A Royal Australian Air Force, Distributed Simulation, Training and Experimentation, Synthetic Range Environment

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ABSTRACT

A Royal Australian Air Force (RAAF) Simulation Roadmap (2007 – 2017) is being developed to identify specific opportunities for simulation and readiness management. The Australian Defence Force (ADF) has defined a vision that "Defence exploits simulation to develop, train for, prepare for, and test military options for Government wherever it can enhance capability, save resources, or reduce risk".

The ultimate objective of this RAAF Simulation Roadmap is to produce and support a Distributed Simulation, Training and Experimentation, Synthetic Range Environment that implements this ADF vision. The RAAF Simulation Roadmap describes the main concepts and technologies to be used in such a RAAF synthetic range system and recommends a program of research over the period 2007 to 2017 to develop such a system.

This paper presents an overview of some of the research carried out so far, upon which the RAAF Simulation Roadmap is based, including:

- The concept of the synthetic range, whereby ADF real-world, operational military platforms, training and experimentation simulators and/or simulation systems can seamlessly interoperate with each other, that is currently being developed;
- Which distributed simulation (eg DIS, HLA or TENA), radio/intercom communications and tactical data link protocols, technologies, gateways and standards need to be adopted and why. Interoperability between RAAF systems, other ADF service and coalition partner systems has also been taken into consideration;
- The real-world, operational platform and simulation architectures that enable such synthetic range systems to seamlessly interoperate with each other; and
- Some of the innovations and lessons learned so far in the development of this interoperable, RAAF/ADF, training and experimentation synthetic range environment.

ABOUT THE AUTHORS

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.

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 Distributed Modelling and Simulation protocols (DIS, HLA and TENA), interoperability and standards, Synthetic Environments, Simulation Architectures, Tactical Data Link interoperability and Network Centric Warfare. In 2005 Dr. Zalcman left DSTO to set up Zalcman Consulting. Dr. Zalcman has authored/co-authored over 80 DSTO, TTCP and Zalcman Consulting research reports and conference papers.

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INTRODUCTION

The Australian Department of Defence (DoD) vision for simulation [ADF DI(G) OPS 42-1, ADSO] is that

"Defence exploits simulation to develop, train for, prepare for and test military options for Government wherever it can enhance capability, save resources or reduce risk."

The Australian DoD Simulation Roadmap deals with simulation support for the wider ADF, and documents a course for achieving this ADF vision for simulation. To achieve this vision will require that the ADF:

- Undergo transformation for assessing and acquiring capabilities. The ADF Simulation Roadmap points out that
- cultural change to enable this transformation is the biggest hurdle to the adoption of simulation in the ADF;
- Recognise that simulation is increasingly used by the ADF's key coalition partners, and this has considerable implications for the ADF regarding coalition training; and
- Adopt and develop network-centric concepts that will transform the ADF from a platform based, network aware force to a seamless Network Centric Warfare (NCW) force.

The RAAF Simulation Roadmap is being developed to:

- Facilitate alignment of RAAF simulation goals with those of the ADF as documented in the ADF Simulation Roadmap;
- Assign specific responsibilities within the RAAF command chain; and
- Document a RAAF programme of simulation research and development activities that is compliant with the overall ADF programme.

This paper describes some of the research upon which the RAAF Simulation Roadmap is based, including:

- The concept of the synthetic range where ADF real-world, operational military platforms, training and experimentation systems can all seamlessly interoperate with each other;
- Which distributed simulation protocol (eg DIS, HLA or TENA [DIS-1, 2, HLA-1, 2, 3, 4, TENA]), radio communications and tactical data link protocols, technologies, gateways and standards need to be adopted and why;
- The synthetic range interoperability model that is key to achieving interoperability; and
- Some of the innovations and lessons learned so far in the development of this highly interoperable, Joint and coalition, training and experimentation, synthetic range environment.

