Australian Contribution to International Simulation Standards Development

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ABSTRACT: *The Australian Defence Science and Technology Organisation (DSTO) has been closely associated with advanced distributed simulation exercises since the mid 1990s. These have included international networking exercises such as those conducted under the auspices of the Coalition Readiness Management System (CReaMS) Project Arrangement between the United States Navy and Royal Australian Navy where many different systems were required to interoperate for the training activity to succeed. Considerable experience has been gained with establishing interoperability among simulations and simulators, generally using the Distributed Interactive Simulation (DIS) protocol. This has led to Australian participation in the Simulation Interoperability Standards Organisation (SISO) via the working groups with a particular interest in DIS. Due to experience with international exercises, Australia's main area of expertise is in simulated communications under DIS. This paper details Australia's contribution to the DIS update effort, which has included contributing to international Simulation Interoperability Workshops, regular international teleconferences, and also submitting formal problem/change requests for issues encountered during simulator testing activities and recent training exercises. The revised DIS standard will benefit both the international and Australian Defence Force training communities by reducing interoperability related defects of newly built training simulators. Australian interest in other simulation interoperability standards such as the Real Time Platform Reference Federation Object Model (RPR-ROM) and the DIS enumerations will also be discussed.*

1 Introduction

Advanced Distributed Simulation (ADS) was created to link simulators, simulations and/or real devices so that the various entities can interact with each other to conduct a simulated game or exercise in the same synthetic battlespace. ADS has been under development since the early 1980s with the Simulator Networking (SIMNET) Project undertaken by the US Defense Advanced Research Projects Agency [1] and has continued through the emergence of Distributed Interactive Simulation (DIS) [2] in the early 1990s and High Level Architecture (HLA) [3] in the late 1990s. In parallel with these efforts, the Test and Training Enabling Architecture (TENA) has been established to enable the live range community to participate in distributed simulation exercises [4].

Air Operations Division (AOD) of the Australian Defence Science and Technology Organisation (DSTO) has been closely associated with advanced distributed simulation exercises for nearly a decade. In that time, considerable experience has been gained with establishing interoperability among simulations and simulators. Recently, AOD has commenced formal involvement with international standards activities.

2 Australian Use of Distributed Simulation for Training

2.1 Project Involvement

By 2010, the Australian Defence Force (ADF) will have acquired sophisticated training simulators for air, maritime, and land assets, many of which will have the capability of being networked to other simulators via Advanced Distributed Simulation to provide enhanced training and mission rehearsal capability.

Existing Australian network-enabled training simulation systems include the Royal Australian Navy's (RAN) Maritime Warfare Training Centre (MWTC) simulators and the Royal Australian Air Force's (RAAF) AP-3C training simulators. Naval On Board Training Systems being acquired for the FFG class can also be networked for enhanced training opportunities. Details of these projects can be found at the reference [5]. It is noteworthy that all these systems will use DIS; indeed considering the FFG Upgrade Project that is upgrading four FFGs and will continue to at least 2008, it is clear that DIS will be in use in the ADF for many more years.

Other systems that may be network-enabled in the future include simulators for the proposed Joint Strike Fighter, F/A-18, Seasprite, Blackhawk, and Armed Reconnaissance helicopter, together with the Airborne Early Warning & Control (AEW&C) aircraft, and the Collins Class submarine.

The Royal Australian Navy (RAN) has developed a plan to link up present and future training systems into a Maritime Warfare Training System (MWTS) as shown in Figure 1.

Figure 1: Anticipated development of Navy's Maritime Warfare Training System

This capability will progress from the currently operational local area network system based at HMAS Watson in Sydney to a nationwide system that will enable joint and coalition task force training.

2.2 CReaMS Collaboration with US Navy

Australia and the United States entered into a formal Coalition Readiness Management System (CReaMS) Project Arrangement (PA) in 2001 [6], to demonstrate an interoperability training capability, with the long-term goal of establishing a persistent mission planning and rehearsal ability. The United States Navy (USN) featured their Battle Force Tactical Training (BFTT) system, which provides DIS interoperability, scenario generation with exercise control, data collection and debrief capabilities. The RAN fielded its MWTC (see section 2.1) that links training simulators for the FFG and ANZAC class assets using DIS.

