Link 16 Interoperability for ADGESIM and the Synthetic Range Interoperability Model – Some Simple Lessons Learned

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Abstract. Previously Royal Australian Air Force (RAAF) Air Combat Officers relied on interaction with live F/A-18s to receive much of their realistic, high fidelity training. Such training was limited and expensive. A virtual environment, training system known as the Air Defence Ground Environment SIMulator (ADGESIM) has been delivered to the RAAF using the Public (DSTO)/Private (YTEK) development model. ADGESIM was rapidly developed and fielded, using a mixture of low cost and cost-effective Commercial-Off-The-Shelf (COTS) and customised “thin client” Government-Off-The-Shelf (GOTS) components. ADGESIM is a high-fidelity simulation system – it stimulates the real, same systems used by the Air Combat Officers thus eliminating most traditional, trainer concurrency problems.

ADGESIM supports the Concept of the Synthetic Range. It currently complies with two of the three main components of the Synthetic Range Interoperability Model. ADGESIM supports Advanced Distributed Simulation (DIS) and radio / intercom interoperability. Link-16 Tactical Data Link interoperability is being investigated for ADGESIM thereby providing full compliance with the three main components of the Synthetic Range Interoperability Model.

Completion of this Tactical Data Link component of the Synthetic Range Interoperability Model will result in a set of Synthetic Range interoperability standards that should be adopted by the ADF. Compliance with such interoperability standards will result in systems (including ADGESIM) that are highly interoperable with other compliant RAAF, Joint and coalition, Live, Virtual and Constructive (LVC) systems.

This paper discusses some lessons learned so far in investigating Link-16 Tactical Data Link interoperability for ADGESIM and the Synthetic Range Interoperability Model.

1. INTRODUCTION

The Concept of the Synthetic Range, including the Synthetic Range Interoperability Model, provides a simplified way of understanding how military systems can interoperate.

The concept of the Synthetic Range [1], [2], where live assets are instrumented to allow their interoperability with virtual and constructive systems in the same virtual synthetic environment, is being developed. Such synthetic range environments are sometimes referred to as LVC (Live, Virtual, and Constructive) environments.

This paper presents some simple (but useful) lessons learned rather than discuss the actual solution proposed which will be reported in a future publication.

1.1 Live Systems

Live systems are “instrumented” real world, operational military platforms that can provide information such as location, system orientation, movement, weapon status, etc. to the synthetic range distributed simulation network in real-time such that this data can be used to interoperate in the synthetic range virtual environment.

1.2 Virtual Systems

Virtual systems comprise training and experimentation simulators that are crewed by people – Human-In-the-Loop (HIL) simulators. These systems may have advanced distributed simulation capabilities that use simulation network protocols. However some form of gateway device may be required to convert the simulation system protocols to the required corporate standard, synthetic range, interoperability protocols.

1.3 Constructive Systems

Constructive systems are synthetic representations of both platforms and people - they act only according to software rules rather than through human direction.
2. THE SYNTHETIC RANGE

Interoperability between LVC systems within a common scenario requires compliance with an agreed set of interoperability standards including network infrastructure, data, interoperability protocols, platform/environment representation, etc. This requires the development of an interoperability model (the Synthetic Range Interoperability Model) that is a crucial part of any synthetic range architecture. All synthetic range systems that are compliant with this set of interoperability standards (ie the interoperability model) should be interoperable regardless of whether the systems are Live, Virtual or Constructive systems.

Synthetic Range systems can share the same common scenario on an advanced distributed simulation network. Synthetic Range systems can also share their Tactical Data Link system data in almost exactly the same way that the real world, operational platforms would normally share this information. However in the Synthetic Range environment the exercise is being carried out in a virtual environment that may bear no relationship to the actual geographical location of the real, training and/or experimentation assets. Also the Tactical Data Link (and simulation scenario) data will (most likely) be distributed over local and wide area networks instead of using radio transmissions to distribute the information.

Some objectives of the Synthetic Range work are to:

- develop the Synthetic Range Interoperability Model and its associated corporate interoperability standards; and
- encourage an ADF (ie DMO) process so that every ADF LVC system that may need to interoperate will be acquired with a set of Synthetic Range Interoperability Model compliant Gateways therefore enabling a useful level of LVC interoperability at time of system delivery and acceptance by the ADF.

