Australian Government
Department of Defence
Defence Science and Technology Organisation

Capabilities of the Revised IEEE DIS Standard and Implications for Australian Defence

Peter Ryan, Peter Ross and Will Oliver

Air Operations Division
Defence Science and Technology Organisation

DSTO-GD-0617

ABSTRACT

Distributed Interactive Simulation (DIS) is a widely-used networking protocol standard that provides a method of communicating entity information among simulators and simulations through Protocol Data Units (PDUs) to create a synthetic environment. During 2011 a significant simulation milestone will be achieved when balloting of the revised DIS standard is completed, and it becomes officially designated as IEEE-1278.1-20XX. This milestone represents over six years of effort by a team of international distributed simulation experts from military, industry, and government organisations including DSTO. The proposed new standard is an extensive revision which clarifies ambiguities present in the current standard, adding new capabilities that reflect changes in military equipment and doctrine and providing for advances in technology such as the Internet, mobile telephony and the widespread use of the Global Positioning System for positional and time data. Five new PDUs have been added to include Information Operations capability, enhanced warfare support, and the ability to communicate information about individual attributes for a particular entity, object, or event. Where possible, backward compatibility has been maintained in the new version to maintain interoperability with existing systems. In this paper we review these new capabilities in detail, and explore what this will mean for the Australian simulation ecosystem.

RELEASE LIMITATION

Approved for public release

Published by

Air Operations Division
DSTO Defence Science and Technology Organisation
506 Lorimer St
Fishermans Bend, Victoria 3207 Australia

Telephone: (03) 9626 7000
Fax: (03) 9626 7999

AR-014-842
September 2010

Capabilities of the Revised IEEE DIS Standard and Implications for Australian Defence

Executive Summary

Distributed Interactive Simulation (DIS) is a widely-used networking protocol standard that provides a method of communicating information among simulators and simulations through Protocol Data Units (PDUs) to create a synthetic environment. DIS has been used since 1993 when it was first standardised by IEEE. There have been two subsequent revisions and the current IEEE standard is dated 1998.

This IEEE DIS standard is being revised by the Simulation Interoperability Standards Organisation (SISO). It is anticipated that balloting of the revised DIS standard will be completed during 2011, and it will become officially designated as IEEE-1278.1-20XX. This milestone represents over six years of effort by a team of international simulation experts from military, industry, and government organisations including DSTO.

The proposed new standard includes an extensive revision, clearing up many ambiguities and adding additional capabilities that reflect changes in military equipment and doctrine, and also advances in technology such as the Internet, mobile telephony, and the widespread use of the Global Positioning System. Five new PDUs have been included to simulate Information Operations, enhanced warfare support, and the ability to communicate information about individual attributes for a particular entity, object, or event.

What are the implications for the Australian simulation community? The current state of DIS-compatible Australian Defence Organisation (ADO) simulators shows that these are largely compliant with the 1998 IEEE standard. Since backward compatibility has been retained wherever possible, most ADO DIS-compatible simulators should be able to interoperate with simulators equipped with the revised standard.

A recurring theme in the revised standard is the need to model new and enhanced military capabilities in a distributed simulation environment. Most of these are not relevant to Australia, as the corresponding assets have not yet been acquired such as multi-stage missiles and Directed Energy weapons. Thus, the ADO simulation community should be made aware of the new standard although it should have minimal impact on existing systems and those proposed under the current Defence Capability Plan.

Most importantly, the refinements and clarifications made to the standard and also the greatly increased explanatory documentation will enable distributed synthetic environments to be constructed in Australia with less integration effort and more certainty of outcome.

Authors

Peter Ryan
Air Operations Division

Peter Ryan is a Principal Research Scientist in DSTO's Air Operations Division. He graduated from Melbourne University with a BSc (Hons) and PhD. After postdoctoral work at the University of Massachusetts, USA he joined DSTO in 1985. During 1988-1989 he was a Visiting Scientist at the Admiralty Research Establishment (Bincleaves) at Weymouth, UK. Within DSTO, he initially worked in Maritime Operations Division on the modelling and simulation of underwater warfare, and since 1998 in Air Operations Division in the field of simulation technology. His main research interests include Advanced Distributed Simulation technologies, real-time simulation, and synthetic environments and their potential to provide enhanced training solutions for the Australian Defence Force. His current position is Head, Standards & Interoperability, within AOD and he is a member of IEEE.

Peter Ross
Air Operations Division

Peter Ross graduated from RMIT University in 2001 with a Bachelor of Applied Science, majoring in computer science. He joined DSTO's Air Operations Division in 2003, where he has undertaken a role in evaluating the use of advanced distributed simulation for collective training. Peter is a member of the Simulation Interoperability Standards Organisation (SISO).

Will Oliver
Air Operations Division

William Oliver holds degrees in Aerospace Engineering and Mathematics. Mr Oliver joined DSTO in 2006 and works in Air Operations Division researching communications and interoperability issues in the area of advanced distributed simulation. Mr Oliver is a member of the Simulation Interoperability Standards Organisation (SISO). Prior to joining DSTO he developed software for flight simulators and simulated maintenance trainers.

Contents

Glossary of Acronyms

ADF	Australian Defence Force
ADO	Australian Defence Organisation
ADS	Advanced Distributed Simulation
ALSP	Aggregate Level Simulation Protocol
AM	Amplitude Modulation
AOD	Air Operations Division
API	Application Programming Interface
CTIA	Common Training Information Architecture
DARPA	Defense Advanced Research Projects Agency
DIS	Distributed Interactive Simulation
DSTO	Defence Science and Technology Organisation
EE	Electromagnetic Emission
ESPDU	Entity State PDU
EW	Electronic Warfare
FH	Frequency Hopping
GPS	Global Positioning System
IEEE	Institute of Electrical and Electronic Engineers
IFF	Identification Friend or Foe
IO	Information Operations
LVC	Live-Virtual-Constructive
LVCAR	Live-Virtual-Constructive (LVC) Architecture Roadmap
NATO	North Atlantic Treaty Organisation
OMT	Object Model Template
PAR	Project Authorisation Request
PCR	Product Change Request
PDG	Product Development Group
PDU	Protocol Data Unit
PN	Product Nomination
PSG	Product Support Group
RAAF	Royal Australian Air Force
RTI	Run Time Infrastructure
SAC	Standards Activity Committee
SDO	Standards Development Organisation
SG	Study Group
SIMNET	SIMulator NETworking
SISO	Simulation Interoperability Standards Organisation
SIW	Simulation Interoperability Workshop
SV	Standard Variable
TENA	Test and Training Enabling Architecture
TO	Transfer Ownership
UDP	User Datagram Protocol
UHF	Ultra High Frequency
UTC	Universal Time Coordinated
VP	Variable Parameters

1. Introduction

Distributed Interactive Simulation (DIS) is a networking protocol standard that provides a method of communicating entity information among simulators and simulations through Protocol Data Units (PDUs) to create a synthetic environment. These PDUs comprise data packets that are broadcast over the simulation network. DIS PDU Standards were developed under the guidance of the DIS Coordinating Committee, and utilised the IEEE Standards approval process [1].

There have been three formal IEEE DIS standards since 1993 reflecting the need to introduce new functionality as simulations and simulators become more sophisticated. These are described in the next section.