Three RAN/USN exercises have been run under the auspices of CReaMS:

- Phase One, the *Preliminary Interoperability Experiment*, took place from 26 - 29 November 2001 between the RAN/DSTO, USN, and Royal Netherlands Navy (TNO). This linked RAN training systems manned by ship crews with USN mockups located on the conference floor at the Interservice / Industry Training Systems and Education Conference (I/ITSEC) 2001 in Orlando and also TNO Computer Generated Force Systems at The Hague [7].
- Phase Two further demonstrated this capability in an expanded coalition warfighter training exercise held during February 2003. This *Encrypted Network Exercise* was conducted between the RAN training systems for ANZAC and ADELAIDE and their US counterparts [8].
- Phase Three investigated the feasibility of "ship-to-ship" simulation connectivity under the *Virtual Coalition Readiness* exercise in September 2003 [9]. The ANZAC and FFG ship simulators were manned by the actual ships' crews. HMAS Watson, the Australian hub, coordinated the connectivity to the United States, while the Combat Direction Systems Activity (CDSA) in Virginia served as the US hub. Connected to CDSA were the Naval Undersea Warfare Center (NUWC) at Newport, Rhode Island; Tactical Training Group Pacific (TTGP), in San Diego; and a US Guided Missile Destroyer (the USS Howard) alongside in San Diego harbour.

Interoperability issues encountered and solved during these exercises were reported previously [10].

2.3 Australian Participation in DMT Activities with USAF

Australia has also signed a Project Arrangement with the United States Air Force (USAF) in Distributed Mission Training (DMT) [11]. This PA aims to conduct behavioral and technical research to increase the effectiveness and range of applications of DMT for national and coalition force operations. DMT research activities will involve USAF and RAAF personnel operating real-time, warfighter-in-the-loop (virtual) simulation systems supported by computer generated (constructive) simulations operating either locally or linked while separated by intercontinental distances. Elements of distributed simulation training research include employment of USAF and RAAF combat aircraft, (AEW&C) aircraft, C4ISR, and Air-to-Air Refuelling aircraft.

Initial connectivity was carried out between Australia and the US in late 2004 with further plans for full exercises in 2005.

3 Australian Standards Activities

3.1 Australian Defence Simulation Office

The Australian Defence Simulation Office (ADSO), established in 1999, has prime responsibility for developing and overseeing the implementation of Australian Defence simulation policy and the Defence Simulation Plan [12]. The Office promotes the development of approaches to gaining and sustaining knowledge via simulation in order for Defence to make the best use of this technology where it can enhance capabilities, save resources and reduce risk.

With assistance from the Australian defence community and industry, ADSO has developed guidance documents for simulation standards and data.

3.2 JOANNE Standards

A set of standards was developed under the DSTO JOint Air Navy Networking Environment (JOANNE) Project that included international, de facto, and local standards for the Australian Defence Organisation [13 - 14]. This set of standards was produced to provide guidance for ADF simulator interoperability. These standards can assist in the networking of ADF simulators and simulations into successful Joint and Coalition synthetic training environments. The standards were evolved through practice with distributed simulation within DSTO, the ADF, and also via experimentation with international partners including The Technical Cooperation Program (TTCP) nations and the USN.

The standards addressed interoperability issues such as DIS versions and de facto usage, voice communications, data link, and other issues. For example, it was necessary to create a schema for site Ids for Australian military training establishments. Since 13 is the DIS country identifier for Australia, it was recommended that Australia uses numbers in the range 13000 - 13999 for DIS exercises as in Table 1.

Table 1: Recommended DIS Site Ids for Australian military training establishments

Organisation	Range of Ids
Navy	13000 - 13199
Air Force	13200 - 13399
Army	13400 – 13599
Joint	13600 - 13700
DSTO	13700 - 13799
Others(Industry etc)	13800 - 13999

Site Ids consistent with this schema have been used for both local DIS exercises and international exercises with the USN and USAF such as those described in section 2.

3.3 Standards Australia

Standards Australia, the leading Australian organisation involved in standards, created a committee in 2004, IT-031, to address modelling and simulation standards [15]. The committee is chaired by the Australian Defence Simulation Office (ADSO) and has representation from the Simulation Industry Association of Australia, DSTO, and other organisations. including academia. Standards Australia is a chapter of the International Standards Organisation (ISO) [16].

The committee seeks to coordinate, develop, disseminate and promote standards for computer modelling and simulation in Australia and contribute to international standards development. It plans to provide standardisation in the field of computer modelling and simulation, including the standardisation of interfaces for the exchange and definition of physical environmental, behavioral, platform/technical, simulation intercommunication, and aural data.

4 Australian Participation in SISO

Australia has been an active contributor to the Simulation Interoperability Standards organisation (SISO) since its inception and earlier contributed to the RPR FOM development and DIS enumerations groups [17].