The Synthetic Range Interoperability Model is being used to develop an interoperability infrastructure that will provide appropriate interoperability of ADF Service, Joint and Coalition LVC systems.

Every (appropriate) ADF LVC system should be acquired with a set of interoperability gateways that comply with a corporate (ie ADF) Synthetic Range Interoperability Model standard. Synthetic Range systems that are compliant with the corporate Synthetic Range Interoperability Model will be highly interoperable with each other.

The Synthetic Range Interoperability Model (Figure 1) addresses interoperability from three points of view:

- Advanced Distributed Simulation;
- Tactical Data Link; and
- Radio Communications interoperability.

The Advanced Distributed Simulation requirements of the Synthetic Range Interoperability Model have already been comprehensively documented [3], [4] and the ability to interoperate between Synthetic Range Radio Communications and real Radio Communications still needs to be addressed.

3. LINK-16 INTEROPERABILITY

A Tactical Data Link (TDL) is defined [5] as a “communications system that supports the exchange of near real-time tactical data between participants using a variety of free or fixed format messages which are characterised by unique transmission characteristics, protocols and standardised message structures”.

A Tactical Data Link is a standardized communications system that transmits digital information concerning intelligence, surveillance and reconnaissance. TDLs allow two or more command and control, platform or weapons systems to communicate via a single or multiple network architecture (including multiple communications media) to exchange tactical information with the objective of fostering situation awareness where Situation Awareness is:

- The ability to identify, process and comprehend the critical elements of information about what is happening on the battlefield with respect to the mission; or
- Knowing what is going on around you!

All Tactical Data Link systems have the same basic components which are:
• A data source (a sensor) such as a radar system;
• A data handling and display system within which data from the data source is coordinated and correlated before being transmitted to the Tactical Data Link system network – this is the ownship tactical data link application;
• A message set that is used to communicate (ie convey information) between tactical data link systems. Link-16 J-series messages [6] enable a common situation awareness to be built up, platforms and weapons to be controlled and coordinated, secure voice communications, the network to be managed, etc.;
• A “transport protocol” that encapsulates the (J-series) message set that enables communication between the Tactical Data Link application and the Tactical Data Link communications systems;
• A hardware interface system to interface the Tactical Data Link application to the Tactical Data Link network; and (if required)
• A (n encrypted) communications system (or an emulation of such a system) that enables Link-16 messages to be relayed over an appropriately setup, Tactical Data Link network comprising various communications media such as UHF, satellite communications, WANs, LANs, etc.

All new major RAAF and RAN systems that have Tactical Data Link (TDL) capabilities are being acquired with Link-16. Therefore Link-16, J-series messages is the preferred ADF (TDL) system [7]. Gateways will provide ADF wide TDL interoperability for legacy systems.

Synthetic Range Interoperability Model compliant systems must be able to distribute TDL messages around the synthetic range (real and/or simulated) TDL network. Therefore synthetic range, TDL interoperability compliance requires that industry standard TDL distribution protocols, such as SISO-J (Simulation Interoperability Standards Organization), SIMPLE (Standard Interface for Multi-Platform Link Evaluation), JREAP (Joint Range Extension Application Protocol), etc., be supported.

Particular message sets are not mandated. It is up to operational platforms and simulation systems to support the most appropriate message sets for their particular requirements. A synthetic range, Tactical Data Link interoperability standard would be similar to

“the ability to interoperate using ADF approved, tactical data link distribution protocols, encapsulating Link 16, J-series messages”.

Alternatively a UK TDL Policy Paper [8] states:

“The following J-series Family TDL message formats shall be implemented by UK platforms to meet the desired end-state in accordance with their roles and Information Exchange Requirements:

a. JTIDS/MIDS Link 16;
b. Tactical BLOS TDL (Link 22 and/or Link 16 Joint Range Extension); and
c. Variable Message Format.”

The ADF Tactical Data Link Authority (ADFTA) (or the Tactical Information Exchange Integration Office (TIE IO)) is responsible for Tactical Data Link testing to ensure Tactical Data Link interoperability at the platform level to achieve Single, Joint and Coalition Tactical Data Link interoperability for the ADF [5]. For any Tactical Data Link system (including synthetic range systems) to interoperate on any ADF Tactical Data Link network the system must comply with ADFTA standards. Therefore synthetic range Tactical Data Link test and evaluation procedures will be those specified by the ADFTA to accredit Tactical Data Link systems for use by the ADF.