IEEE standards are reviewed for currency every five years and are either revised or retired as formal standards. Since the most recent IEEE 1278.1 DIS standard was released in 1998, accordingly, in 2003, a decision had to be made about the future of the standard that had reached its fifth year. The Simulation Interoperability Standards Organisation (SISO) created a working group, the DIS Study Group, to examine the feasibility of extending the standard and this soon reached a critical mass of interest in a revised version of DIS.

The decision to proceed to a full revision of the standard was made in 2005 and a DIS Product Group was formed. The work of this group has now progressed the revised DIS standard through 15 drafts (draft 15 dated April 2010) [2]. The new standard will be known as IEEE 1278.1-20XX.

The revised standard will incorporate many new features. Since the latest standard was approved in 1998, both warfare and simulation technology have made rapid advances that need to be reflected in an updated standard. Further, there has been a revolution in the use of technologies such as mobile telephony and the Internet. The new standard needs to allow for such new and enhanced civilian and military capabilities in a distributed simulation environment.

In this report, the changes to the standard are discussed together with their implications for the Australian Defence Organisation (ADO).

2. Distributed Interactive Simulation

The US Defense Advanced Research Projects Agency (DARPA) sponsored the SIMNET program in the early 1980s to network together manned tank trainers [3]. SIMNET was the first implementation of large-scale, real-time, human-in-the-loop simulator networking for team training and mission rehearsal and was very successful with over 300 simulators linked in a single exercise. The SIMNET architecture and protocols evolved into the Distributed Interactive Simulation standard in the early 1990s.

DIS has since undergone the IEEE standardisation process three times:

- IEEE 1278-1993 (1993) [4]: this initial version principally supported land warfare.
- IEEE 1278.1-1995 (1995) [5]: this version added electromagnetic interactions and other features.
- IEEE 1278.1a-1998 (1998) [5, 6]: this further extended DIS to support a richer set of warfare capabilities including Identification Friend or Foe (IFF), underwater acoustics and environmental features.

These versions of the standard are referred to as protocol versions 2, 5, and 6 respectively. There have also been several draft versions that served as de facto standards while the community sought IEEE publication - DIS version 1.0 (May 1992), DIS version 2.0 - third draft (May 1993), and DIS version 2.0 - fourth draft-revised (March 1994).

DIS has evolved considerably over nearly two decades. The initial DIS 1.0 standard, IEEE 1278-1993 [4], had only 10 PDUs which supported the appearance and movement of entities, weapons firing, detonation of ordnance, collision detection, and logistical resupply of units. This version had a strong US Army influence particularly aligned to tank exercises reflecting its development from SIMNET [5].

The draft DIS 2.0 standards (2.0.3 and 2.0.4) and IEEE 1278.1-1995 [5] defined 27 PDUs to provide additional functionality supporting voice radio and tactical data links, simulation management, electromagnetic emissions, and laser interactions for smart munitions.

The latest update to the standard, IEEE 1278.1a-1998 [6], included 40 new PDUs that provide additional support for emissions, entity information/interaction, mine warfare, entity management, field instrumentation, communications and environment.

These DIS versions are summarised in Table 1 below.

Table 1: DIS Protocol version numbers

DIS Version Number	DIS Protocol Version
0	Other
1	DIS 1.0 (May 1992)
2	IEEE 1278-1993
3	DIS 2.0.3 (May 1993)
4	DIS 2.0.4 (March 1994)
5	IEEE 1278.1-1995
6	IEEE 1278.1a-1998

The current standard strictly comprises both IEEE 1278.1-1995 [5] that includes 27 PDUs and IEEE 1278.1a-1998 [6] that includes 40 additional PDUs. Despite the considerable expansion in the number of PDUs in this latest version, it should be noted that few of these have been implemented in fielded systems. A timeline of the development of DIS is shown in Figure 1.

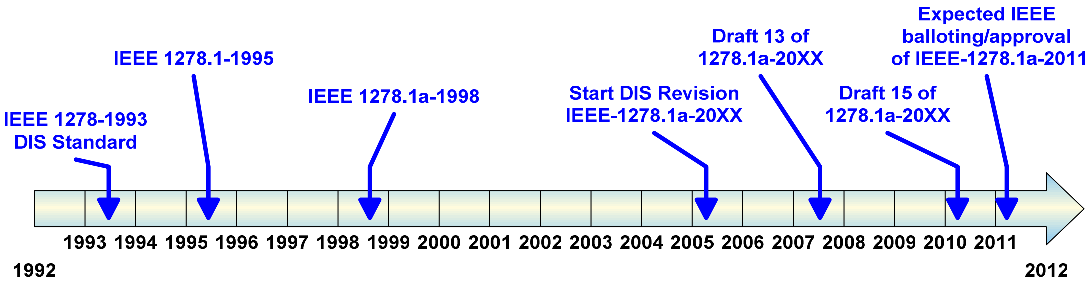

Figure 1: Development of DIS

The IEEE 1278.1 standards define the application protocol and PDU set. These are accompanied by four other IEEE standards:

- IEEE 1278.2: IEEE Standard for Distributed Interactive Simulation Communication Services and Profiles [7]
- IEEE 1278.3: IEEE Recommended Practice for Distributed Interactive Simulation Exercise Management and Feedback [8]
- IEEE 1278.4: Trial-use Recommended Practice for Distributed Interactive Simulation - Verification, Validation, and Accreditation [9]
- IEEE 1278.5 : Fidelity Description Requirements (never published) [10].

3. SISO/IEEE Standardisation Process

The Simulation Interoperability Standards Organisation (SISO) is an international organisation dedicated to the promotion of interoperability and reuse for the benefit of a broad range of modelling & simulation communities [11]. SISO's Conference Committee organises Simulation Interoperability Workshops (SIWs) in the US and Europe. SISO's Standards Activity Committee develops and supports simulation interoperability standards, both independently and in conjunction with other organisations. SISO is recognised as a Standards Development Organisation (SDO) by NATO and as a Standards Sponsor by IEEE.

Typically, the Standards Activity Committee (SAC) establishes a Study Group to consider specific issues. Each Study Group operates under specific Terms of Reference that identify the issues it is being asked to consider and the specific questions it is asked to address.

After consensus has been reached within the group, a decision is made to apply for formal SISO approval to begin product work. This initiates the SISO Balloted Product process. The group proposing the product develops a SISO Product Nomination (PN) and presents it to the SAC.

After the PN is approved by the Executive Committee, the SAC creates a Product Development Group (PDG). If the proposed product is either a revision to an existing IEEE standard or intended as a new IEEE project, the SAC and PDG develop a Project

Authorisation Request (PAR) and submit it to IEEE. Upon IEEE approval, the PDG assumes a dual role of an IEEE Working Group.

Once the PDG has completed its work, it presents the status of the Product to the SAC for approval to begin balloting. If the Product is approved for balloting, the SAC issues a call to SISO community members to join the balloting pool.

PDGs developing IEEE standards follow SISO procedures up to the point of actual balloting. All SISO-sponsored IEEE standards are balloted and approved using established IEEE procedures. Upon completion of balloting and product approval under IEEE procedures, the PDG completes the requirements to develop Terms of Reference and establishes a Product Support Group.

In the present case, the DIS Product Development Group, approved by SISO in 2005, developed a standard means of submitting changes, namely via a Problem Change Request template – PCR. Over 200 of these were submitted during the five years development of the revised standard. These PCRs were incorporated iteratively into draft revisions of the standard, as shown in Figure 2.