AUSTRALIAN DEPARTMENT OF DEFENCE SIMULATION CAPABILITY

The Australian DoD Simulation Roadmap identifies and discusses simulation infrastructure and practice. The ADF have appropriate simulation systems and skills to address individual training. However whilst there are some futuristic simulation capabilities being developed [ADSO, Zalcman-1] there are no current, practical implementations of systems designed to support ADF transformation from platform-centric to information-centric concepts such as network-enabled warfare.

Royal Australian Navy (RAN) and Army simulation capabilities are being developed [ADSO, Ryan] to meet Service needs. These systems have the potential to support and enhance RAAF efforts to achieve cooperative training and experimentation outcomes in the Joint and Coalition spheres. The ADF Simulation Roadmap discusses strategies and objectives however no corporate (ie ADF wide) interoperability standards exist. The ADF Simulation Roadmap identifies a need for such standards, and notes that these may evolve from legacy systems in the shorter term, to be replaced systematically later in an ordered development process.

Current ADF simulation systems could evolve into a distributed simulation environment. Therefore the concept of a synthetic range [Zalcman-2)], where live assets are instrumented to allow their interoperability with virtual and constructive systems in the same virtual exercise space, is being developed. Such synthetic range environments are sometimes referred to as LVC (**L**ive, **V**irtual, **C**onstructive) environments.

LVC activities have been demonstrated in the RAN CReaMS (**C**oalition **Rea**diness **M**anagement **S**ystem) programme where real USN ships shared a common synthetic range with USN and RAN virtual and constructive systems. The ADF Exercise *Talisman Sabre 07* will demonstrate LVC interoperability between maritime, land, and air assets in a prototype synthetic range environment.

THE CONCEPT OF THE SYNTHETIC RANGE

A synthetic range concept is being developed to assist in the interoperability of ADF Service, Joint and Coalition LVC systems. The synthetic range concept provides a simplified way of understanding how LVC military systems can interoperate. To understand the synthetic range concept it is important to know:

- What a synthetic range is;
- What kind of systems can be combined within a synthetic range; and
- What is required in a synthetic range system interoperability model to provide appropriate interoperability for participating systems.

What Is A Synthetic Range?

Synthetic range systems can interoperate with each other and share a common scenario over a distributed simulation network no matter where these systems are geographically located throughout the world. Synthetic Range systems can share real and virtual tactical data link system information in almost exactly the same way as in live operations where data is shared through datalinks or other communications media.

In a synthetic range the entirety of the test and training event will be represented in a virtual world that may bear no relationship to the actual geographical location of the participating LVC systems. For example, live aircraft operating in an instrumented bombing range in the Australian Northern Territory might be training with ship simulators physically located in Sydney thousands of kilometers away. However in the scenario the ships and aircraft might be collocated in a virtual space such as the Shoalwater Bay Training Area (SWBTA) in Northern Queensland. Through virtualisation, voice and data communications can continue between the ships and aircraft as if they were actually all physically located in the SWBTA. Bombs could be dropped on virtual targets that coincide with actual target locations in the real bombing range. Simulation scenario and tactical data link data would be distributed between the live, instrumented aircraft and a ground station using real radio communications. However data between the (aircraft) ground station and the virtual ship simulators located in Sydney would be distributed over wide area networks connecting the two locations. This allows the use of real (or virtual) bombs and ammunition by the aircraft without danger to ships or people.

Therefore a synthetic range comprises a group of participating systems interoperating in a virtual environment by exchanging data over a distributed network infrastructure. An interoperability model and an associated set of interoperability standards allows a synthetic range architecture to be developed.

Different Types of Synthetic Range Systems

A synthetic range system can be broadly classified as belonging to one of three different types of systems – Live, Virtual, or Constructive.

Live systems are "instrumented" real world, operational military platforms. Instrumentation (Embedded or On-Board-Training-Systems, Air Combat Manoeuvring 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. This 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 Live, synthetic range systems.

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

Constructive systems are entirely synthetic representations of both platforms and people. They exist only within the simulation network and act according to software rules rather than through human direction.

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 that is a crucial part of the 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.