4. MAIN LESSONS LEARNED

4.1 Understanding the Link-16 Technology

Link-16 is a difficult technology to understand because:

• Link 16 is a complex technology;
• Link-16 information (other than real Link-16 data) is not classified but is difficult to obtain;
• Only cleared (US DoD, ADF etc.) personnel or contractors have access to Link-16 information therefore it is military only; and
• If real Link-16 data is used a secret classification will probably be required.

Therefore anything to do with Link-16 will be “difficult, complex and expensive”!

However to design Link-16 systems you do not need to understand all Link-16 technology – you only need to understand the technology components that are of relevance to your design as long as you are sure that your Link-16 system can interoperate as far as is required! For example to add Link-16 to ADGESIM [1], [2] does not require knowledge of the Link-16 network. An ADF Link-16 network will be designed by the ADFTA (TIE-IO) however what may be required is the ability to create and/or load real Link-16 network load files, and run and interoperate in detailed test TDL scenarios and exhibit the same data link behaviour as would occur in an actual, live data link network.

4.2 Are COTS Solutions Available

ADGESIM was rapidly developed and fielded, using a mixture of low cost and cost-effective Commercial-Off-The-Shelf (COTS) and customised “thin client” Government-Off-The-Shelf (GOTS) components.
ADGESIM is a high-fidelity simulation system – it stimulates the real, same systems used by the Air Combat Officers thus eliminating most traditional, trainer concurrency problems.

The objective of adding TDL interoperability to ADGESIM is to provide TDL training between C² (eg Air Combat officers) and nonC² (eg F/A-18) units.

A COTS Link-16 solution is available for the main MSCT, Command and Control (C²) component of ADGESIM. This COTS TDL MSCT C² component in itself will provide some (limited) Link-16 TDL training for RAAF Air Combat officers. However the nonC² (eg F/A-18) TDL component will need to be developed.

The training requirement was analysed to enable a cost-effective, Link-16 interoperability for ADGESIM, solution to be proposed. The recommended solution (Figure 2) is a mixture of COTS and GOTS as is the current ADGESIM system without Link-16.

4.3 Start With an Appropriate Link-16 SDK

Because Link-16 is a complex, closed technology it is much more cost-effective to start with an appropriate “Industry Standard” Link-16 Software Developers Toolkit (SDK) that will save a considerable amount of development time.

Link-16 Software Development Toolkits are expensive however the use of an appropriate toolkit should ensure that your Link-16 applications can be developed in a timely manner, interoperate in detailed test TDL scenarios and exhibit the same data link behaviour they would in an actual, live data link network.

A Link-16 SDK that supports multiple Link-16 transport protocols should be considered as this will result in considerable flexibility when providing interoperability with a Link-16 network.

Not using an industry standard Link-16 SDK will most likely require (ie result in) a considerable effort to develop all the Link-16 components required. In the case of ADGESIM an interface between the core ADGESIM component (the Solipsys MSCT [1], [2]) and an industry standard Link-16 SDK has already been developed and is available free of charge. This COTS interface partially offsets the cost of the Link-16 SDK.

4.4 Understand the Security Aspects of Dealing With Link-16

Link-16 SDKs require US clearance to even view documentation that comes with such toolkits. A comprehensive clearance process will be required to purchase a Link-16 SDK. Also the use of such toolkits can only occur in an appropriate (cleared / accredited / classified) development environment. A possible acquisition delay of several months should be factored into any development process. The use of real Link-16 data will most likely require secret accreditation.

4.5 Which Link-16 Transport Protocol?

A “transport protocol” is defined as a protocol that encapsulates and enables Link-16 Tactical Data Link messages (ie J-series messages) to be distributed between Tactical Data Link applications on an operational Tactical Data Link network.

Several transport protocols have evolved to satisfy specific needs. As military TDL systems evolve further in mission scale and complexity, different Tactical Data Link implementations will need to interoperate.