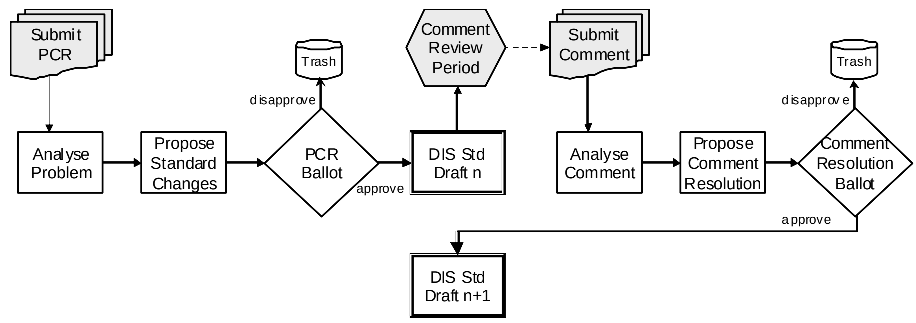

Figure 2: Iterative standards development within SISO's DIS Product Development Group

4. Other Interoperability Standards and Protocols

DIS is only one of a series of standards that have been used to connect simulators and simulations. Others include ALSP, HLA, CTIA, and TENA. Brief descriptions of these follow in the next subsections.

4.1 Aggregate Level Simulation Protocol (ALSP)

Aggregate Level Simulation Protocol (ALSP) is a protocol and supporting software that enables simulations to interoperate with one another [12]. ALSP consists of:

- ALSP Infrastructure Software that provides distributed run-time simulation support and management;
- A reusable ALSP Interface consisting of generic data exchange message protocols; and
- Participating simulations adapted for use with ALSP.

ALSP has been largely replaced by the High Level Architecture (HLA). It was used by the US military to link analytic and training systems, principally those using constructive simulations. ALSP was developed in the early 1990s but was never standardised by IEEE.

4.2 High Level Architecture (HLA)

High Level Architecture (HLA) is a general purpose architecture for distributed computer simulation systems [13]. HLA comprises:

- Interface Specification that defines how HLA compliant simulators interact with the Run-Time Infrastructure (RTI). The RTI provides a programming library and an application programming interface (API) compliant to the interface specification;
- Object Model Template (OMT) that specifies what information is communicated between simulations and how it is documented; and
- HLA Rules that simulations must obey to be compliant to the standard.

HLA was initially standardised by IEEE in the early 2000s [14-17]. A revised version, HLA Evolved, has now also been standardised by IEEE [18-20]. In contrast to DIS, HLA does not specify the format of the data packets transmitted on the network leading to interoperability issues.

4.3 Test and Training Enabling Architecture (TENA)

The Test and Training Enabling Architecture is an object-oriented data transport architecture [21]. TENA was developed principally for the US training range community to support interoperability among Live, Virtual and Constructive simulations in real-time. The core of TENA is the TENA Common Infrastructure that includes:

- TENA Middleware - high performance, real-time, low-latency communication infrastructure used by range resource applications and tools during execution of a range event.
- TENA Repository that contains all the relevant TENA information that is not specific to a given test or training event, such as the software library containing the TENA Middleware, standardised range resource interface definitions, and executable versions of the TENA utilities and tools, along with related documentation.
- TENA Logical Range Data Archive that stores and provides for the retrieval of all of the persistent information associated with a test or training event.
- TENA Object Model that enables semantic interoperability among range resource applications by encoding all the information that needs to be communicated among those range applications.
- TENA tools, utilities, and gateways that assist the user in creating and managing an integration of range resources, as well as in optimising the TENA Common Infrastructure.

4.4 Common Training Instrumentation Architecture (CTIA)

The Common Training Instrumentation Architecture (CTIA), developed by Lockheed Martin for the US Army, is the core software component of training instrumentation systems [22]. CTIA provides the technical architecture that ensures commonality across training instrumentation systems and interoperability across live, virtual and constructive training tools. CTIA consists of standards and protocols to be used by system developers [22].

4.5 Architecture Roadmap Study

In 2007 the US Department of Defence published the Live-Virtual-Constructive (LVC) Architecture Roadmap study (LVCAR) [23]. It sampled 110 sites and found DIS and HLA architectures to be the most widely used (Figure 3).

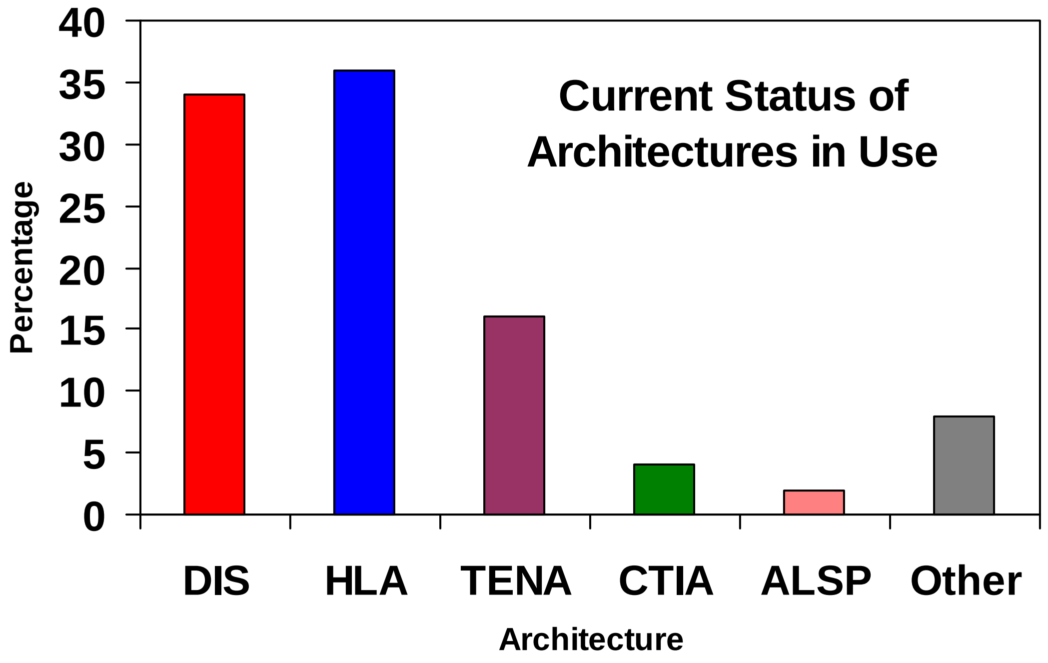

Figure 3: 2007 Survey of architectures used for simulation interoperability (adapted from [23])

These protocols fulfil differing requirements of the interoperability spectrum as summarised in Table 2 using a traffic light scheme (green – compliance; yellow – meets requirement to some extent; red – does not meet requirement). These requirements were defined by the LVCAR study team as critical for achieving interoperability and are listed in Table 2.

Table 2: Summary of Requirements (adapted from [23]). Green indicates a high degree of compliance; yellow indicates issues; while red indicates lack of support for the requirement.