A SYNTHETIC RANGE SYSTEM INTEROPERABILITY MODEL

An appropriate set of ADF corporate, synthetic range compliant, interoperability standards is being developed to enhance capability and reduce risk and cost.

The synthetic range system interoperability model addresses interoperability from three points of view:

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

Note that the architecture / interoperability model (Figure 1) is a *minimum* starting point – it does not preclude later enhancement of the current components or addition of other new components to this model.

Advanced Distributed Simulation Interoperability

Synthetic range participants can use Distributed Interactive Simulation (DIS), High Level Architecture (HLA), or Test and Training Enabling Architecture (TENA) to provide interoperability between systems.

DIS was chosen as the RAAF distributed simulation protocol of choice between federations because:

- Most ADF Advance Distributed Simulation systems use the IEEE Distributed Interactive Simulation (DIS) 1278.1 or 1278.1A standard;
- DIS is widely used by Australia's main coalition partner - the USA [Zalcman-3, Berry, Grescke];
- ADF tactical data link accreditation requires the stimulation and testing of TDL systems using DIS PDUs. Synthetic range systems are fully compliant with this requirement;
- HLA systems may be more flexible however they have their own, unique, additional (inter-federation) interoperability problems [Tudor];
- TENA is a developing technology and is basically not used in the ADF; and
- An appropriate design of these synthetic range interoperability standards will enable external interoperability with HLA and TENA systems using cost-effective, COTS gateways.

An Advanced Distributed Simulation Protocol Independent Approach To Interoperability

The synthetic range concept interoperability model is being developed to be distributed simulation protocol independent.

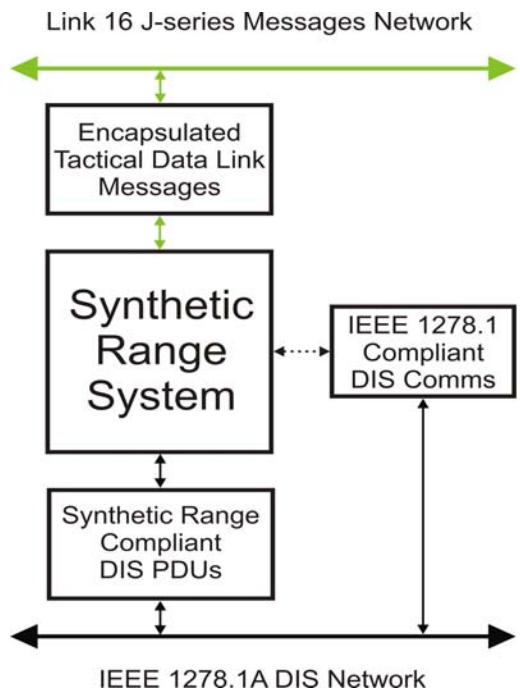

Figure 1. The Synthetic Range Architecture / Interoperability Model

For external interoperability (between federations) only standard (ie no experimental) IEEE DIS Protocol Data Units (PDUs) are supported. A *minimum* standard set of DIS PDUs for any synthetic range distributed simulation system (a platform with sensors and weapons) has been developed [Zalcman-3].

Therefore for HLA, HLA Federation Object Models (FOMs) based on the HLA Real-Time Platform Reference Federation Object Model (RPR-FOM) [RPR-FOM] are required. Similarly for the HLA RPR-FOM equivalent TENA Logical Range Object Model.

This should result in highly interoperable, protocol independent systems and interoperability between such DIS, HLA, or TENA systems should be able to be achieved using currently available, cost effective, Commercial-Off-The-Shelf (COTS) gateways and software development toolkits [MaK].

Tactical Data Link Interoperability

All new 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 [Filippidis-1]. However legacy RAN Link 11, Army VMF (Variable Message Format) and Euro-Grid systems will require gateways to provide ADF wide TDL interoperability.

Synthetic range 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 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".

The ADF Tactical Data Link Authority (ADFTA) 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. 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.

Corporate standards, requiring J-series interoperability, need to be developed and mandated. Such corporate standards would reduce risk and cost to the ADF.

