

## **Synthetic Range LVC Interoperability for the Royal Australian Air Force**

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### **ABSTRACT**

The Royal Australian Air Force relies mainly on simulators and operational platform training for combat crew readiness. Large-scale, operational exercises provide opportunities to train crews in team and inter-team skills. However, cost, fatigue life concerns, range site capabilities, weather, and frequency of event limitations make this only a partial solution to crew readiness training. With little network capability, a significant gap exists between training obtained using stand-alone simulators and training obtained using live training exercises for combat crews. Alternative training methods, such as USAF DMO Synthetic Range LVC training, need to be considered to prepare and maintain RAAF combat crew readiness for joint and coalition team operations [Blacklock].

The Concept of the Synthetic Range, including the Synthetic Range Interoperability Model, provide a simplified way of understanding how Live, Virtual and Constructive (LVC) systems can interoperate. The long-term objective of this work is that every LVC system that may need to interoperate is acquired with a set of Synthetic Range Interoperability Model capabilities that support the same set of corporate standards to enable a common level of LVC interoperability the at time of system delivery and acceptance by the Australian Defence Force (ADF).

This paper presents an overview of some of the research carried out, and innovations and lessons learned so far, upon which the Concept of the Synthetic Range and the Synthetic Range Interoperability Model are based, including:

- The Concept of the Synthetic Range - that describes how ADF LVC operational military platforms and training and experimentation simulation systems should be able to seamlessly interoperate with each other;
- The Synthetic Range Interoperability Model - that defines which distributed simulation (eg DIS, HLA or TENA), radio/intercom communications and tactical data link protocols, technologies, gateways and standards need to be adopted in the Synthetic Range architecture and why, in order to achieve interoperability between RAAF, ADF service and coalition LVC systems; and
- How the RAAF Air Defence Ground Environment SIMulator (ADGESIM) training simulator (developed by the Australian Defence Science and Technology Organisation (DSTO)) has been used as a test bed to implement Synthetic Range Interoperability Model interoperability standards.

### **ABOUT THE AUTHORS**

**Dr. Lucien Zalcman** has a Ph. D. in Experimental Physics from Melbourne University and a Graduate Diploma in Computing Studies from the Royal Melbourne Institute of Technology. Dr. Zalcman worked for DSTO for 21 years in the areas of LVC interoperability, Simulation System Architectures, Synthetic Environments, Tactical Data Link interoperability and Network Centric Warfare. In 2005 Dr. Zalcman set up Zalcman Consulting. Dr. Zalcman has authored/co-authored over 80 DSTO, TTCP and Zalcman Consulting research reports and conference papers.

**Jon Blacklock** joined the RAAF as an Air Defence Officer in 1978. Postings followed as a fighter controller, as a Space Operations Senior Director and Combat Crew Commander in the US Defense Support Program supporting nuclear non-proliferation and missile early warning systems. Staff tours were completed as Project Manager for the ADF Air 5077 Airborne Early Warning & Control (eg AWACS) Project, and in ADF HQ as requirements manager. Mr. Blacklock joined the ADF's Defence Science and Technology Organisation (DSTO) in 2001 as Head of Air Projects Analysis in the Air Operations Division of DSTO. His current activities involve the management and development of synthetic environments for training (eg ADGESIM), experimentation and Force development in aerospace control and battle management.

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### **INTRODUCTION**

In 1997 a prototype Mission Training Center was developed in a hangar on the flight line by researchers and engineers from the US Air Force (USAF) Research Lab in Mesa, Arizona.

Four state-of-the-art F-16C simulators with visual systems were networked with two A-10 simulators, a C-130 flight simulator, and an AWACS weapons controller console. The eight simulators could fly together against computer-generated air and ground threats in a virtual reproduction of the Nevada ranges. Operational pilots and controllers flew complex missions that combined close air support, air escort, and airdrop in a single integrated training scenario. The mission unfolded on large video monitors that showed several types of real-time views, including cockpit displays, aerial maneuvering, ground movements, and weapons delivery. To many of those who witnessed this event, the networked simulators were a revolutionary training technology [Chapman].

Today [Portrey (2007)] simulation technology allows warfighters to train continuously and maintain a high state of combat readiness by using cost-effective simulation in conjunction with live operations and training missions. Current development of LVC systems for training and mission rehearsal, the rapid advancement of networking technologies and protocol standards/architectures, such as Distributed Interactive Simulation (DIS) and High Level Architecture (HLA), have all contributed to an environment where highly-distributed training, mission rehearsal, operations support, and multi-force Distributed Mission Operations (DMO) joint/coalition exercises have become a reality.

There are currently no formal Australian Defence Force (ADF) or Royal Australian Air Force (RAAF) corporate interoperability standards for LVC systems. Without such (appropriately specified) interoperability standards, LVC systems may be acquired with interoperability capabilities, but may not be able to interoperate with each other.

