A Simulation System Interoperability Standard – What Is It and Why Have It?

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Abstract. In the ADF, high-fidelity, distributed simulation, training simulators can often cost in excess of 100 million dollars. In most cases the distributed simulation capabilities of these training systems are neither well specified nor are they well documented after delivery of the training system. ADF distributed simulation Interoperability Standards need to be developed. Corporate interoperability standards reduce the complexity of specifying these complex training systems. Training system interoperability standards assist in determining how interoperable different systems are with each other. Interoperability standards can also reduce costs to the ADF by enabling expensive simulator components (visual and sensor models, terrains, etc.) to be separately specified and shared.

A set of DIS Interoperability Standards have been produced for the DSTO developed Air Defence Ground Environment Simulator (ADGESIM) that is used operationally by the RAAF to train RAAF Air Defence Controllers. This paper discussed the development of these interoperability standards, what information is contained in such standards and how this information can be used to enhance training capabilities and opportunities at reduced costs.

1. INTRODUCTION

Over the next decade the ADF will acquire platform and training systems that can be networked together using Advanced Distributed Simulation (ADS). The adoption of such ADS technologies will enable increased and enhanced training capabilities and opportunities at reduced costs.

Interoperability between ADF (and Coalition) live and virtual (and constructive), platform and training systems is achieved using the Distributed Interactive Simulation (DIS), the High Level Architecture (HLA) or the newly emerging Test and Training Range Enabling Architecture (TENA) technologies.

Every simulation system should have a well documented distributed simulation “Interoperability Standard”. Such a standard should document all important distributed simulation interoperability parameters, such as the DIS PDUs used, and for each DIS PDU used which DIS PDU data fields will be populated, the Entity Set used, etc.

When interoperability is required between simulation systems, “Interoperability Standard” documentation can be compared to determine what initial interoperability is possible. This is one of the initial actions of a “Federation Agreement” that must be drawn up between participating simulation systems in a Federation exercise where many simulation systems may take part in a combined Distributed Simulation exercise.

An Interoperability Standard document has been developed for the DSTO developed Air Defence Ground Environment Simulator (ADGESIM) [1], [2], [3] used operationally by the RAAF to train RAAF Air Defence Controllers. This paper describes why such an Interoperability Standard is required and what such an Interoperability Standard (document) is comprised off.

2. WHY HAVE AN INTEROPERABILITY STANDARD?

An Interoperability Standard should document as much information as possible regarding the distributed simulation interoperability of the simulation system.

In a distributed simulation exercise simulation systems are connected together using a local, and possibly a wide, area network. Part of the initial setup phase of preparing for a distributed simulation exercise with multiple participants is to determine exactly how interoperable the participating simulation systems are.

Although some interoperability analysis can be done beforehand what normally occurs is that simulation systems are connected and the federation runs through the exercise scenario and the behaviour of the participating simulation systems is observed. Interoperability problems are then identified and addressed.

If Interoperability Standards exist an initial interoperability analysis could be carried out by examining and comparing the data documented in each Interoperability Standard for each participating system.
Interoperability problem areas could then be identified and addressed before using resources and/or incurring costs to connect individual simulation systems.

A distributed simulation Interoperability Standard should document distributed simulation data that must be determined or defined before distributed simulation exercises can be carried out. It simply saves resources (ie time/people/money) if this data is conveniently available beforehand.

3. WHAT’S IN AN INTEROPERABILITY STANDARD?

Exactly what distributed simulation data is defined/documented in any particular Interoperability Standard depends on exactly what that Interoperability Standard is trying to document.

The Entity ID record in the Entity State (ES) PDU identifies the simulation system site (the ESPDU Site ID) and the simulation application (the ESPDU Application ID) that simulates the entity described by the Entity State PDU. Site IDs and Application IDs need to be standardised however these parameters need to be standardised in higher level standards such as in an “ADF Distributed Simulation Interoperability Standard” for the Site ID data and in for example a “HMAS WATSON Distributed Simulation Interoperability Standard” for the Application ID data.