Radio Communications / Intercom Interoperability

Previous ADF training systems (AP-3C, HMAS WATSON FFG, ANZAC team trainers, etc.) were delivered with proprietary internal communications sub-systems. However these systems were unable to interoperate externally using simulated radio communications or intercoms. New ADF simulation acquisitions are usually specified to come with COTS DIS or HLA radio communications capabilities.

An appropriate synthetic range, communications interoperability standard would be similar to

"the ability to interoperate using IEEE 1278.1 Radio Communications Family PDUs".

Suitable test and evaluation procedures will need to be developed to enable synthetic range radio communications systems compliance to be tested.

SYNTHETIC RANGE PLATFORM AND SIMULATION SYSTEM ARCHITECTURES

Most recently acquired ADF training simulators have interfaces to enable external, distributed simulation interoperability. These systems simulate tactical data link and radio communications / intercom capabilities for use within the simulator. However these systems may not have externally interoperable tactical data link or radio communications / intercom capabilities and expensive modifications may be required (as occurred for the FFG and the ANZAC ship team training systems at the Navy HMAS WATSON Maritime Warfare Training Centre (MWTC)) to upgrade these systems to provide external IEEE DIS radio communications and real tactical data link interoperability capabilities.

Modern operational systems can be acquired with embedded or On-Board-Training-Systems (OBTS). If such an OBTS, stimulated architecture is adopted the high-fidelity, training system "falls out in the wash" – it is the OBTS minus the real-world, operational platform plus emulated components to replace relevant, missing real-world, operational platform components.

Although an OBTS increases the cost of the operational system this is offset by the fact that most of the high-fidelity, standalone training system has then already been developed as part of the operational system. The standalone training system is then exactly the same equipment as is used in the real-world operational system thus reducing concurrency problems considerably. Common components reduce the cost of maintenance and if the real-world operational system is upgraded the training system can be upgraded in exactly the same way instead of requiring extensive (and costly) modifications to the emulated training system.

Legacy air platforms (eg F-5, F-14, F-15, F-16 F/A-18, Hawk, Tornado aircraft) can be made synthetic range compliant using aircraft mounted, instrumentation pods and ground-based systems such as the Cubic ACMI system [Cubic] recently purchased for RAAF F/A-18 aircraft. In-flight data and weapons events are collected and recorded. Data is relayed in near real-time to ground stations for exercise control and aircrew debrief functions, and can provide interoperability with other synthetic range like systems. This allows aircrews to train away from fixed ranges in any available airspace. The Cubic ACMI devices use TENA to implement distributed simulation functionality between the aircraft and the ground stations. Synthetic range gateways may be required.

Synthetic range compliant, stimulated systems with embedded or On-Board-Training-Systems (OBTS) are recommended. Such systems usually support real tactical data link equipment and capabilities. COTS products (eg ASTi) are available that can provide interoperability between real and DIS / HLA simulated voice communications systems.

Therefore synthetic range, real-world operational platforms and simulation systems, that are compliant with a corresponding set of corporate interoperability standards and that will seamlessly interoperate with each other, can be specified and acquired.

MODELING AND SIMULATION (SUPPORT) FOR THE ROYAL AUSTRALIAN AIR FORCE

The ADF Defence Science and Technology Organisation (DSTO) provides the ADF with its main research and development capability. Some of DSTO's main objectives are to provide scientific and technical support to defence operations, investigate future technologies for defence, ensure Australia is a smart buyer and user of defence equipment, help develop new defence and national security capabilities, and reduce cost of ownership of existing defence assets. The synthetic range concept is being developed in the DSTO RAAF Aerospace Synthetic Environment Component (RASEC) and Net Warrior projects to research ADF platform and training systems interoperability.

RAAF simulation systems for RAAF Airborne Early Warning and Control (AEW&C) aircraft, ground based air defence controllers and F/A-18 pilots are being acquired with distributed simulation capabilities. However because no ADF corporate interoperability standards exist these systems may have limited interoperability with each other therefore limiting their usefulness for an ADF, Air Battle Management, Mission Training Centre (MTC).