Currently the RAAF relies mainly on simulators and operational platform training for combat crew readiness. Large-scale, operational exercises provide opportunities to train crews in team and inter-team skills. However, cost, fatigue life concerns, range site capabilities, weather, and frequency of event limitations make this only a partial solution to crew readiness training. With little network capability, a significant gap exists between training obtained using stand-alone simulators and training obtained using live training exercises for combat crews. Alternative training methods, such as USAF DMO Synthetic Range LVC training, need to be considered to prepare and maintain RAAF combat crew readiness for joint and coalition team operations [Blacklock].

The Concept of the Synthetic Range, including the Synthetic Range Interoperability Model, provides a simplified way of understanding how LVC systems can interoperate. The long term objective of this work is that every LVC system that may need to interoperate is acquired with a set of Synthetic Range Interoperability capabilities that support the same set of corporate standards to enable a common level of LVC interoperability at the time of system delivery and acceptance by the Australian Defence Force.

This paper presents an overview of some of the research carried out, and innovations and lessons learned so far, upon which the Concept of the Synthetic Range and the Synthetic Range Interoperability Model are based, including:

- The Concept of the Synthetic Range - that describes how ADF LVC operational military platforms and training and experimentation simulation systems should be able to seamlessly interoperate with each other;
- The Synthetic Range Interoperability Model - that defines which distributed simulation (eg DIS, HLA or TENA), radio/intercom communications and tactical data link protocols, technologies, gateways and standards need to be adopted in the Synthetic Range architecture and why, in order to

achieve interoperability between ADF service and coalition LVC systems; and

- How the RAAF Air Defence Ground Environment SIMulator (ADGESIM) training simulator (developed by the Australian Defence Science and Technology Organisation (DSTO)) has been used as a test bed to implement Synthetic Range Interoperability Model standards.

The aim of this work is to assist the ADF/RAAF to migrate towards a highly interoperable, LVC corporate synthetic environment (i.e. Synthetic Range) thus enabling the significant gap that exists between training obtained using stand-alone simulators, and training obtained using live training exercises for combat crews, to be narrowed.

A set of corporate LVC interoperability standards, processes, common applications and databases need to be developed for use by acquisition projects (i.e. as unambiguous specifications) so that LVC systems can be appropriately specified, delivered and accepted with an “out-of-the-box” level of corporate interoperability that will enable coalition LVC training.

#### **WHY DO WE NEED A SYNTHETIC RANGE?**

Within the RAAF a significant gap exists between stand-alone simulator training and training obtained using live platforms for combat crews.

Traditional pilot training consists of ground-based training, simulation-based training, and live flight training to teach avionics usage and cognitive flying skills. While ground-based training can be an economical method of pilot training, it is not robust enough to cover critical dynamic skills. Live flight training can provide this enhanced training capability. However, to train for a typical operational sortie would require blue and red forces and possibly AWACS assets. Gathering these assets together, including fuel, planning and coordination, and possible access to live training ranges, would most likely be highly cost-prohibitive and time consuming. Also, use of real assets adds to platform wear, requiring additional maintenance and accelerated ageing of the air fleet.

In recent years, training capabilities have moved beyond cognitive skills training to tactical operations training using squadron-based pilot training systems that interoperate in a distributed training environment such as the US Air Force’s Distributed Mission Operations (DMO) environment and the US Navy’s Naval Aviation Simulation Master Plan (NASMP)

environment. These systems must fully represent the weapons platforms in an operational environment to include authenticated avionics and sensor models, air threats, integrated air defense systems, and command and control nodes. These systems must interoperate from base to base through government operated networks via standards-based protocols [Lechner].

According to Chapman [Chapman] senior US Air Force leaders consistently emphasise two themes in advocating the USAF DMO program:

- A significant portion of combat training for new weapons and combat systems, such as the F-22, can only be accomplished in high-fidelity simulators. For land-based fighter and bomber aviators the most demanding tasks of a combat mission occur between takeoff and landing: formation flying, air refueling, engaging an enemy air defense system, delivering weapons close to ground forces, etc.; and
- The battlespace is a dynamic interactive environment among other military actions and the adversary. Military pilots need to train as part of the entire kill chain.

Real combat sorties are 3 to 6 times longer than training missions. Most of the added flight time is spent getting to and from the target area, an important but expensive and mundane activity. Depending on a number of factors, it takes 2 to 3 years of operational flying to produce an experienced pilot; 3 to 4 years if formal training is counted.

DMO training missions are designed to maximize exposure to the most crucial mission skills. Only about 15 minutes of a wartime mission is complex and intensive, and may include releasing weapons close to friendly forces, attacking a time critical target, or engaging an unknown air contact. While usually only occurring once during an operational mission, these situations can be practiced several times during a training sortie. Training sorties are fairly short, usually 75 to 90 minutes.