A simulation system interoperability standard (such as the “ADGESIM Interoperability Standard”) should only address the data that is specific to that simulation system and (conceptually) does not change no matter how or where that simulation system is used.

4. WHAT’S IN A SIMULATION SYSTEM (EG ADGESIM) INTEROPERABILITY STANDARD?

A Zalcman Consulting “ADGESIM DIS Interoperability Standard – Part A – Analysis and Justification” report has been produced [4].

This report presents data, and the analysis and justification behind decisions concerning the use of this data. Users of interoperability standards do not normally want analysis and justifications as to why things were done the way they were done – they simply want the relevant data presented as efficiently as possible.

The “ADGESIM DIS Interoperability Standard – Part A – Analysis and Justification” report contains information in addition to data that would normally be present in a simulation system interoperability standard. This is because (starting) data that would normally be found in higher level, ADF corporate simulation interoperability standards is not currently available because the corporate simulation standards are not available.

Therefore three additional standards (without any analysis or justification information) have been produced. They are:

- Part B – Supported DIS PDUs and DIS PDU data fields;
- Part C – A Standard Australian Entity Set; and
- Part D – An ADGESIM Standard Entity Set.

4.1 Which DIS PDUs Are Supported In ADGESIM

One of the objectives of producing an ADGESIM (simulation system) interoperability standard is to enable a (cost-effective) paper analysis and comparison to be made to determine whether an external simulation system would be able to interoperable appropriately with ADGESIM (the simulation system).

Alternatively the ADGESIM interoperability standard will also indicate whether ADGESIM (ADGESIM applications) will be able to interoperate appropriately with external simulation systems.

Although similar these are two different requirements. For example suppose I have an “external” simulation application that provides its full functionality through interoperating with the DIS Entity State PDU.

Table 1 lists the DIS PDUs that are required to provide interoperability with the ADGESIM [5].

Because ADGESIM supports the DIS ESPDU the external simulation application will be capable of interoperating fully (ie display its full functionality) with ADGESIM as long as the appropriate ESPDU data fields required by the external simulation application are appropriately populated.

However the external simulation application will not interoperate appropriately (ie stimulate the full ADGESIM functionality) with all the ADGESIM applications because the external simulation system does not support the functionality provided by the Fire, Detonation, Comment, Electromagnetic Emission, Transmitter, Signal and IFF PDUs.

Table 1: DIS PDUs Supported by ADGESIM

<table>
<thead>
<tr>
<th>PDU Type</th>
<th>PDU Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Entity State</td>
</tr>
<tr>
<td>2</td>
<td>Fire</td>
</tr>
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<td>26</td>
<td>Signal</td>
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<tr>
<td>28</td>
<td>IFF</td>
</tr>
</tbody>
</table>

Table 1 actually shows the DIS PDU support required by the total ADGESIM system for complete interoperability with external simulation systems.
In addition to the information shown in Table 1 the ADGESIM DIS Interoperability Standard also indicates which DIS PDUs are required to provide interoperability with each individual ADGESIM application. Unfortunately external simulation systems that only support the DIS ESPDU, will not provide complete interoperability for any individual ADGESIM application.

4.2 Which DIS PDU Fields Are Supported in ADGESIM

The ADGESIM DIS Interoperability Standard indicates which DIS PDUs are supported by ADGESIM as a complete simulation system as well DIS PDUs supported by each individual ADGESIM application.

However this is not the complete picture. As well as supporting the appropriate DIS PDUs, the appropriate data fields within the required DIS PDUs must also be appropriately supported (ie populated).

If a particular data field in a particular required DIS PDU is not populated appropriately, this may cause a significant loss of interoperability (ie functionality) in a particular (or several) ADGESIM application(s).

The ADGESIM DIS Interoperability Standard indicates which DIS PDU data fields, for which DIS PDUs, must be appropriately populated for every ADGESIM application. This is achieved through the development of “Interoperability Matrix” tables. Table 2 (ADGESIM DIS Fire PDU Interoperability Matrix) shows the interoperability requirements for the individual ADGESIM applications, the complete ADGESIM system, and the data fields within the DIS Fire PDU.