4.1 SISO DIS Enumerations Group

DIS provides a standard set of enumerations for entities and also for weapons, sensors, communication devices, environmental descriptors and other attributes. This is a highly comprehensive set that includes virtually the entire US and former Soviet inventories, as well as those of other major nations such as Germany, France and the UK.

SISO maintains these enumerations via its reflector SISO-ENUM. These enumerations are regularly updated to reflect user requirements and have also been used to incorporate updates to the DIS standard for the IFF PDU that were not addressed in the 1998 standard.

DSTO has provided enumerations for all the Australian assets to this group such as the Collins submarines, ANZAC frigates and FFGs. There is also a proposal to include all Australian assets in a later revision of the SISO enumerations document so that Australian assets can be identified in simulation exercises, even if the platforms were designed or built elsewhere [18]. For example, both the US and Australia operate F/A-18 aircraft but there is currently no way in which to distinguish the Australian F/A-18s from the US F/A-18s in a distributed simulation exercise. The scheme proposed utilises the specific and extra fields in the entity enumeration to uniquely identify Australian assets. A section of the proposed enumerations is included in the Table below (note: K = Kind, D = Domain, CID = Country of Design; C = Category; SC = Subcategory; SP = Specific; E = Extra).

Table 2: Proposed enumerations for some Australian air combat assets

Platform	**DIS Enumeration**						
Fighter / Air Defence	**K**	**D**	**CID**	**C**	**SC**	**SP**	**E**
AF/A-18A (Australia)	1	2	225	1	9	11	0
AF/A-18B (Australia)	1	2	225	1	9	12	0
A/F-35A (CTOL) (Australia)	1	2	225	1	12	4	0

4.2 RPR FOM Product Development Group

The Real-time Platform Reference Federation Object Model (RPR-FOM) Product Development Group within SISO is close to finalizing RPR FOM version 2. The RPR-FOM was developed to aid the transition from DIS to HLA for platform level simulators. Version 2 of the RPR FOM provides an HLA implementation of the functionality contained in the 1998 IEEE 1278.1a DIS standard. The PDG has determined that the planned Version 3 of the RPR FOM will track the updated DIS standard.

DSTO and also the Australian Army contributed to early drafts of the SISO RPR-FOM 2.0 standard.

4.3 DIS Specialist and Product Groups

More recently the main focus of Australian standardisation efforts has been in Distributed Interactive Simulation. With many Australian training simulators adopting DIS as the primary networking architecture, it was felt that Australia should contribute to the revision of the DIS standard.

Standards for DIS Protocol Data Units (PDUs) were developed under the guidance of the DIS Coordinating Committee based in the US through a series of DIS Workshops run from 1989 to 1996. When mature, these standards were subject to the rigorous Institute of Electrical and Electronic Engineers (IEEE) Standards approval process [19], [20], [21]. However, the standard was last updated in 1998 [21] and significant developments have occurred in the simulation community during this time as DIS users have developed various ad hoc changes to the rules.

The 1998 DIS standards were reaffirmed in 2002 and it was anticipated that the standard would not need to be further updated due to the US DoD directive concerning adoption of HLA. However, that directive was subsequently modified to allow continued use of DIS and HLA by DoD agencies for the foreseeable future as it was recognized that DIS was the backbone for large military training systems such as BFTT.

DSTO (AOD) has been involved with the DIS SG since October, 2003 and Australian industry has also participated. DSTO has participated via international teleconferences with the US and has also attended DIS SG meetings held at I/ITSEC 2003 and Euro-SIW 2004.

The DIS SG and PDG operate mainly via the reflector maintained by SISO (SIW-SG-DIS) and interested parties are invited to subscribe and submit comments or formal Problem/Change Requests (PCRs). To date, over 120 PCRs have been submitted to the reflector including eight from Australia. These address either changes to the existing standard or clarification on use of existing DIS Protocol Data Units (PDUs). The level of interest in this Study Group highlighted the need for continued SISO support of DIS.

The Australian contribution to this effort is described in detail in the following section.

5 Australian Contribution to DIS SG and PDG

Throughout all three CReaMS exercises, successful voice communications proved to be the most challenging task. This is primarily due to the vagueness of the DIS standard regarding the population of Transmission PDU fields. Six DIS voice systems were employed during the CReaMS series of exercises [10] that provided many challenges for successful interoperability.