Each of these simulation systems (and other LVC systems of interest) needs to comply with the same, identical set of corporate interoperability standards to achieve "maximum" interoperability. The DSTO RASEC and Net Warrior projects, along with other ADF Air Battle Management Mission Training Centre systems of interest, are discussed below.

The DSTO RASEC Task

The Virtual Air Environment (VAE) was a RAAF / DSTO project that identified how simulation could be used to support operational management, training, planning and force development. The VAE delivered simulation systems to support Air Defence Controllers in the RAAF Surveillance and Response Group. In 2003 the VAE evolved into the RAAF Aerospace Synthetic Environment Component (RASEC) task. The concept of the synthetic range (and the RAAF Simulation Roadmap) is being developed under RASEC to:

- Define, prototype, and demonstrate an **A**ir **W**arfare **A**ssessment and **R**eadiness **E**valuation **S**ystem (AWARES);
- Evolve VAE basic training simulation components to support experimentation, advanced training, test and evaluation of C4I systems being acquired, and certification of the command team training process;
- Define and implement distributed simulation systems for RAAF air battle managers to allow for joint and coalition training, command team certification, pre-deployment training and mission rehearsal; and
- Research connecting legacy simulation systems and extending distributed simulation training to other RAAF Force Element Groups.

The DSTO Net Warrior Project

A series of DSTO Net Warrior exercises is planned to develop ADF Network Centric Warfare interoperability [Filippidis 1, 2, Zalcman 1, 2]. Through experimentation these Net Warrior exercises will address NCW and mission system techniques and technologies to enhance ADF war fighting capabilities.

In the short term Net Warrior will be used to enhance DSTO Battlelab interoperability. However, Net Warrior will be extended to research ADF training systems and operational platform interoperability. Because RASEC and Net Warrior are managed by the DSTO Air Operations Division, integration of RAAF systems will be investigated initially.

The Air Defence Ground Environment Simulator

To support air battle manager training the high-fidelity, Air Defence Ground Environment Simulator (ADGESIM) [ADGESIM 1, 2], (Figure 2) has been developed under RASEC. An ADGESIM Link-16 capability is currently being developed by the DSTO Intelligence, Surveillance and Reconnaissance (ISR) Division's ISR Analysis and Integration Laboratory (ISRAIL) (Figure 3).

With such a Link-16 capability ADGESIM will be substantially synthetic range compliant.

The AEW&C OMS Training System

An Airborne Early Warning and Control (AEW&C) (Figure 4) capability is being acquired by the ADF. The AEW&C Operational Mission Simulator (OMS) is the "back-end" simulator for the AEW&C system. The AEW&C OMS system is due for delivery in 2008/2009.

The objective of the AEW&C OMS is to train crews in all roles assigned to the AEW&C aircraft using a realistic, simulated environment under control of instructors. The AEW&C OMS will be capable of conducting the full range of AEW&C operations as identified in the AEW&C Concept of Operations. Unfortunately the AEW&C OMS, as originally specified, is not synthetic range compliant because:

- It supports IEEE 1278.1 (version 5) DIS. It does not support the IEEE 1278.1A (version 6) DIS IFF PDU and therefore the distributed simulation interface is limited in its capabilities;
- The tactical data link capability of the AEW&C OMS does not support the appropriate USA Link-16 J-series messages standard used by the ADF. Therefore (most likely minor) incompatibilities may occur; and
- External radio communications interoperability is not supported in the AEW&C OMS.

Rather than interrupt the delivery of the already specified AEW&C OMS, documentation for an "add-on" Engineering Change Proposal (ECP-80) was developed to address the deficiencies mentioned above. The ECP-80 specified AEW&C OMS is synthetic range compliant. The ADF is currently "in negotiation" with Boeing regarding the implementation of ECP-80.