An approach to solving the limitations and deficiencies of Live training is to incorporate and integrate Live platform training with Virtual and Constructive distributed mission training as has been done with the USAF Distributed Mission Operations [Lechner].

Although placing Virtual and Constructive entities “on the range” to interact with Live systems may limit training value for missions requiring visual contact, Electronic Warfare (EW) and Intelligence, Surveillance and Reconnaissance (ISR) assets may find

that robust computer-generated range environments offer a more realistic training experience against a broader set of current and emerging threat systems than is currently available using range-based threat systems [Hambleton].

Colegrove et al. have reported an “optimal training mix” of live to simulator training events that are required for an experienced and inexperienced pilot to be proficient (will occasionally make an error) and highly proficient (will rarely make an error) (Table 1).

**Table 1. Predicted Optimal Training Mix**

	Proficient		Highly Proficient	
	Live	Simulation	Live	Simulation
Inexperienced	15	7 (32%)	21	8 (28%)
Experienced	12	5 (29%)	17	7 (29%)

As a result of this work, fighter and bomber training managers are implementing new simulation training requirements. In future, simulation training will comprise between 20 and 30% of the required training within the USAF Combat Air Forces [Colegrove].

In March 2006, the US Air Force decided that approximately 20% of its F-15C live-fly training requirement would be done in DMO-capable simulator systems and that these DMO sorties would be counted towards the 500 hour “experience” metric [Chapman].

### WHAT IS A SYNTHETIC RANGE?

Synthetic range LVC systems can interoperate over a network in a common virtual synthetic environment no matter where these systems are geographically located throughout the world.

Synthetic Range systems can share the same common (“ground truth”) scenario on an advanced distributed simulation network.

Real operational (i.e. Live) systems share situation awareness over “real-world, military networks” mainly using terrestrial, satellite, and tactical data link systems such as Link-16 and Link-11. To provide realistic training, Synthetic Range LVC systems must also share their operational and tactical data link system information similar to the way that real, operational platforms would normally share this information.

Real, world, military-grade, voice/intercom communications interoperability between Synthetic Range LVC military systems must also be supported to

allow operations in the synthetic environment space to interoperate with Live operational systems.

In a synthetic range, the entirety of the test and training event will be represented in a virtual environment where the location of the virtual environment entities may bear no relationship to the real, geographical location of the participating LVC systems.

According to Daly et al. [Daly]

*“Synthetic environments are simulations that represent activities at a high level of realism. These environments may be created within a single computer or over a distributed network connected by local and wide area networks and are augmented by realistic special effects and accurate behavioral models. They allow visualisation of, and immersion into, the environment being simulated” [US].*

### LIVE, VIRTUAL AND CONSTRUCTIVE SYSTEMS

A synthetic range system can be broadly classified as belonging to one of three different types of systems - Live, Virtual, or Constructive (LVC). The commonly used LVC system definitions are shown in Figure 1.

- **Live** = real people in real locations using real equipment
- **Virtual Simulation** = real people in simulators
- **Constructive Simulation** = simulated entities in a simulated environment

**Figure 1. Some Common Definitions of LVC**

#### Live Systems

Live systems are “instrumented” real world, operational military platforms. Instrumentation (Embedded or On-Board-Training-Systems, Air Combat Maneuvering Instrumentation (ACMI) systems, etc.) attached to these Live systems 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 interoperate in the synthetic range virtual environment. Live system data may need to be distributed via radio telemetry to a dedicated, ground station where it is distributed to other synthetic range participants using standardised, simulation network protocols. In the same way, data from other synthetic range participants must be converted from the standardised simulation network protocols and

provided in an appropriate form to the Live, synthetic range compliant systems.

Live training exercises real people using real equipment in a real environment [UK]. Live Simulation is defined as real people operating real systems in a virtual environment [NATO M&S Vision]. The Navy conducts this type of training at sea while ships are underway [Daly].

### **Virtual Systems**

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

Virtual training exercises real people in simulated equipment in a simulated environment [UK]. Virtual Simulation is defined as using real people operating simulated systems [NATO M&S Vision]. Virtual training usually involves wargaming in-house (in a building) using simulation equipment [Daly].

### **Constructive Systems**

Constructive systems are synthetic representations of both platforms and people that act according to software rules rather than human direction.

Constructive training exercises simulate people in simulated equipment in a simulated environment [UK]. Constructive Modeling or Simulation is defined as simulated people operating simulated systems [NATO M&S Vision]. It is the most “artificial” of all active (non-classroom) training and it involves only the practical application of cognitive skills. Constructive training can include personal computer (PC) or tabletop wargaming that focuses primarily on strategic, operational, or tactical decision-making [Daly].

