Australian Contribution to International Simulation Standards Development

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Abstract. Air Operations Division of 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. This experience has led to participation in the international Simulation Interoperability Standards Organisation (SISO) that develops, maintains and promotes standards for simulation interoperability such as Distributed Interactive Simulation (DIS) and High Level Architecture (HLA). In 2003 a SISO study group was formed to evaluate the need for an updated DIS standard. In its initial six months of operation, over 100 problem/change requests were submitted from the user community, primarily for editorial corrections and clarifications. This Study Group has since transitioned to a SISO Product Development Group with charter to develop a revised edition of the DIS standard. This paper details AOD's contribution to the update effort, which has included attending international Simulation Interoperability Workshops, regular international teleconferences, and also submitting formal problem/change requests for problems encountered during simulator testing activities and recent training exercises (such as those under the RAN/USN Coalition Readiness Management System Project Arrangement). The revised standard will benefit both the international and Australian Defence Force training communities, by reducing interoperability related defects of newly built training simulators.

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. The simulation nodes may be collocated or may be geographically remote from each other.

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]. SIMNET was transitioned to the US Army and is still in service for training tank crews. ADS development 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 of 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. STANDARDS ACTIVITIES

Standards are essential for establishing interoperability and reuse among the ADF's training simulators.

2.1 International Standards

International simulation standards are those defined by the leading international organisations developing the relevant standards for simulation. Within the field of distributed simulation, the organisations responsible include:

- The Institute of Electrical and Electronic Engineers (IEEE) is the leading authority in many technical areas, and supports over 900 active standards with 700 under development [5]. IEEE standards have 'gold' status, being regarded as authoritative. However, since development of IEEE standards can be a slow process, other options are frequently explored.
- The Simulation Interoperability Standards Organisation (SISO) is an industry consortium [6] that focuses on facilitating simulation interoperability and reuse across the simulation community. SISO is now actively developing and issuing standards for simulation interoperability. The SISO standardisation process is proving to be a useful alternative to IEEE certification.

- The International Standards Organisation (ISO), based in Geneva [7] is the world's largest developer of standards. Within the simulation area, ISO manages development of such standards as the Synthetic Environment Data Representation and Interchange Specification (SEDRIS), Extensible 3D (X3D), and Environmental Data Coding Specification (EDCS).

2.2 DIS Workshops

DIS was developed from the earlier SIMNET simulation network project [1]. 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 that were run from 1989 to 1996. When mature, these standards were subjected to the IEEE standards approval process [8], [9], [10]. The latest standard, IEEE 1278.1a-1998, was released in 1998 [10].

There are also various draft versions – for example, DIS 2.04 was the draft that evolved into IEEE 1278.1, and DIS 2.14 the draft for the IEEE 1278.1a-1998 standard. DIS versions can also be designated by a number, as shown below in Table 1.

Table 1: Versions of DIS

1	DIS version 1.0 (May 1992)
2	IEEE 1278-1993
3	DIS version 2.0 – 3rd draft May 1993
4	DIS PDU version 2.0 – 4th draft March 1994
5	IEEE 1278.1-1995
6	IEEE 1278.1A-1998

2.3 SIW Workshops

The development of HLA and other standards for simulation interoperability is managed through the Simulation Interoperability Workshops (SIW) that evolved from the earlier DIS workshops. SISO runs three interoperability workshops each year; two are held in the US and, since 2001, there has also been a third workshop held in Europe. Similarly to DIS development, the mature SISO products are ultimately submitted to IEEE for balloting.

HLA, in contrast to DIS, is a methodology designed to support distributed simulation exercises. However, the functionality of DIS can be preserved in the HLA world through the use of the standard Real-time Platform Reference Federation Object Model (RPR-FOM) that was designed to support DIS-like platform level simulations.