Such Interoperability Matrix tables enable interoperability for each ADGESIM application and for the complete ADGESIM system, to be determined (cost-effectively).

In a traditional military distributed simulation system a well documented Interface Design Document [6] could include the information that should be available in an Interoperability Standard.

4.3 An Australian Standard Entity Set

An Australian Standard Entity Set [7] has been developed as part of the analysis and justification for the ADGESIM Standard Entity Set.

A standard DIS entity set for Australian simulation systems and exercises should not normally be part of a simulation system interoperability standard. This should be part of a higher level standard such as the “ADF Distributed Simulation Interoperability Standard” mentioned above in section 3. However each simulation system should develop its own standard entity set derived from the Australian Standard Entity Set and this simulation system entity set should be part of every simulation system interoperability standard. The ADGESIM Standard Entity Set is discussed further in section 4.4.

Any simulation system that has its entity set derived from a corporate Australian Standard Entity Set should be able to interoperable with any other simulation system that also has its entity set derived from the corporate Australian Standard Entity Set – from the entity set point of view. They should have a common understanding of the entities within their virtual environment that can interoperate with each other.

The Australian Standard Entity Set should contain coalition and opposition forces. Therefore planning for any coalition distributed simulation exercise with Australian participation should start by examining the Australian Standard Entity Set. Any Australian simulation system that has developed its own simulation system entity set from the Australian Standard Entity Set should then be reasonably compliant with the entity set used in the coalition exercise, at least from the Australian entities point of view.

An Australian Standard Entity Enumeration Set is required so that each simulator participating in an (ADF) exercise has the same common understanding of what entity is being described by the information (ie the Entity Type record) in the Entity State PDU.

It should be highly cost-effective to develop an Australian Standard Entity Enumeration Set. If a simulation system standard enumeration set (derived from an Australian Standard Entity Enumeration Set) is defined at simulator specification time the simulator should be delivered with the corresponding (and appropriate) visual and sensor data (and any other information) required by the simulator. Simulation system test acceptance procedures should test to make sure all the simulation system standard entity set capabilities have been delivered. Constantly adding or changing enumerations after a simulator has been delivered may be expensive compared to having the appropriate data and functionality initially delivered as part of the simulation system.

A corporate standard entity set, resulting in the development of corporate visual and behavioural model and sensor libraries, will enable further efficiencies to be achieved.

The concept of an Australian Standard Entity Set for Australian ADS exercises and simulation systems has been discussed previously.

Unfortunately both these (slightly different) enumeration sets are now out of date and neither contain enumerations for commercial aircraft. Both of these enumeration sets were simply recommendations and were never accredited or adopted as an ADF standard as such.

The Simulation Industry Association of Australia (SIAA) enumeration set is incomplete in that it only addresses Australian entities – it does not define
enumerations for friendly or opposing forces or for weapons. Also the SIAA entity set is over three years old and some of its proposed “Australianised” enumerations have been allocated to entities from other countries.

The previous JOANNE [8] and SIAA [9] entity sets have been merged, modified and updated to form the current (ADGESIM) Australian Standard Entity Set. Commercial airline entities have been added.

### 4.4 A Simple Solution to the Advanced Distributed Simulation, Country of Operation Problem

In the DIS enumeration system only the country to which the design of the entity is attributed is considered. There is no easy way to specify the country of operation in DIS. Because HLA and TENA systems generally adopt the DIS enumeration system this problem flows through to HLA and TENA systems.

Australia generally specifies the requirements for a military platform using an open tender process. However, although the winning tendered platform may be built in Australia it is usually based on an already existing, overseas designed, system. Alternatively, and possibly more so in the future, a model similar to the JSF acquisition model, whereby several countries (Britain, Italy, the Netherlands, Turkey, Canada, Australia, Denmark and Norway) financially pledge a commitment to possibly purchase a USA designed military platform to reduce overall costs, may be adopted.