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 the synthetic range architecture. All synthetic range systems that are compliant with this set of interoperability standards (i.e. the interoperability

model) should be interoperable regardless of whether the systems are Live, Virtual or Constructive.

## **THE SYNTHETIC RANGE INTEROPERABILITY MODEL**

A *Synthetic Range Interoperability Model* is used as a tool to simplify (i.e. assist in) the understanding and development of an appropriate Synthetic Range architecture - it simplifies understanding how military LVC systems can interoperate.

The Synthetic Range Interoperability Model addresses LVC interoperability from three points of view:

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

### **Advanced Distributed Simulation Interoperability**

Sharing a common (ground truth) scenario on an advanced distributed simulation network in a Synthetic Environment will reduce costs considerably by not requiring real platforms for every entity in the scenario. The potential of this approach was demonstrated in Australia with LVC participants from the US and ADF participating in Exercise Talisman Sabre 07. Further savings may be achieved by building distributed (and re-usable) system capability and functionality using smaller (but more dedicated) distributed simulation applications rather than creating a single large LVC software system. The DSTO developed Air Defence Ground Environment SIMulator (ADGESIM) RAAF trainer uses such a distributed architecture and the ADGESIM applications can be individually reused in other DIS simulation systems.

### **Voice Communications Interoperability**

Voice communication is the common variable tying LVC entities regardless of the operating domain – it is a basic component of the synthetic battle space [Rumpel].

### **Tactical Data Link Interoperability**

Supporting real Tactical Data Links realistically simulates the real world NCW environment and enhances the fidelity and capabilities of Synthetic Range, multi-player, multiple site exercises.

The Synthetic Range Interoperability Model can be used to develop a basic set of (corporate) interoperability standards that are required by all

interoperable ADF LVC systems. A simplified, initial set of Synthetic Range interoperability standards is shown in Table 2.

Note that the model described in Table 2 is a *minimum* starting point - it does not preclude later enhancement of current components or addition of other components to the ADF corporate model or to a specific (eg Royal Australian Navy) version of the model.

**Table 2. Simplified ADF Corporate Synthetic Range Interoperability Model**

<b>LVC Synthetic Range Interoperability Model</b>
ADS: DIS - IEEE 1278.1/A, or HLA equivalent
Radio Communications : DIS - IEEE 1278.1, HLA equivalent, or Real Radio
Tactical Data Link : Link-16 - Standard Link-16 Transport Protocol

However, the basic Advanced Distributed Simulation, Radio Communications, and Tactical Data Link interoperability components must be precisely and unambiguously defined in order to be able to specify and develop (i.e. hopefully guarantee) a certain level of initial interoperability at system delivery and acceptance by the ADF. Without appropriately defining these initial three components the Synthetic LVC interoperability will be difficult to achieve and further development of other LVC interoperability standards may be fruitless.

### HOW DO OTHERS DO THIS?

A comprehensive analysis of Synthetic Range Interoperability Model data available in the literature has been carried out [Zalcman (2010-1)]. The data of relevance is shown in Table 3.

The NATO Modeling and Simulation Standards Profile [NATO NMSSP] recommends that only standards included in the NMSSP be used for NATO and partner nations' LVC programs or projects. As such the objective of the NMSSP appears to be more to reduce risk rather than attempt to guarantee interoperability.

The authors of this paper believe that the NATO NMSSP is deficient and requires more work because:

- It lacks standards related to Live simulations – eg it does not mention Live radio or the JREAP Link-16 transport protocol; and

- It is confusing – it supports DIS, HLA and TENA; however, HLA is a promulgated NATO Standard (STANAG 4603).

It also mentions that the results of the recently released US DoD LVC Architecture Roadmap [LVCAR] were not available for the NMSSP where the LVCAR recommended two strategies:

- **Actively Manage Existing Architectures** - multiple architectures may be desirable if they can be easily integrated by developing common gateways, translators, object models, tools, processes and procedures; and
- **Convergence** - produce policy and procedures to encourage the architectures to converge towards a single architecture as far as possible. However, any attempt to mandate a single architecture on an unwilling user-base is certain to meet strong resistance and likely to fail! In the USA more than five different architectures (DIS, HLA, TENA, ALSP, CTIA, etc.) are in common use whereas in Australia the vast majority of LVC systems are DIS or HLA.

The recommended ADF Corporate Synthetic Range Interoperability Model (Table 4) has been produced from this analysis. Any LVC system that supports these recommended interoperability standards should be (hopefully highly) interoperable with the other LVC systems shown in Table 3 or at least be made to be interoperable with these systems.