Due to a focus on High Level Architecture [11] across the past 5 years at the SIWs, there have been no further updates to the DIS standard. However, it is expected that DIS will coexist with HLA, as each offers solutions in different areas of simulation. For platform training simulator interoperability, DIS is still the preferred networking solution. More recently, SISO standards activity in DIS has recommenced.

2.4 JOANNE Standards

A set of standards was developed under the JOint Air Navy Networking Environment (JOANNE) Project that included international, de facto, and local standards for the Australian Defence Organisation [12]. This set of standards was developed 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 developed through practice with distributed simulation within DSTO, the ADF, and also via experimentation with international partners including The Technical Cooperation Program (TTCP) nations.

3. AUSTRALIAN PROJECTS

3.1 Project Involvement

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 systems can be found on the Defence Material Organisation (DMO) site [13].

It is noteworthy that all these systems use DIS. Indeed considering the FFG Upgrade Project that is upgrading four FFGs and will continue to at least 2008, it is expected 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 helicopters, together with the AEW&C, and the Collins Class submarine.

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

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

3.2 CReaMS Exercises

Australia and the United States entered into a formal Coalition Readiness Management System (CReaMS) Project Arrangement (PA) in 2001 [14], to demonstrate an interoperability training capability, with the long-term goal of establishing a persistent mission planning and rehearsal ability. The 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 3.1) 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 [15].
- 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 operations room crews of HMAS ANZAC and ADELAIDE and their US counterparts [16].
- Phase Three investigated the feasibility of "ship-to-ship" simulation connectivity under the *Virtual Coalition Readiness* exercise in September 2003 [17]. 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.

4. SISO DIS STANDARDS ACTIVITY

SISO's goal is to encourage standardisation between simulations. Since it is now clear that both DIS and HLA will be used for the foreseeable future, the DIS standard needs to be updated to correct known errors, provide much needed clarifications, incorporate new capabilities and reflect actual DIS usage. The standard was last updated in 1998 and significant developments have occurred in the simulation community during this time as DIS users have developed various ad hoc changes to the standard.

The 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 US military training systems such as BFTT.

4.1 DIS Study Group

The DIS Study Group (SG) formally commenced in September, 2003 at the Spring Simulation Interoperability Workshop and has been meeting regularly via teleconference both within the US and internationally with Australia and Europe.

The DIS SG's charter was initially to survey the DIS community to determine the need to update IEEE 1278.1 and also to compile a list of deficiencies and change requests, including new PDUs that have been implemented, and to scope the extent of needed updates to the standard. With the establishment of the DIS SG, the new PDU's could be reviewed for usefulness by the M&S community. Many DIS users also expressed interest in the need to clarify and interpret the DIS standard (s).

It should also be noted that the final 1998 IEEE DIS standard contained many new PDUs such as Underwater Acoustic and IFF with little guidance as to their usage. It was intended that the SG could provide guidance on the use of these new PDUs.

The DIS SG operates mainly via an e-mail reflector maintained by SISO (SIW-SG-DIS) and interested parties are invited to subscribe and submit comments or formal Problem/Change Requests (PCRs) [6]. To date, over 100 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 PDUs. The level of interest in this Study Group highlighted the need for continued SISO support of DIS.

4.2 DIS Product Development Group

The DIS Product Group (PDG) formally commenced at the September 2004 SIW meeting. The PDG has the charter of producing a revised IEEE 1278.1 standard and also examining the other DIS standards in the 1278 series to determine if these also need updating or should be reaffirmed. These other IEEE standards are:

- 1278.2-1995 IEEE Standard for DIS - Communication Services and Profiles
- 1278.3-1996 IEEE Recommended Practice for DIS - Exercise Management and Feedback

- 1278.4-1997 IEEE Recommended Practice for DIS - Verification, Validation and Accreditation

The DIS PDG may also develop additional products such as an XML database and a developer's guide. The PDG has also established a private reflector to evolve the standard (SAC-PDG-DIS).