According to the latest SISO enumeration document [10], “Compliance with this document is mandatory for participation in a DIS exercise”. If strict compliance with the DIS enumerations is adhered to, all JSF aircraft in a DIS system, regardless of whether the aircraft are operated by Britain, Italy, the Netherlands, Turkey, Canada, Australia, Denmark or Norway, will appear as USA JSF aircraft.

In ADF distributed simulation exercises the country of operation problem always requires the adoption of some compromise. With the delivery of the JSF to several countries the country of operation problem will be further exasperated therefore the problem should be addressed.

A solution [11] to the DIS country of operation problem is discussed in the “ADGESIM DIS Interoperability Standard – Part A – Analysis and Justification” report and this solution has been incorporated in the Australian (and therefore the ADGESIM) Standard Entity Set.

### 4.5 An ADGESIM Standard Entity Set

ADGESIM will be required to interoperate with other ADF and coalition simulators.

A simulation system entity set has been developed from an Australian Standard Entity Set.

An Air Defence Sensor system, such as the Westinghouse TPS-43 radar system currently used by the RAAF, will normally be setup to only detect airborne, Cessna size objects flying at speeds in excess of approximately 100 knots. However depending on the sensor location and clutter parameters of such a system other entities, such as a semi-trailer traveling at speed on a freeway, may also be detectable. Small slow moving UAVs may not be detected.

For ADGESIM only airborne, Cessna size objects flying at speeds in excess of approximately 100 knots will be considered. Therefore the ADGESIM Standard Entity Set will be made up from air platforms from the Australian Standard Entity Set. These entities are required to support the ADGESIM Sensor LINK application.

Other ADGESIM applications interoperate with missiles fired at entities. Therefore Australian Standard Entity Enumeration Set missile entities must also be supported in the ADGESIM Standard Entity Set.

The Standard ADGESIM Entity Set defines all the entities (ie the minimum entity set) that ADGESIM must support to be able to interoperate correctly with external distributed simulation applications.

### 5. SUMMARY AND CONCLUSIONS

An “ADGESIM DIS Interoperability Standard” has been produced.

Corporate distributed simulation data, such as the data documented in an Australian Standard Entity Set, should be documented in or as corporate standards.

A simulation system interoperability standard (such as the “ADGESIM Interoperability Standard”) should only address the data that is specific to that simulation system and (conceptually) does not change no matter how or where that simulation system is used.

Some examples where interoperability standards can be used to reduce costs and/or enhance training capabilities are by:

- Documenting commonly used corporate distributed simulation data;
- Using this documented information to produce corporate libraries that can be shared by other simulation systems such as entity visual and sensor models, terrains, etc.;
- Using the documented, corporate, distributed simulation data (eg interoperability information such as which DIS PDUs may be required) to cost-effectively specify distributed simulation training systems;
- Using the simulation system interoperability standard information to cost-effectively determine interoperability with other simulation
systems rather than determining interoperability more expensively by trial and error; and

• Using corporate distributed simulation standards to develop re-usable, corporate “Test and Acceptance Procedures” [12].

A simulation system DIS interoperability standard should document which PDUs are used and, within those DIS PDUs used, which DIS PDU data fields must be populated appropriately to ensure interoperability (or reduce interoperability risk). This must be documented for the simulation system as a whole, and for each distributed simulation component of the simulation system if the simulation system is made up from multiple, distributed simulation components such as ADGESIM is.

An Australian Standard Entity Set (ie corporate standard distributed simulation data) has been developed as part of the “ADGESIM DIS Interoperability Standard – Part A – Analysis and Justification” report. This was necessary as a suitable Australian Standard Entity Set is not available.

Such an Australian Standard Entity Set can then be used as the starting point to develop any simulation system (eg ADGESIM) standard entity set.

An ADGESIM Standard Entity Set has been developed using the Australian Standard Entity Set.

A solution to the DIS country of operation problem has been developed further.

REFERENCES
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<th>Sensor Link</th>
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