The model components shown in Table 4 are more precisely and unambiguously defined than those in Table 2. The DIS PDUs supported (and therefore their HLA equivalents) are now shown in Table 4. However this is still not sufficient and actual PDU fields required, and the data (i.e. enumerations) that will populate these fields, also need to be defined.

LVC systems supporting the Recommended ADF LVC Synthetic Range Interoperability Model standards shown in Table 4 (along with the relevant PDU fields and enumerations) should be highly interoperable with the USAF, USN and UK RAF Mission Training through Distributed Simulation (MTDS) LVC systems (Table 3) [Khetia], [Ludwig] and [Dudfield].

Developing a complete description of the Recommended ADF LVC Synthetic Range Interoperability Model shown in Table 4 (along with the relevant PDU fields and enumerations) is the main objective of the work described in this paper.

**Table 3. Comparison of Synthetic Range Interoperability Models from the Literature**

<b>Model Name</b>	<b>ADS</b>	<b>Radio Comms</b>	<b>Tactical Data Link</b>
USAF (DTE5)	DIS IEEE 1278.1/A Entity State PDU Fire/Detonate PDU EE PDU IFF PDU	ASTi DACS Transmitter PDU Signal PDU Receiver PDU	Link-16 SISO-J
USN (DTE5 and Watson experiments)	DIS IEEE 1278.1/A Entity State PDU Fire/Detonate PDU EE PDU IFF PDU HLA DTE FOM MaK RTI	ASTi DACS Transmitter PDU Signal PDU Receiver PDU	Link-16 SIMPLE
US Army (DTE5)	DIS HLA DTE FOM MaK RTI MATREX FOM MATREX RTI	ASTi DACS Transmitter PDU Signal PDU Receiver PDU	None? (must now be VMF)
UK MASC	DIS HLA	DIS Voice Comms Transmitter PDU Signal PDU	Link-16 SISO-J
NATO Spanish LVC	DIS IEEE 1278.1/A HLA IEEE 1516 RPR-FOM V2D17 MaK RTI	Verbal	Link-16 SISO-J (DIS and HLA)
JADE II JJTTC	DIS IEEE 1278.1/A HLA IEEE 1516 RPR-FOM V2D17 MaK RTI DLC Compliant	VoIP	Link-16 JREAP Socket-J / SISO-J ?
NATO NMSSP	DIS IEEE 1278.1/A HLA IEEE 1516 RPR-FOM V1 and V2 TENA	No mention	Link-11 and Link-16 SIMPLE and SISO-J
Recommended ADF Corporate Synthetic Range Interoperability Model	DIS IEEE 1278.1/A Entity State PDU Fire/Detonate PDU EE PDU IFF PDU HLA DoD V1.3 or IEEE 1516 equivalent RPR-FOM V2D17 DLC Compliance	DIS IEEE 1278.1/A Transmitter PDU Signal PDU Receiver PDU or HLA RPR-FOM equivalent	Link-16 JREAP SIMPLE SISO-J

For virtual or constructive simulation systems the model can be simplified by requiring that only the SISO-J [SISO] Link-16 transport protocol be supported. Compliance with this model can then be fully achieved using only DIS or HLA, therefore simplifying such systems.

**Table 4. The Recommended ADF LVC Corporate Synthetic Range Interoperability Model**

<b>ADF Corporate Synthetic Range Interoperability Model</b>	
ADS: DIS IEEE 1278.1/A	Entity State PDU Fire PDU Detonate PDU Electromagnetic Emission PDU IFF PDU
or equivalent	HLA DoD V1.3 or IEEE 1516 DLC Compliance FOM is based on RPR-FOM V2D17
Radio Communications : IEEE 1278.1 Radio Communications Family PDUs Transmitter PDU Signal PDU or HLA RPR-FOM equivalents	
Tactical Data Link : Link-16 JREAP, SIMPLE and SISO-J Link-16 Transport Protocols	

**ADGESIM**

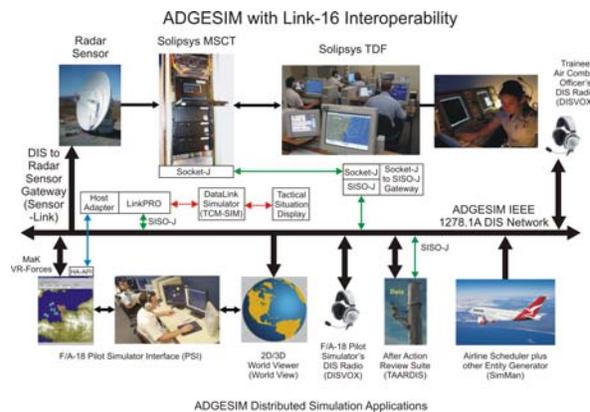
A virtual training system known as the Air Defence Ground Environment SIMulator (ADGESIM) is being developed at DSTO’s Air Operations Division (AOD) [Blacklock], [Zalcman (2010-2)]. ADGESIM is used by the RAAF to train Air Combat Officers. It is a high-fidelity, simulation system – it stimulates the same software used in the operational system thus alleviating most traditional, trainer concurrency problems.