Three options were proposed for the DIS update effort:

- Alternative 1: Prepare a Draft IEEE 1278.1b Document. This would be limited to changed material only and users would require both the IEEE 1278.1-1995 and 1278.1a-1998 editions to complete the documentation.
- Alternative 2: Prepare a Draft IEEE 1278.1-200X Document. This would replace IEEE 1278.1 and 1278.1a with a new 1278.1-200x version. This would offer a single source document with the most widespread authoritative appeal to the international community.
- Alternative 3: Prepare a SISO Standards Document - DIS Protocol Version 7. This approach would develop a balloted document that would be the equivalent of a Revision b to the IEEE 1278.1 Standard. It could be cited as a standard to be used in conjunction with 1278.1.

At the Fall 2004 SIW, it was decided to opt for alternative 2 that requires a complete update of IEEE 1278.1. This will create a single source document for DIS, and users would be made aware of the new version even if they are not SISO members as it would appear in the IEEE catalogue as the latest version.

4.3 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 also maintains the 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.

AOD 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].

4.4 RPR FOM Product Development Group

The Real-time Platform Reference Federation Object Model (RPR-FOM) Product Development Group within SISO is close to finalising 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 RPR-FOM PDG has now determined that the planned Version 3 of the RPR FOM will track the updated DIS standard.

AOD also contributed to early drafts of the SISO RPR-FOM standard.

5. AUSTRALIAN STANDARDS ACTIVITY

DSTO (AOD) has been involved with the DIS SG and PDG 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 [19 - 20]. The Australian contribution to these groups is discussed in the next sections.

5.1 Communications in DIS

Throughout all three CReaMS exercises, successful voice communications have been 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 [21].

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 centre of the world that, by convention, are propagation-less. As a result, each voice system may be built to a different interpretation of the standard.

As a result, six PCRs were submitted to the DIS SG addressing issues with the Transmitter PDU. These are summarised as:

PCR 68: Centre-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 centre 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 four modulation fields in the Transmitter PDU should be used. As a result, some voice system 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. Some DIS voice systems implement intercoms using the traditional IEEE 1278.1 Transmitter and Signal PDUs. Whilst IEEE 1278.1a added Intercom-specific PDUs, adoption of these new PDUs is minimal. It is suggested that the Transmitter and Signal PDU approach for intercom usage be documented in the standard.

PCR 118: Samples in Signal PDU: The number of samples in the Signal PDU can affect both the latency and bandwidth utilisation.

5.2 Other Contributions

PCRs have also been developed in other areas including:

- *PCR 95:* Dead reckoning: the default thresholds for dead reckoning are inadequate for fast moving entities such as aircraft
- *PCR 119:* Timeout and deactivation rules for the Electromagnetic Emission and Underwater Acoustic PDU

5.3 Standards Australia

Standards Australia created a committee in 2004, IT-031, to address the requirement for Australian modelling and simulation standards [22]. 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. Standards Australia is a chapter of ISO.

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, behavioural, platform/technical, simulation intercommunication, and aural data.

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 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)
- Address issues with the rapidly changing Advanced Distributed Simulation environment

6.2 Creation of Tiger Teams

To make the task of updating the standard manageable, the DIS PDG has created Tiger Teams to address:

- Radio/Transmitter Issues
- Transfer Control
- Link 16
- Draw Objects PDU

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

6.3 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)
- Entity ID Reuse Clarification
- New PDU Header Status field (Transfer Control)
- Miscellaneous Editorial Corrections
- Event ID Clarification
- Transmitter PDU Clarifications
- Special Entity Type field
- Emission PDU modifications

7. CONCLUSIONS

AOD has been involved with SISO standardisation activities for several years with respect to DIS enumerations and the RPR FOM. Recently, the Division has also become involved in the renewed DIS standardisation 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 become involved with other emerging standards such as the Link 16 simulation standard and the Extensible Modelling and Simulation Framework (XMSF).

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