There are really only three Link-16 “transport protocols” that should be of interest:

- STANAG 5602 – is the NATO Standardisation Agreement (STANAG) known as SIMPLE (Standard Interface for Multiple Platform Link Evaluation) [9]. SIMPLE is the Tactical Data Link transport protocol standard used for both RAN and USN simulation systems (for Link-11 and Link-16) and (possibly) real operational platforms (ships, submarines etc).

- SISO-STD-002-2006 – is the SISO (Simulation Interoperability Standards Organization) standard for Link-16 interoperability for DIS/HLA simulation systems (SISO-J) [10]. ADGESIM applications are standalone DIS applications and SISO-J would be a cost-effective solution for these applications. SISO-J is the transport protocol supported by USAF simulators which ADGESIM already interoperates with (without Link-16 interoperability) in various experiments / training exercises [11], [12]; and

- MIL-STD-3011 – the Joint Range Extension Application Protocol (JREAP) [13]. JREAP is the most popular modern tactical data link transport protocol as it enables the range of a Link-16 network to be extended using media other than JTIDS/MIDS systems.

4.6 ADF Joint and Coalition Interoperability

The Link-16, J-series message set is the recommended Synthetic Range Interoperability Model message set. Use of any other message set (Link-11, VMF, etc) will require an appropriate gateway to the recommended J-series message set.

As long as an industry standard Link-16 transport protocol (SIMPLE, SISO-J, JREAP, etc) is supported a device such as a Northrop Grumman Gateway Manager can be used to “gateway” between transport protocols.

Another objective of developing the Concept of the Synthetic Range and having a Synthetic Range Interoperability Model is to develop highly interoperable LVC systems. Table 1 shows the difference between US and ADF Service Synthetic Range Interoperability Models [14], [15].
Table 1 infers that the ADGESIM Synthetic Range Interoperability Model appears to be highly compliant with the USAF model and is also very similar to the USN and the RAN models [16]. Therefore ADGESIM should be highly interoperable with USAF and (using COTS gateways where required) other RAAF, RAN, and USN Synthetic Range LVC systems.

Table 1: USA and ADF Synthetic Range Interoperability Models

<table>
<thead>
<tr>
<th>ADF</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Army: ADS: DIS, HLA</td>
<td>ADS: DIS, HLA, TENA;</td>
</tr>
<tr>
<td>Comms: ASTi DIS;</td>
<td>Comms: ASTi DIS;</td>
</tr>
<tr>
<td>TDL: Not Known</td>
<td>TDL: Not Known</td>
</tr>
<tr>
<td>Navy: ADS: DIS;</td>
<td>ADS: DIS;</td>
</tr>
<tr>
<td>Comms: ASTI DIS;</td>
<td>Comms: ASTi DIS;</td>
</tr>
<tr>
<td>TDL: Link-16 SIMPLE</td>
<td>TDL: Link-16 SIMPLE</td>
</tr>
<tr>
<td>Air Force: ADS: DIS, HLA;</td>
<td>ADS: DIS;</td>
</tr>
<tr>
<td>Comms: DIS, HLA;</td>
<td>Comms: ASTi DIS;</td>
</tr>
<tr>
<td>TDL: Link-16 SISO-J (DIS and HLA)</td>
<td>TDL: Link-16 SISO-J</td>
</tr>
</tbody>
</table>

5. ADGESIM WITH LINK-16

The recommended ADGESIM Link-16 solution is shown in Figure 2 where:

- The Link-16 interface to the MSCT is COTS;
- ADGESIM PSI TDL interoperability will be developed (GOTS) to simulate non-C² entities (F/A-18s) with Link-16 interoperability;
- The ADGESIM World View application will be developed (GOTS) to be a customized Link-16 Tactical Situation Display application;
- SISO-J (DIS) is used within ADGESIM as this enables the TAARDIS application to record and replay Link-16 without further development;
- Multiple transport protocols are supported; and
- The TDL SDK is cost-effectively shared between the COTS and GOTS ADGESIM Link-16 applications.

REFERENCES


5. ADF DEFENCE INSTRUCTIONS (GENERAL) OPS 10-3, “Tactical Digital Information Link standards, implementation, interoperability, compatibility, configuration management, operational assurance, testing and training”, Australian Department of Defence, Canberra, ACT, 18 October, 2002.


Figure 2: ADGESIM with Link-16 Interoperability.