ADGESIM is being developed in conjunction with the Concept of the Synthetic Range and the Synthetic Range Interoperability Model. ADGESIM is compliant with two of the three main components of the Synthetic Range Interoperability Model shown in Table 4 - it supports IEEE 1278.1/A DIS including DIS Radio/Intercom communications.

Full (C<sup>2</sup> and nonC<sup>2</sup>) Link-16, tactical data link interoperability is currently being developed for ADGESIM [Zalcman (2010-2)] using the SISO-J transport protocol [SISO-J] to reduce cost and

complexity. To provide a suitable spectrum of tactical data link training, Link-16 interoperability needs to be provided between the C<sup>2</sup> Solipsys (MSCT) system and the non-C<sup>2</sup> ADGESIM (F/A-18) Pilot Simulator Interface (PSI) application. The ADGESIM TAARDIS Logger already supports DIS therefore it already supports DIS SISO-J Link-16 interoperability.

The development system (Figure 2) will be compliant with the ADF Synthetic Range Interoperability Model defined in Table 4 and should therefore also be highly interoperable with the USAF Distributed Mission Operations systems [Aldinger].



**Figure 2. Synthetic Range Interoperability Model Compliant ADGESIM**

**AN AOD MISSION TRAINING CENTRE**

ADGESIM, the Desktop Aircraft (eg F/A-18) Cockpit Simulator (DACS), and the AEW&C (Airborne Early Warning & Control) high-fidelity (Wedgetail Integration/Research Environment - WIRE) simulation systems are all being developed within AOD.

If the DACS and WIRE systems are made to be ADF Synthetic Range Interoperability Model compliant then all these systems should be highly interoperable with each other and with USAF DMO systems.

RAAF Air Battle Management (ABM) teams are responsible for the tactical command and control of all air assets in the battlespace and are typically comprised of a Tactical Director and a number of Fighter Controllers. The Tactical Director allocates assets and manages operations within the air battle, overseeing and directing the Fighter Controllers, and communicates with other command elements and external agencies. The Fighter Controllers liaise with pilots in order to direct aircraft in accordance with

instructions, procedures, the tactical plan, and as directed by the Tactical Director [Shanahan]. The AOD ADGESIM, DACS, AEW&C systems could be connected to interoperate to form a DMO compliant AOD Air Battle Management Mission Training Centre.

Such an AOD Air Battle Management Mission Training Centre could be used to:

- Do experimentation, research and development to help develop ADF corporate interoperability standards such as (i.e. based on) the USAF DMO standards. The objective of this work is to reduce risk and cost when acquiring future LVC components, training systems and operational platforms with LVC capabilities;
- Test, evaluate and/or develop LVC components (Blue, Red and White Forces CGF applications, Loggers, After-Action-Review applications, etc.) which could be used (i.e. re-used) to reduce cost and risk for current and future ADF training systems and future operational platforms with LVC interfaces; and
- Construct an AOD Air Battle Management Mission Training Centre to demonstrate how a RAAF Air Battle Management Mission Training Centre facility could be used to do:
  - Cost-effective coalition, DMO training; and
  - Experimentation, research and development of future operational capabilities.

with the objective of assisting the RAAF to transition to Distributed Mission Operations.

### **A RAAF MISSION TRAINING CENTRE**

In 2005 the UK's Ministry of Defence established a Capability Concept Demonstrator (CCD) as the first phase of its Mission Training through Distributed Simulation (MTDS) Program. The 30 month CCD program aimed to de-risk the UK MTDS program by establishing user requirements through a series of demonstration events at a contractor owned facility at RAF Waddington. These user requirements would be used to underpin the MoD's future competition for delivery of the full UK MTDS program [Saltmarsh].

The CCD facility initially comprised a network of fast jet cockpit simulators and an AWACS simulator networked together through a comprehensive exercise management and control room with an integrated planning, briefing and debriefing suite to support the aircrew learning experience. The system was also

provided with a secure networking and encryption room to allow it to be connected to and interoperate with other training systems around the world.

At the end of the 30 month CCD program the RAF and UK Army agreed to convert the original Research and Development CCD facility to a training capability to deliver mission specific training to UK Land forces before they embark on operations in Afghanistan. The original requirement to deliver 8 weeks of activity over a 30 month period with no requirement for reliability was extended to 44 weeks per year of training and research activity for an additional period of four years at a defined level of availability. The physical layout and capability of the system was approximately doubled and the training facility was to be run by less skilled simulator operators and technicians who had never been involved in the system. This required an appropriate standard of documentation and a system that performed in a well defined and stable way.