Requirement	DIS	HLA	TENA	CTIA	ALSP
Create a distributed simulation, allow systems to join & resign; provide for initialisation and destruction of the distributed simulation instance					
Support publish and subscribe information management (filtering)					
Quality of Service					
Interoperate with HLA federations					
Save and restore operation					
Region-based information management (filtering)					
Support multiple message types					
Transfer of Ownership					
Synchronise applications					
Object Oriented design					
Global Event Ordering					
Specification for tools and utilities					

5. Principal Changes to DIS IEEE 1278.1 Standard

The principal changes between IEEE 1278.1-1995/IEEE 1278.1a-1998 and the proposed revised standard are described in the following subsections.

The existing standard has many ambiguities and thus extensive clarification has been added throughout the standard. The DIS Exercise section has been expanded into a comprehensive section covering detailed requirements related to simulations, enumerations, objects, heartbeats, timeouts, thresholds, gateways and communication services.

All identifiers used in the standard were clarified and consistent and simplified terminology adopted. To provide flexibility and reduce the number of heartbeats, entity heartbeats are now defined by entity kind, domain, and whether the entity is moving or stationary.

Whenever possible, backward compatibility has been maintained by reusing existing fields. For example, all PDUs have a 96-bit header that defines protocol version, exercise identifier, PDU type, timestamp, length, with a 16-bit padding field. In the draft standard, this has been split into an 8-bit PDU Status record and an 8-bit padding field as shown in Table 3.

Table 3: PDU Status Field

Previous Versions	Revised Version
Protocol Version – 8 bit enumeration	Protocol Version – 8 bit enumeration
Exercise ID – 8 bit enumeration	Exercise ID – 8 bit enumeration
Protocol Family – 8 bit enumeration	Protocol Family – 8 bit enumeration
Timestamp – 32 bit integer	Timestamp – 32 bit integer
Length – 16 bit integer	Length – 16 bit integer
Padding – 16 bits	*PDU Status Field – 8 bits*
	Padding – 8 bits

The PDU Status record is used to indicate status information that either (1) affects the processing of this specific PDU, (2) provides information related to the interpretation of one or more data fields or their content, or (3) provides information that affects the processing of an entity, other object or environmental process associated with this PDU. Bit 0 is proposed to be used to indicate the transferred status of an entity and bits 1 -2 to designate whether the entity is Live (1), Virtual (2), or Constructive (3). Other uses have been proposed for the remaining bits.

Other PDUs such as Fire and Detonation can make use of this functionality to indicate whether a munition, non-munition, or expendable (such as chaff or flare) has been fired and detonated.

PDUs from the new version that use this field will be backwardly compatible with earlier versions of DIS. These earlier versions will not process this field and will thus simply ignore the additional status information.

5.1 New Functionality for Information Operations

Information Operations (IO) refers to the integrated employment of electronic warfare (EW), computer network operations, psychological operations, military deception, and operations security to influence, disrupt, corrupt, or otherwise affect enemy information and decision making while protecting friendly information operations.

To support Information Operations, a new IO family has been added that defines two new PDUs:

- *IO Action PDU* that communicates an IO attack or the effects of an IO attack on one or more target entities. This PDU contains information that can be used by a receiving simulation to model the effects of an IO attack.
- *IO Report PDU* that communicates the effects of an IO attack on one or more target entities. The information contained in this PDU is used by a receiving simulation to determine whether to continue an IO attack or change attack parameters. It can also be used for IO data analysis and identification of interoperability problems.

By their nature, these PDUs will generally be used for classified operations with the PDUs themselves containing classified data concerning particular Information Operations.

5.2 Modifications to Electromagnetic Emissions

Considerable changes have been made to the Electromagnetic Emission (EE) PDU. Its use has been clarified to remove ambiguities such as notifying other systems of beam on/off status, and operation of the heartbeat/changed data update mechanisms.

The previous standard was ambiguous on the requirement for all emitters from one system to be included in a single EE PDU. The new standard has introduced the Complete Entity, Complete Emitter, and Complete Beam methods.

- *Complete Entity:* In the Complete Entity issuance method, a single EE PDU fully describes all active emitters associated with an entity.
- *Complete Emitter* method: In the Complete Emitter issuance method, a single or multiple EE PDUs may be issued to describe the emitters associated with an entity, with each PDU fully describing all active beams associated with each emitter described in that PDU. In contrast with the Complete Entity issuance method, the Complete Emitter method does not require that all of an entity's active emitters be described in each EE PDU issued.
- *Complete Beam* method: In the Complete Beam issuance method, a single EE PDU describes a subset of the entity's active beams, with each beam fully described. This method supports multi-beam emitters in cases where some beams update much more frequently than others.

Further, a new jammer field has been added using an existing padding field to better support a wider range of multi-resolution simulations. The new standard will also be able to support more complex systems such as phased array radars to some level of fidelity and features such as radar side lobes.

Phased array emitters can be modelled by using specific beam function values to model time sharing. For example, a single emitter may be represented using separate beams with time-shared search, time-shared acquisition, time-shared track, time-shared command guidance and time-shared illumination beam functions.

5.3 Warfare Upgrade

Representation of weapons and their effects has been enhanced with the addition of two new PDUs:

- A new Directed Energy Fire PDU has been added to support high-fidelity directed energy engagements, typically involving laser weapons and also microwave and acoustic weapons. This PDU is used in conjunction with the existing Fire and Detonation PDUs.
- A new Entity Damage Status PDU has been added to communicate detailed damage information sustained by an entity from either a weapon, a collision with another object, or for some other reason. This PDU enables damage to a specific location on an entity to be conveyed whether or not that location is associated with an articulated or attached part.

The new Annex A contains details concerning the use of these two additional PDUs. The Warfare - General Requirements section has also been rewritten to incorporate the use of the Fire and Detonation PDUs for expendables and the use of the Detonation PDU for non-munition explosions.

The new standard also allows for a detailed representation of submunition operations including visual appearance, from the time the initial submunition dispenser is launched until the time that all the individual bomblets either explode or become duds. This is shown in Figure 4 with seven stages as described in detail in Annex A:

A. Fighter aircraft with smart weapon,
B. Smart weapon launched; Tactical Munition Dispenser opens to release canister
C. Submunition canisters released
D. Submunition canisters open 4 skeets each and rocket fires
E. Skeets ejected
F. Projectiles fired
G. Projectiles detonate

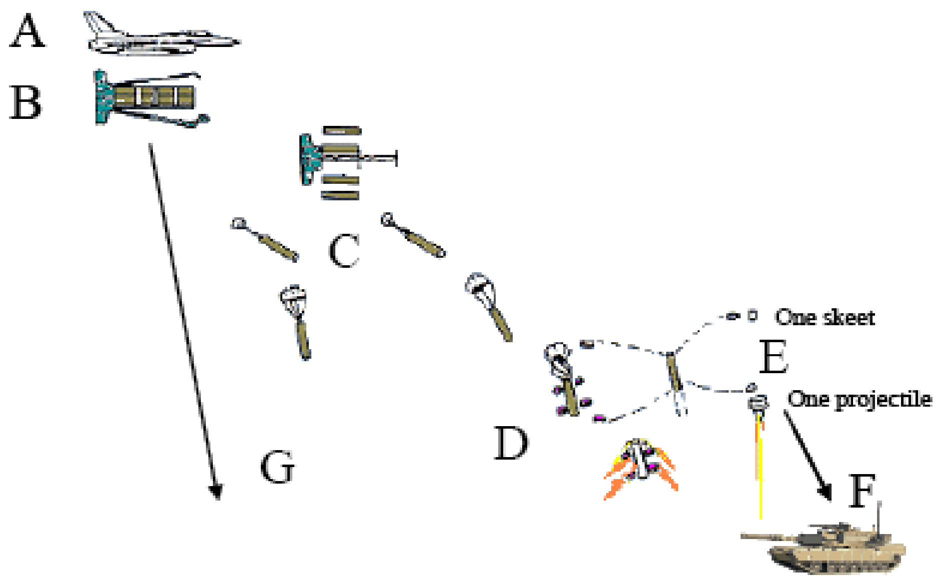

Figure 4: Simulation of Submunitions (taken from [2])

Non-munition explosions (such as a fuel tank spontaneously exploding) are also supported. These are handled using the Detonation PDU with the PDU Status field (refer to section 5) set to 'Non-Munition' to communicate to other simulations that an entity has exploded.

