weapon and threat) within the training or testing scenario. For example, the ACMI ranges are currently constrained to the simulations they host within their local systems.

e. Use/Reuse existing or emerging simulations developed in other modeling and simulation communities for training or testing.

f. Conduct after-action reviews for test directors/analysts immediately after conducting a test mission at a remote site. A go/no-go decision for a test is only as good as the data that can be analyzed for the next mission. Live flight tests are very expensive and a decision maker doesn't usually have the luxury to wait until his analysts have all pertinent data to make an informed decision. Using DIS compatible systems, the analysts and decision maker can see it in real-time and playback the information immediately for analysis.

g. Commingle test and training instrumentation on a single range without interference to accommodate specific test/training objectives. Sometimes test and training objectives are combined to save cost and manpower. If both types of systems were interoperable through DIS, a single range could accommodate both missions with a minimum of instrumentation and effort.

h. Smoothly evolve to new or upgraded instrumentation without concern for backwards compatibility. There is no guarantee that future technologies to improve the way we instrument live vehicles will always be backwards compatible to older systems. In addition, not every range is going to get that new technology at the same time. If each system is DIS interoperable, the older systems can continue to interact with the newer systems through the DIS nodes.

NEXT DIS IMPLEMENTATION

The ACTS Program Office has been providing the DoD training ranges airborne instrumentation since the mid 70's for aircraft tracking, weapon and threat simulation. This instrumentation has been successfully used to train aircrews through live exercises such as the Air Force's Red Flag exercise at Nellis AFB. None of the current ACTS systems are DIS compliant.

The Nellis Range could use DIS today. The Red Flag Measurement and Debriefing System (RFMDS) is an airborne instrumentation system that supports real-time combat training for up to 36 high activity aircraft with an assortment of weapon and threat simulation capabilities. This system and its replacement, the Nellis Air Combat Training System (NACTS), could enjoy many of the benefits discussed earlier in this paper having a DIS interface. The RAJPO is committed to helping them realize the full potential of DIS using a combined exercise and test to be conducted at Nellis AFB. The exercise, called Warrior Flag 97, is an ADS exercise to provide multiservice air operations center training and Air Force theater air control system battle management operator training. The test, called Project Strike II, will exercise and evaluate the events of a sensor-to decision maker-to shooter cycle against a time critical target. All live participants will be used for the test. The operators will be trained using primarily DIS interfaced virtual and constructive simulations from across the country with the Project Strike II test fulfilling the live portion. The Nellis RFMDS system is being looked at to support this combined effort. The system will need a DIS capability.

In addition to having the RFMDS, the Nellis Range controls several range facilities that perform no-drop bomb scoring for the Air Force operational command, using ground radar. A typical scenario has a B-52 flying over a range target and dropping simulated weapons. When a crew member releases the simulated weapons, a tone is telemetered to the training range. The range records the time of the tone and, using range radar TSPI of the aircraft, calculates whether the bombs hit their intended target. The increasing precision of our air-to-ground weapons requires better accuracies than can be provided using radar. In addition, the radars are old and expensive to maintain. The Nellis Range Group would like to replace the radars using current GPS-based airborne instrumentation and advanced data link telemetry to provide highly accurate TSPI, low maintenance equipment, and a DIS interface to conduct air crew debriefs at their home stations around the country. In addition, these systems could integrate into a Red Flag or like exercise (assuming the RFMDS/NACTS are DIS compliant) for air-to-ground drops.

SUMMARY

The time is right for the test and training communities to work together to accomplish the DoD's development test, operational test, and training requirements. The RAJPO has already developed a DIS-compatible instrumentation system that has proven itself in several training exercises. The modeling and simulation community supports the continued use of DIS and the Range Commanders Council supports the integration of test and training instrumentation. The RAJPO fully supports the ACTS community making existing and future training instrumentation DIS compatible.

Making existing and future ACTS instrumentation systems DIS compatible would benefit the Air Force immensely. Such a DIS capability would result in interoperability of existing and future test and training airborne instrumentation systems as well as create a standardized connection to other virtual and constructive systems. This capability would clearly enhance the military services' ability to train its warfighters and test its advanced weapon systems.

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