Some systems require only the frequency field to be set, whereas others require the modulation parameters to be set. Some systems required the receiver's frequency to be identical to that of the transmitting simulators. The DIS standard does not explicitly define how to implement encrypted communications, nor does it describe how receivers should interpret transmissions from the center of the earth that, by convention, are propagation-less. As a result, each voice system may be built to a different interpretation of the standard.

Six PCRs were provided to the DIS SG addressing issues with the Transmitter PDU. These are summarized as:

- *PCR 68: Center-of-the-Earth transmissions.* For instructor-assisted training and testing purposes it is frequently necessary to send voice transmissions whereby the receiving stations ignore line-of-sight and propagation rules. An unofficial convention exists to indicate propagation-less transmissions, where the Transmitter PDU antenna location field is set to (0,0,0), that is at the center of the earth in the DIS geocentric coordinate system.

- *PCR 69: Use of pseudo-encryption.* There is ambiguity in the DIS standard as to how plain and crypto communications are indicated in the Transmitter PDU.

- *PCR 70: Use of Modulation Fields*. There is little guidance in the DIS standard as to how the modulation fields in the Transmitter PDU should be used. As a result, some voice systems ignore these fields, whereas others require the receiver to be set to the same modulation as the transmitter.

- *PCR 71: Frequency Matching*. The standard does not explicitly require that a radio should receive a given transmission within the tolerance allowed by the bandwidth although this may be implicit. However, some voice systems have been implemented which require an exact frequency match between transmitter and receiver to allow reception, resulting in inhibition of voice communications.

- *PCR 72: Intercom application*. Most DIS voice systems implement intercoms using the traditional IEEE 1278.1 Transmitter and Signal PDUs. Whilst IEEE 1278.1a added Intercom-specific PDUs [21], use of these new PDUs is minimal. It is suggested the Transmitter and Signal PDU approach be documented in the standard.

- *PCR 118: Number of samples in Signal PDU*. The number of samples of data in the Signal PDU can affect both the latency and bandwidth utilisation. This PCR aims to provide guidance to the user.

5.1 Other Contributions

PCRs have also been developed in other areas including:

- *PCR 95:* The default thresholds for dead reckoning are inadequate for fast moving entities such as aircraft. Guidance will also be provided as to which dead reckoning algorithm is most appropriate for a given entity.

- *PCR 119:* This PCR addresses Timeout and deactivation rules for the Electromagnetic Emission and Underwater Acoustic PDU.

6 Future Developments

With the decision to develop a revised version of the DIS standard, the PDG has commenced working on this effort.

6.1 Changes to the Standard

Changes to the DIS standard can be categorised as:

- Editorial corrections.
- Clarifications to the standard
- Updates to reflect current DIS usage, such as the use of multiple heartbeat and timeouts.
- Integrity changes.
- Moving material from the Enumerations Document back into the standard where it properly belongs. This includes the IFF PDU rules and record formats.
- Changes to existing PDUs to support the current simulation environment and to improve interoperability with HLA.
- Inclusion of existing experimental PDUS that are already in use and additional PDUs to encompass other functionality (for example, to model IFF Mode 5 Cooperative Identification System)

To make the task of updating the standard manageable, the DIS PDG created four Tiger Teams to address (a) Radio/Transmitter Issues, (b) Transfer Control, (c) Link 16, and (d) Draw Shape PDU. The proposed Draw Shape PDU allows the transmittal of shapes on to terrain maps.

Australia joined the Radio/Transmitter team since this was the area of greatest concern with recent distributed simulation exercises.

6.2 Initial DIS Update

The initial DIS update will address the issues that are most mature and the least controversial. These may include:

- Transfer Control Update
- Fire and Detonation PDU Clarifications
- Time Clarification
- Heartbeat/Timeout Update (to reflect present usage)
- New PDU Header Status field (Transfer Control)
- Miscellaneous Editorial Corrections
- Event ID Clarification
- Transmitter PDU Clarifications
- Special Entity Type field
- IFF PDU clarifications

It is anticipated that the Australian group will contribute to most of these areas.

7 Conclusions

DSTO (AOD) has been involved with SISO standardization activities for several years with respect to DIS enumerations and the RPR FOM. Recently, the Division has also become involved in the renewed DIS standardization activities resulting from experiences with interoperability exercises with the US. It is expected that the revised DIS standard will benefit both the international and Australian Defence Force training communities, by reducing interoperability related defects of newly built training simulators.

While the initial focus has been on DIS and HLA, it is also anticipated that DSTO will also become involved with other emerging SISO standards such as the Link 16 simulation standard and the Extensible Modeling and Simulation Framework (XMSF) initiative.

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