Chaff and flare expendables are treated using the Fire and (optional) Detonation PDUs with PDU status set to 'Expendable'. Signal and illumination flares can be supported as well as countermeasure types.

5.4 Radio Communications

The Transmitter PDU has been revised to include Variable Transmitter Parameters records, in addition to the existing Modulation Parameters record and Antenna Pattern records.

While the 1998 version added two specific Intercom PDUs (Intercom Signal and Intercom Control), these have not been used widely and intercom has generally been modelled using the existing Transmitter and Signal PDUs. This process has now been formalised as Simple Intercom in the revised standard.

Propagation-less transmissions are used when line-of-sight, range and other propagation effects are either not required or for training, testing and troubleshooting where propagation models may interfere with these activities. The revised standard requires that the Antenna Location X, Y, and Z subfields each be set to zero to indicate such transmissions.

A HAVE QUICK radio is a UHF AM radio used for tactical communications using Frequency Hopping (FH) for jam resistant operations. These radios, used by the RAAF, can now be simulated at a basic and high fidelity. Live HAVE QUICK radios may be interfaced to simulated HAVE QUICK radios if there is a simulated high fidelity HAVE QUICK radio present with the correct interfacing capability. Basic HAVE QUICK simulated radios may also interface with live radios through a high fidelity HAVE QUICK radio that has such a capability.

5.5 Transfer Ownership

The Transfer Control Request PDU was added in DIS version 6 to enable simulations to transfer control of entities. The Transfer Control function has been renamed the *Transfer Ownership* function and the Transfer Control Request PDU has been re-titled the Transfer Ownership (TO) PDU. The entire TO function has been revised to improve its functionality in the new standard. These changes include:

- Transfer Ownership can now be either: *Push Transfer* where one simulation desires to transfer ownership to another simulation or *Pull Transfer* where a simulation requests to take control of another simulation's entity.
- The TO PDU requires Simulation Management and Simulation Management with Reliability PDUs.
- Making use of the new PDU Status record to indicate entity transfer status.

Transfer Ownership can be used to transfer a simulated entity from one simulation to another. For example, if one simulation is modelling an aircraft and another a threat missile, latency issues across the network may affect the fidelity of the engagement. By transferring the simulated missile to the same system as the aircraft, higher fidelity should be achieved. TO can also be used to transfer entities among constructive and virtual systems to achieve more realistic simulations.

5.6 New Attribute PDU

A new Attribute PDU has been introduced to communicate information about individual attributes for a particular entity, other object, or event. This PDU shall not be used to exchange data available in any other PDU except where explicitly mentioned in the PDU issuance instructions within this standard.

The Attribute PDU has two functions:

- PDU Extension – a means to extend *any* PDU by creating new Attribute Records that can be sent in an Attribute PDU. The Attribute PDU for a *State* PDU can be sent at any time. A *transient* PDU (eg Fire) can be extended by bundling the Attribute PDU with it.
- Partial Updates – a mechanism for new PDUs that allows them to send changed data fields only instead of having to send all the data fields for the PDU type where the PDU issuance rules allow.

The Attribute PDU can be used to save bandwidth by only sending PDU information that has changed. It also provides a means to extend DIS by adding the ability to send additional data fields that are not contained in the original PDU.

5.7 Interrogate Friend or Foe

Transponder and Interrogator requirements have been updated to support high fidelity Mode 5 IFF and Mode S systems.

Mode 5 is the new military mode that replaces Mode 4 IFF, although existing Mode 4 equipped aircraft will continue to carry that equipment. The new Mode 5 transponders will include additional operational information about an aircraft included in their replies in addition to transmitting existing Mode 1, 2, 3/A, C and even Mode 4 data if available.

Mode Select (S) is a new civilian radar beacon system added to the present civilian Mode A and Mode C systems that are used for air traffic control. Mode S provides enhanced aircraft data that is downlinked to Air Traffic Control facilities on interrogation. The first phase of Mode S has already been implemented in Europe: all aircraft, including US military aircraft, are required to have a Mode S capability.

Mode 5 and Mode S equipped military aircraft will be coming on line over the next 2-10 years. US and NATO countries are retrofitting existing C4ISR systems that have interrogators to add both a Mode 5 and Mode S interrogation capability.

5.8 Time Requirements

Time requirements have been extensively clarified and revised. This includes clarification on:

- terminology, with some new terms added to the DIS glossary such as GPS Time, Clock Skew, and Wall Clock Time
- absolute and relative timestamps
- simulation, real-world, and elapsed time
- issuance and receipt rules
- dead reckoning
- use of Start/Resume and Stop/Freeze PDUs
- synchronisation

Some of these changes reflect advances in communications technology. For example, there is now the ability to synchronise PDUs to GPS time: a simulation can obtain the present synchronised time using the GPS satellite constellation. This can generally provide UTC time, usually to within 100 μs.

Annex H also contains advice on managing time errors due to network latency and how to process timestamps in PDUs to reduce error.

5.9 Dead Reckoning

The original standard contained ambiguities in determining criteria to issue update Entity State PDUs. The standard stated that:

When the entity's actual position/ orientation has varied from the dead reckoned position/orientation by more than a threshold value, the simulation application shall issue an Entity State PDU to communicate the entity's actual position and orientation to other simulation applications.

For positional dead reckoning this could be interpreted to mean either:

- when the vectorial change exceeds threshold, that is outside the bounding sphere with radius equal to threshold in Figure 5.
- when one of the coordinate values exceeds threshold, that is outside the bounding cube of side equal to the threshold.

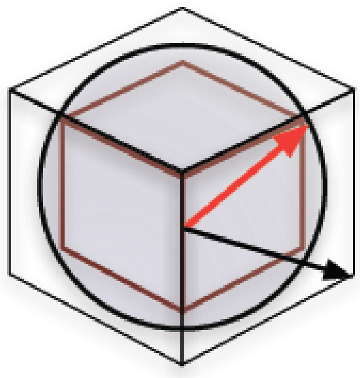

Figure 5: Inset and bounding cube (taken from [24])

The wording has now been revised to mandate the second interpretation. This is easier to implement and is also computationally cheaper than calculating squares and sums of coordinate values.

Ambiguities and errors in the existing dead reckoning algorithms have also been removed. Annex E - Dead Reckoning has been completely revised to clarify requirements although retaining all the existing formulae.

Other updates including the addition of a new quaternion approach [25] to model rotation. The standard Euler angle approach can lead to singularities (the so-called gimbal lock effect) and many simulations use a geometric (or quaternion) rotation scheme internally. This addition provides the flexibility of using either the Euler angle or the geometric representation for orientation dead reckoning.