The AOD Air Battle Management MTC could be used to advise on the development of a RAAF Air Battle Management MTC. Initially the RAAF MTC would be comprised of similar components (ADGESIM, DACS, AEW&C WIRE, low cost Blue and Red Forces, CGF White Forces, Loggers, After-Action-Review, etc.) to those found in the AOD Air Battle Management MTC.

Providing connectivity to, and interoperability with, the co-located RAAF Williamtown high-fidelity training systems (ADGESIM, AEW&C Operational Mission System, Super Hornet, etc. training systems) would enable these trainers to participate (as part of a RAAF Air Battle Management MTC) in Joint or Coalition LVC training that:

- May not be able to be done at all using real operational platforms – too dangerous;
- May only be able to be done rarely using operational platforms – too expensive and difficult to get all the required resources ( Live platforms, manpower, etc.) together; or
- May only be able to be done using (RAAF high-fidelity) simulators - experimentation.

Although each individual high-fidelity training system at RAAF Williamtown (ADGESIM, AEW&C OMS, Super Hornet training systems, etc.) will be able to train using its own internal systems, each system will not have a high-fidelity representation of the other systems. Such a RAAF Air Battle Management MTC would be a new capability for the RAAF.

## CONCLUSIONS

Live platform training can provide enhanced training but it can also be inefficient, extremely expensive and require considerable human resources to organise. A significant gap exists between training obtained using stand-alone simulators and training obtained during live training exercises for combat crews.

A mixture of Live and Virtual training may be the optimal way to train.

In the US simulation technology allows warfighters to train continuously and maintain a high state of combat readiness by using cost-effective simulation alternatives in conjunction with live operations and training missions. LVC capabilities for training and mission rehearsal, the advancement of networking technologies and protocol standards such as DIS and HLA have all contributed to an environment where highly-distributed training, mission rehearsal, operations support, and multi-force DMO joint / coalition exercises have become an everyday reality [Portrey].

The USAF DMO Program enables multiple LVC players at the same or multiple sites to participate in training scenarios ranging from individual and team sorties to full theater-level coalition battles.

Coalition DMO is designed to deliver cost-effective and realistic multi-national LVC training.

In the USAF approximately 20% of F-15C training will be done in DMO simulation systems.

An increasing portion of combat training for new weapons and combat systems (F-22, JSF, etc.) can only be accomplished in high-fidelity networked (LVC) simulators. You cannot fire Live weapons at Live platforms during training.

Platform development by experimentation may only be able to occur in networked simulators as the platform being developed may not yet exist!

In Australia the RAAF makes no use of any LVC DMO type capability whatsoever!

Appropriate ADF or RAAF LVC corporate interoperability standards do not exist!

Efficient LVC training relies on having an appropriate set of interoperability standards, processes and common databases in place.

Unless the RAAF adopts new technologies such as DMO, it will become more difficult and expensive to participate in coalition training and maintain minimum levels of mission readiness.

Other coalition Air Forces are developing LVC interoperability with USAF DMO systems to advance coalition training. It seems logical for the RAAF to proceed in the same direction to be able to easily and cost-effectively participate in future coalition LVC training exercises.

## RECOMMENDATIONS

For the ADF / RAAF it is recommended that:

- An ADF/RAAF coalition LVC Interoperability Policy and Strategy be developed;
- A set of corporate interoperability standards including common object models, common gateways and applications, and common federation agreements be developed;
- All ADF LVC Systems be specified to comply with these corporate interoperability standards to enable a common level of LVC interoperability at time of system delivery and acceptance by the ADF;
- The two recommended LVCAR strategies: Actively Manage Existing Architectures; and Convergence – be adopted by the ADF; and
- Both DIS and HLA be supported.

For DSTO's Air Operations Division it is recommended that:

- An AOD Air Battle Management Mission Training Centre be developed;
- An AOD MTC be initially constructed by integrating ADGESIM, DACS, and WIRE LVC interoperable systems with other DMO type components (gateways, SAFs, etc.);
- The AOD MTC be made compliant with USAF DMO interoperability standards; and that;
- The AOD MTC be used to demonstrate to the RAAF how a RAAF Air Battle Management Mission Training Centre could be used:
  - Do cost-effective coalition, DMO training; and
  - Experimentation and development of future operational capabilities.

with the objective of assisting the RAAF to transition to USAF compliant Distributed Mission Operations.