For simulations using a geometric (or quaternion) rotation scheme internally there is a simpler method of calculating the dead reckoning matrix. For such simulations the extra information required to construct the dead reckoning matrix is a unit vector oriented in the direction of the axis of rotation. The rarely-used 120-bit Other Parameters record in the Entity State PDU is used to carry the scaled axis of rotation.

Between the scaled axis of rotation and the existing dead reckoning information in the Entity State PDU, all the information required to form the rotation matrix is available without any trigonometric functions being executed. This provides a more coherent, geometrical interpretation of the rotation matrix and avoids both the computational burden and singularities inherent in the Euler angle based approach.

As no existing fields in the PDU are altered the approach ensures that simulations not using a geometric rotation scheme can still perform dead reckoning exactly as they do at present ensuring both schemes will be compatible.

5.10 Heartbeats

Related to dead reckoning is the DIS heartbeat mechanism. Heartbeat PDUs are issued when there has been no significant data change and a predetermined interval of real-world time has elapsed since the last PDU was issued. Heartbeats confirm that the relevant entity or data is still active in the exercise.

The original DIS concept had a single heartbeat value for all entity types, regardless of kind, domain or whether the entity was stationary or moving. However, experience in conducting DIS exercises identified a need to set different heartbeat rates for different types of entities. In the revised DIS version, the user can now define separate heartbeats for all entity types (e.g. air, surface, subsurface), objects such as environmental processes and other supplemental attributes such as electromagnetic emission status for radars.

The concepts of full and partial heartbeat compliance have also been introduced:

- Partial Heartbeat Compliance refers to a simulation that (1) does not implement a separate heartbeat parameter for each local entity type, and for all other local objects and supplemental attribute PDUs that it can transmit or (2) does not implement a separate timeout value for each remote entity kind and domain, for stationary remote entities, and for other remote object and supplemental attribute PDUs that it can receive and process.
- Full Heartbeat Compliance refers to a simulation that (1) implements a separate heartbeat parameter for each local entity type, and for all other local objects and supplemental attribute PDUs that it can transmit and (2) implements a separate timeout value for each remote entity kind and domain, for stationary remote entities, and for other remote object and supplemental attribute PDUs that it can receive and process.

Similarly, the use of timeouts and threshold values has been extended. Annex F: Heartbeats, Timeouts, and Thresholds provides details on these changes.

5.11 Records

The Record section (6.2) has been greatly expanded to include many new record types required for the revised standard. Further, Variable Parameter Records have been defined for existing PDUs and Standard Variable Records for the new PDUs.

5.11.1 Variable Parameter Records

The 128-bit Articulation Parameter record found in the Entity State and other PDUs has been renamed the Variable Parameter (VP) record to denote that its original design supports more than just its use for articulated and attached parts records. This now provides a way for additional information to be associated with entities within the Entity State PDU, and detonation events within the Detonation PDU.

Use of the VP record has been proposed for the Entity State, Entity State Update, Detonation, and Transmitter PDUs. VP records have been defined to date for Articulated Parts, Attached Parts, Entity Association, Entity Type, and Separation. There are up to 256 such VP records that can be defined. The Entity Association VP record is described in Table 4. This VP record is used to communicate the association or dissociation of two entities, or of an entity with another object and is included in the Entity State PDU of each entity. For example, if an aircraft entity is towing a decoy entity, the Entity Association VP record shall be contained in the Entity State PDUs describing both the aircraft and the towed decoy.

Table 4: Entity Association Variable Parameters Record

Field Size	Field Name	Data Type
8	Record Type	8 bit enumeration
8	Change Indicator	8 bit enumeration
8	Association Status	8 bit enumeration
8	Association Type	8 bit enumeration
48	Associated Entity/Object	Entity Identifier Record (see 6.2.2 of [2])
16	Own Station Location	16 bit enumeration
8	Connection Type	8 bit enumeration
8	Group Member Type	8 bit enumeration
16	Group Number	16 bit integer
Total Entity Association VP record size = 128 bits		

It is envisaged that other PDUs will also utilise this new capability to extend their functionality.

5.11.2 Standard Variable Records

To make the variable record section format consistent for new and some existing PDUs, a new general record definition was developed. This record is defined as a template for all other variable records in the five PDUs that are new to DIS Version 7, for the new Variable Transmitter Parameters Record in the Transmitter PDU, and for the new Layers 3 and 4 in the IFF PDU.

The Standard Variable Specification record shall be used when a PDU requires a variable record section. This provides the issuing simulation with the ability to include any number of Standard Variable records (also called SV records) that are either PDU-specific or are applicable to the processing of the PDU per exercise agreement. The names of the Standard Variable records for a specific PDU are customised to identify the PDU with which they are associated.

For example, the SV records designed for use in an Entity Damage Status PDU are called *Damage Description record*s. The revised standard (section 6.2.17) defines only one example of this – the Directed Energy Damage Description record. The structure of these records is shown in Table 5. The italicised items define the Directed Energy Damage Description record.

Table 5: Standard Variable Record structure for Directed Energy Damage Description record

Field Size	Field Name	Data Type
16	No. of Damage Description Records	8 bit enumeration
16	Damage Description Record #1	*Record Length (= 40 bytes)*
16	*Padding*	*16 bits unused*
96	*Damage Location (x,y,z)*	*x,y,z all 32 bit floating point*
32	*Damage Diameter*	*32 bit floating point*
32	*Temperature*	*32 bit floating point*
8	*Component Identification*	*8 bit enumeration*
8	*Component Damage Status*	*8 bit enumeration*
8	*Component Visual Damage Status*	*8 bit record of enumerations*
8	*Component Visual Smoke Color*	*8 bit enumeration*
48	*Fire Event ID (site; application; event)*	*Site:application:event; all 16 bit unsigned integers*
16	*Padding*	*16 bits unused*
Total Directed Energy Damage Description record size = 320 bits		

5.12 Entity Separation

Entity separation has been addressed by clarifying how it is to be done for various situations including multi-stage missiles and submunition portrayal. There are two types of entity separation:

a) *Sequential separation.* The separation of one entity from another in a fixed, sequential pattern such as a multi-stage missile where each stage separates in a fixed sequence.

b) *Non-sequential separation.* The separation of one entity from another in a non-sequential pattern such as munitions launched from a fighter aircraft.

A multi-stage missile can be modelled as either a single entity for its entire flight with no separate entities created or with separate entities that represent the planned separation of components. These operations can now be represented accurately using Entity State, Fire, and Detonation PDUs with appropriate VP records for Entity Type, Attached Parts and Entity Separation. Full details are included in Annex A – Warfare.

5.13 New and Revised Annexes

Seven new annexes have been added as follows:

- Annex A: Warfare (Normative). This Annex provides additional requirements related to PDUs used to support the warfare functional area.
- Annex B: Specific Transponder and Interrogator Systems (Normative). This Annex contains detailed requirements applicable to specific transponder and interrogator systems.
- Annex C: Radio Systems (Normative). This Annex contains detailed requirements applicable to specific radio systems.
- Annex D: Objects (Normative). This Annex contains detailed requirements related to object types and primary and secondary identifiers.
- Annex F: Heartbeats, Timeouts, Thresholds (Informative). This Annex provides guidance on how to maintain interoperability when some simulations have implemented the new entity timeout requirements and some have not.
- Annex G: Time Calculations and Uses (Informative). This Annex provides additional information on time and its uses in a distributed simulation environment.
- Annex H: Transfer Ownership (Normative). This Annex contains detailed requirements for transfer ownership.

The existing Annexes have also been extensively revised.

5.14 Changes to Enumerations

DIS is supported by SISO reference document SISO-REF-010 [26] that contains enumerations for entities, systems, and effects. These enumerations are of three kinds:

(1) entity type enumerations that define entities (typically military platforms such as ships and aircraft);

(2) value-pair enumerations that define specific values for equipments such as radar modes; and

(3) bit-mask enumerations that set specific bits in a field to define system characteristics such as appearance of an entity.

These enumerations require considerable revision to support IEEE-1278.1-20XX. Due to their enhanced functionality, the sections describing Transfer, Radio Ownership Communications, IFF, Simulation Management, and Warfare need to be further populated.

New enumerations have also been added such as the Entity Status Record, an unused 8-bit field in the existing standard PDU header that defines whether an entity has been transferred from another simulation application and whether the entity is Live, Virtual, or Constructive (refer to section 5).

Of course, the new PDUs themselves need new PDU-type enumerations (an 8-bit record in the PDU Header field). These enumeration values are:

- 68 Directed Energy Fire PDU
- 69 Entity Damage Status PDU
- 70 Information Operations Action PDU
- 71 Information Operations Report PDU
- 72 Attribute PDU

These new PDUs also have additional associated enumerations. For example, the IO Action PDU requires new enumerations for IO Warfare, IO Simulation Source, IO Action Type, IO and Action Phase.

The IFF enumerations have been completely revised to allow for the new Mode S/Mode 5 capabilities as have the enumerations related to Radio Communications.

5.15 Further Proposed Changes

Further changes were proposed that did not make it into the final draft standard [2].

A Draw Shape PDU was proposed to communicate information about a region of interest or a geometric shape/object that is not defined by the standard entity enumerations. For example, the PDU could be used to draw threat rings or cones in lightweight simulations where the sensor itself is not being simulated.

An extension schema was proposed for enumerating life forms to greater detail than is possible in the present standard. This could use VP records to provide additional detail such as weapons being carried.

Enhanced visualisation was also proposed using VP records to communicate details such as car lights flashing or opening a door.

Such changes may be included in a later revision of the DIS standard as it continues to evolve.

5.16 Summary of Changes

The main changes to the standard can be summarised in Table 6.

Table 6: Summary of changes to DIS Standard

Area	Changes Summary
Editorial consolidation	The standard is now published as a single document
Clarifications	Throughout document
Information Operations	New capability; two new PDUs
Emissions	Removal of ambiguities; complete entity, complete emitter, complete beam methods
Warfare Upgrade	Directed Energy and Entity Damage Status PDUs; support for submunitions
Radio Communications	PDUs revised; Simple Intercom and propagation-less communications formalised
Transfer Control	Revised to include Push/Pull transfers
Attributes	New capability to communicate additional data
Interrogate Friend or Foe (IFF)	Updated to support high fidelity Mode 5 and Mode S IFF
Time requirements	Extensive clarification
Dead Reckoning	Addition of quaternion method for rotations; ambiguities and errors removed
Heartbeats	Separate heartbeat requirements for different entity types
Variable Parameter Records	New capability that extends some existing PDUs
Standard Variable Records	Capability to extend new PDUs
Entity Separation	Clarification on simulation of multistage missiles and submunitions
New Annexes	Seven new annexes added; existing annexes revised
Enumeration additions	New enumerations required to support new PDUs and other added functionality

5.17 Latest Draft Standard – P1278.1-20XX

The latest draft standard is P1278.1-20XX Draft 15 (delta), a 707 page PDF file dated April 2010 [2]. This can be compared to DIS version 1 IEEE-1278-1993, a 107 page document, DIS version 5 IEEE-1278.1-1995, a 138 page document, and IEEE-1278.1a-1998, a 213 page document.

Considering that the current version is described by both the 1995 and 1998 standards combined totalling roughly 350 pages, it can be seen that the revised draft of 707 pages represents a considerable increase. The new standard will become version 7 of the DIS protocol.

6. Implications for Australian Simulation Community

What are the implications for the Australian simulation community when this new version is passed by the IEEE balloting process? Should we adopt this new standard without reservation, or remain with the existing standard? What opportunities does the new standard offer to the Australian Defence Organisation (ADO)?

The concepts of forward and backward compatibility need to be introduced where:

- *Backward Compatibility* is defined as the ability of a receiving simulation to correctly process PDU data fields from older DIS versions without software modifications.
- *Forward Compatibility* is defined as the ability of a receiving simulation to correctly process or ignore PDU data fields from newer DIS versions without software modifications.

The current state of DIS-compatible ADO simulators shows that these are largely compliant with the 1998 (version 6) standard [27]. In general when developing the new standard, the approach was taken to retain backward compatibility wherever possible so that most ADO version 6 compatible simulators should be able to interoperate with new version 7 compatible simulators. If a new version 7 PDU is received that cannot be processed by an existing system, the approach should be taken to reject such a PDU. Some software changes may be required for existing systems to enable these to process version 7 PDUs without causing problems. Version 7 compatible simulators may also need to be able to read version 6 PDUs for interoperability with existing legacy systems that may not be upgraded.

Further, all version 7 compatible simulators may not be able to process the contents of all incoming PDUs. For example, a simulator may not recognise a Visual VP record that contains colour and other appearance information and be unable to process it. This information should be discarded by the receiving simulator. Table 7 captures this using colours to indicate the expected level of compatibility among simulators with different versions of DIS interfaces.

Table 7: Matrix for version 6 and 7 compatible simulators with colour coding indicating level of compatibility (green = highly compatible; orange = some issues expected; red = may have significant issues). Extra features refers to items such as VP records that have been introduced in version 7 of DIS.

	DIS Version 6 Simulator	DIS Version 7 Simulator	DIS Version 7 + extra features
DIS Version 6 Simulator			
DIS Version 7 Simulator			
DIS Version 7 + extra features Simulator			

A recurring theme in the revised standard is the need to model new and enhanced military capabilities in a distributed simulation environment. Examples of this include the Mark XIIa IFF system, which is likely to be acquired by Australia in the next decade [28], and phased array radars, which are inadequately treated in the existing standard. Of the new provisions, many are not relevant to Australia, as the decisions to acquire the corresponding assets and capabilities have not yet been made. Examples here include multi-stage missiles, submunitions, and Directed Energy weapons. The authors are unaware of any requirement for the current generation of ADO simulators to provide distributed Information Operations modelling.

Perhaps most significantly, the refinements and clarifications made to the standard and also the greatly increased explanatory documentation will enable distributed simulation environments to be constructed in Australia with less integration effort and more certainty of outcome.

7. Conclusions

The IEEE DIS standard is being revised by SISO following a decision to extend the existing 1998 standard.

The new standard includes an extensive revision, clearing up many of the ambiguities in the existing version and adding additional capabilities for Directed Energy weapons, Damage Status, Information Operations, Transfer Control, Electronic Warfare, IFF, and the ability to extend the existing PDU set with an Attribute PDU.