## REFERENCES

- [Aldinger] – Aldinger, M. and Keen, S. (2007), “*CAF DMO Standards-Based Approach for Achieving M&S Interoperability*”, NATO Modelling and Simulation Group Conference (MSG-056) “Improving M&S Interoperability, Reuse and Efficiency in Support of Current and Future Forces”, Prague, October 2007.
- [Blacklock] - Blacklock, J. and Zalcman, L., (2007) “*A RAAF Distributed Simulation, Training and Experimentation, Synthetic Range Environment*”, IITSEC 2007 Proceedings, Orlando, USA, Nov 2007.
- [Chapman] - Chapman, R. (2006) “*Accreditation Policy and Practice for Immersive Warfighter Simulators*”, Proceedings of the IITSEC 2006 Conference, Orlando, Florida, USA, November 2006.
- [Colegrove] - Colegrove, C. et al., (2009) “*Defining the Training Mix – Sorties, Sims and Distributed Mission Operations*”, Proceedings of the IITSEC 2009 Conference, Orlando, Florida, USA, November 2009.
- [Daly] - Daly, M. and Thorpe, D. (2009) “*Balancing Simulated and Live Naval Fleet Training*”, IITSEC 2009 Proceedings, Orlando, Florida, USA, Nov 2009.
- [Dudfield] – Dudfield, H., et al. (2009), “*The Impact of Fidelity Levels On Distributed And Collocated Fast Jet Participants During Multinational Training*”, SimTecT2009 Proceedings, Adelaide, June 2009.
- [Hambleton] - Hambleton, O. and Lollar, G., (2008), “*USAF Coalition DMO: Achieving Multinational Full Mission Training In Integrated LVC Environments*”, 2008 European Simulation Interoperability Workshop, Edinburgh, Scotland, June 2008, 08E-SIW-045.
- [Lechner] - Lechner, R. and Huether, C. (2009) “*Integrated Live Virtual Constructive Technologies Applied to Tactical Aviation Training*”, IITSEC 2008 Proceedings, Orlando, Florida, USA, November 2008.
- [Khetia (2009)-1] - Khetia, S., (2009) “*Enabling DMT*”, Proceedings of the IITSEC 2009 Conference, Orlando, Florida, USA, November 2009.
- [Ludwig] - Ludwig, A., Kilby, K., and Khetia, S. (2009), “*A Demonstrator of Mission Training Through Distributed Simulation: Lessons Learnt in Linkages to National and International Networks*”, SimTecT2009 Proceedings, Adelaide, June 2009.
- [LVCAR] – Henninger, A. et al. (2008) “*LVC Architecture Roadmap (LVCAR) – Final Report*”, Institute for Defense Analyses, Modeling & Simulation Coordination Office (M&S CO), US DoD, Sept 2008.
- [NATO M&S Vision] - 5000 TC-701/TT-2368, (2008), NATO Allied Command “*Transformation Modeling and Simulation Vision*”, December 2008.
- [NATO NMSSP] - AMSP-01(A), (2009), NATO M&S Standards Profile, Dec 2009.
- [Portrey] - Portrey, A., et al. (2007), “*DMO Today and Tomorrow: Science and Technology Support for Competency Based Training and Ops*”, Proceedings of the 2007 Spring Simulation Interoperability Workshop, Norfolk, VA, USA, March 2007, 07S-SIW-072.
- [Rumpel] - Rumpel, B., and Vila, R., (2007), “*Distributed Training in Europe*”, IITSEC 2007 Proceedings, Orlando, Florida, USA, November 2007.
- [Saltmarsh] - Saltmarsh, J. and Beattie, D., (2009) “*Distributed Synthetic Air-Land Training – Demonstration to Delivery*”, IITSEC 2009 Proceedings, Orlando, Florida, USA, November 2009.
- [Shanahan] – Shanahan, C., et al. (2009), “*Exercise Black Skies 2008: Enhancing Live Training Through Virtual Preparation*”, DSTO Research Report DSTO-RR-0344, November, 2009.
- [SISO] - SISO Standard for LINK 16 Sims, SISO-STD-002-2006, [www.sisostds.org](http://www.sisostds.org)
- [UK] – UK Ministry of Defence, (2005) “*Synthetic Environment and Modelling and Simulation (SEMS) Glossary*”, <http://192.5.30.131/issues/simulation/glossary.htm>
- [US] - U.S. Department of Defense (1995) “*Modeling and Simulation (M&S) Master Plan*”, (DoD Publication number 5000.59-P)
- [Zalcman (2010) - 1] - Zalcman, L., and Blacklock, J. (2010) “*USAF DMO and an ADF Synthetic Range Interoperability Model – What Are They and Why Does the RAAF Need Them?*”, DSTO Draft Report, 2010.
- [Zalcman (2010) - 2] - Zalcman, L., Ross, P., and Blacklock, J. (2010), “*Link-16 Interoperability for Air Combat Officer Training at RAAF Williamtown and RAAF Sale Using the ADGESIM and AWSIM Trainers*”, SimTecT2010 Conference, Brisbane, Australia, June 2010.