The dead reckoning and heartbeat mechanisms, essential for maintaining simulation entities during an exercise, have also been extended. There are five new PDUs and seven new annexes to describe various aspects of the emerging standard. There are also changes to the accompanying enumerations required for the new version.

The ADO simulation community should be made aware of the new standard although it should have minimal impact on existing systems.

8. References

1. IST (1994) *DIS Vision: A Map to the Future of Distributed Simulation*. Orlando, Florida, US, Institute of Simulation and Training, University of Central Florida

2. SISO (2010) *IEEE P1278.1-20XX: Standard for Distributed Interactive Simulation - Application Protocols, Draft 15*. Simulation Interoperability Standards Organisation

3. Miller, D. C. and Thorpe, J. A. (1995) SIMNET: the advent of simulator networking. *Proceedings of the IEEE* 83 (8) 1114-1123

4. IEEE (1993) *IEEE -1278-1993: Standard for Information Technology - Protocols for Distributed Interactive Simulation Applications: Entity Information and Interaction*.

5. IEEE (1996) *IEEE 1278.1-1995: Standard for Distributed Interactive Simulation - Application Protocols*.

6. IEEE (1998) *IEEE 1278.1a-1998: Standard for Distributed Interactive Simulation - Application Protocols*.

7. IEEE (1996) *IEEE 1278.2-1995: Distributed Interactive Simulation Communication Services and Profiles*.

8. IEEE (1997) *IEEE1278.3-1996: Recommended Practice for Distributed Interactive Simulation Exercise Management and Feedback*.

9. IEEE (1998) *IEEE 1278.4-1997: Trial-use Recommended practice for Distributed Interactive Simulation - Verification, Validation, and Accreditation*.

10. IEEE *IEEE 1278.5 - Fidelity Description Requirements (never published)*.

11. *Simulation Interoperability Standards Organisation*. Available from: www.sisostds.org

12. *Aggregrate Level Simulation Protocol*. Available from: http://en.wikipedia.org/wiki/Aggregate_Level_Simulation_Protocol

13. *High Level Architecture*. Available from: http://en.wikipedia.org/wiki/High_Level_Architecture_(simulation)

14. IEEE (2000) *IEEE 1516-2000: Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) - Framework and Rules*.

15. IEEE (2001) *IEEE 1516.1-2000: Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) - Federate Interface Specification*.

16. IEEE (2001) *IEEE 1516.2-2000: Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) - Object Model Template (OMT) Specification*.

17. IEEE (2003) *IEEE 1516.3-2000: Recommended Practice for High Level Architecture (HLA) Federation Development and Execution Process (FEDEP)*.

18. IEEE (2010) *IEEE 1516.1-2010: Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) - Federate Interface Specification*.

19. IEEE (2010) *IEEE 1516.2-2010: Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) - Object Model Template (OMT) Specification*.

20. IEEE (2010) *IEEE 1516-2010: Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) - Framework and Rules*.

21. Powell, E. T., et al. (2003) The Test and Training Enabling Architecture (TENA) 2002 Overview and Meta-Model (03E-SIW-041). In: *European Simulation Interoperability Workshop*, Stockholm, Sweden: 16-19 June, 2003

22. Lockheed-Martin. *Common Training Instrumentation Architecture (CTIA)*. (2009) Available from: http://www.lockheedmartin.com/products/CommonTrainingInstrumentationArchit/index.html.

23. Richbourg, R. and Lutz, R. (2009) LVC Architecture Roadmap (LVCAR) - Architecture. In: *TTCP JSA-TP2 Simulation Interoperability Focus Area Workshop*, Washington, DC: April 6-8, 2009, Modelling and Simulation Coordination Office

24. Valle, T. (2006) *Dead Reckoning Error Techniques*. Orlando, Florida, US, Sparta, Inc

25. Valle, T. (2006) *Orientational Dead Reckoning*. Orlando, Florida, US, Sparta, Inc

26. SISO (2006) *DIS Enumerations*. SISO-Ref-10, US, Simulation Interoperability Standards Organisation

27. Ryan, P., et al. (2006) Interoperable Aerospace Training Simulators within the Australian Defence Force. In: *SimTecT 2006*, Melbourne, Australia: 29 May - 1 June, 2006

28. Australia. Dept. of Defence and Defence Materiel Organisation (Australia) (2009) *Defence capability plan 2009 : public version*. Public ed. Australia, Industry Division Defence Materiel Organisation

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION DOCUMENT CONTROL DATA					1. PRIVACY MARKING/CAVEAT (OF DOCUMENT)
2. TITLE Capabilities of the Revised IEEE DIS Standard and Implications for Australian Defence			3. SECURITY CLASSIFICATION (FOR UNCLASSIFIED REPORTS THAT ARE LIMITED RELEASE USE (L) NEXT TO DOCUMENT CLASSIFICATION) Document (U) Title (U) Abstract (U)		
4. AUTHOR(S) Peter Ryan, Peter Ross and Will Oliver			5. CORPORATE AUTHOR DSTO Defence Science and Technology Organisation 506 Lorimer St Fishermans Bend Victoria 3207 Australia		
6a. DSTO NUMBER DSTO-GD-0617	6b. AR NUMBER AR-014-842		6c. TYPE OF REPORT General Document	7. DOCUMENT DATE September 2010	
8. FILE NUMBER 2009/1136160	9. TASK NUMBER NAV 07/074	10. TASK SPONSOR Training Authority Maritime Warfare	11. NO. OF PAGES 23	12. NO. OF REFERENCES 28	
13. DOWNGRADING/DELIMITING INSTRUCTIONS To be reviewed three years after date of publicationDSTO-GD-0617			14. RELEASE AUTHORITY Chief, Air Operations Division		
15. SECONDARY RELEASE STATEMENT OF THIS DOCUMENT *Approved for public release* OVERSEAS ENQUIRIES OUTSIDE STATED LIMITATIONS SHOULD BE REFERRED THROUGH DOCUMENT EXCHANGE, PO BOX 1500, EDINBURGH, SA 5111					
16. DELIBERATE ANNOUNCEMENT No Limitations					
17. CITATION IN OTHER DOCUMENTS Yes					
18. DSTO RESEARCH LIBRARY THESAURUS http://web-vic.dsto.defence.gov.au/workareas/library/resources/dsto_thesaurus.shtml Simulation, Distributed Simulation, Standards, Synthetic Environments					

19. ABSTRACT

Distributed Interactive Simulation (DIS) is a widely-used networking protocol standard that provides a method of communicating entity information among simulators and simulations through Protocol Data Units (PDUs) to create a synthetic environment. During 2010 a significant simulation milestone will be achieved when balloting of the revised DIS standard is completed, and it becomes officially designated as IEEE-1278.1-20XX. This milestone represents over six years of effort by a team of international distributed simulation experts from military, industry, and government organisations including DSTO. The proposed new standard is an extensive revision which clarifies ambiguities present in the current standard, adding new capabilities that reflect changes in military equipment and doctrine and providing for advances in technology, such as the Internet, mobile telephony and the widespread use of the Global Positioning System for positional and time data. Five new PDUs have been added to include Information Operations capability, enhanced warfare support, and the ability to communicate information about individual attributes for a particular entity, object, or event. Where possible, backward compatibility has been maintained in the new version to maintain interoperability with existing systems. In this paper we review these new capabilities in detail, and explore what this will mean for the Australian simulation ecosystem.