The Hornet F/A-18 Simulators

The RAAF has acquired three interoperable, L-3 Link F/A-18 training simulators (similar to systems used by the USN and the Canadian Air Force - Figure 5) known as the **H**ornet **A**ir **C**rew **T**raining **S**ystem (HACTS).

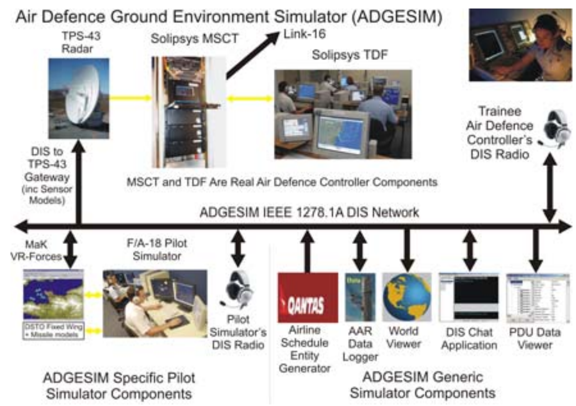

Figure 2. The RASEC Developed ADGESIM.

Initially only the two cockpits at RAAF Williamtown (the other is at RAAF Tindal) will interoperate. The HACTS systems are HLA systems using a FOM based on the RPR-FOM, and have ASTi [ASTi] (Telestra) HLA radio communications. Tactical data link interoperability between the RAAF Williamtown HACTS cockpits appears to use real Link-16, J-series messages encapsulated within a proprietary protocol.

HACTS systems will participate in the ADF Joint Combined Training Centre *Talisman Sabre* coalition exercise to be carried out in mid 2007 (JCTC TS07). JCTC interoperability documentation is not available. HACTS to JCTC interoperability will occur using:

- A HACTS HLA (DMSO RTI) to JCTC backbone HLA (VTC RTI) Bridge to achieve distributed simulation interoperability;
- HACTS Link-16, J-series messages may not be utilised during TS07; and
- ASTi HLA radio communications will be converted to ASTi DIS radio communications.

A HLA backbone is being used in TS07. DIS Gateways are planned to provide interoperability with the synthetic range compliant RAN Maritime Warfare Training Centre simulators at HMAS WATSON.

CREATING AN ADF AIR BATTLE MANAGEMENT MISSION TRAINING CENTRE

ADGESIM, the AEW&C OMS and HACTS systems will be located at the RAAF Williamtown air base. If these systems could interoperate they would form a prototype RAAF Air Battle Management Mission Training Centre (MTC) that could provide an initial RAAF capability to conduct virtual large-force development and training with little impact to logistics, environment, and war fighting resources. Such a multi-system, high-fidelity simulation capability has not previously been available to the RAAF.

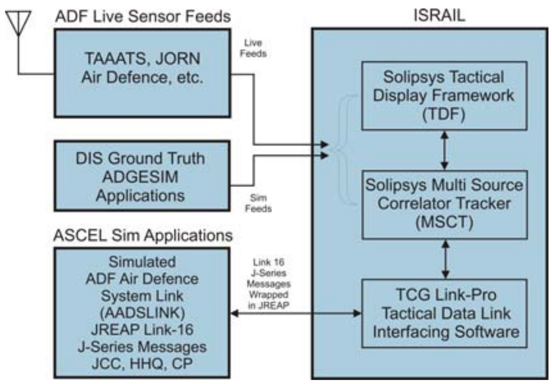

Figure 3. The DSTO ISRAIL Laboratory.

Such MTC systems are used for theatre wide (air force, joint and coalition) mission rehearsal exercises in the USAF Distributed Mission Operations (DMO) program (Figure 6) and could help the RAAF provide a ready, trained and rehearsed fighting force, and along with an appropriate AWARES system, a means to certify component commanders and staff [Cochrane].

Figure 4. The RAAF, AEW&C aircraft.

Currently RAAF fighter pilot training relies on stand-alone simulators and in-flight training for combat crew readiness. With no networked capability, stand-alone simulator use primarily emphasises abnormal / emergency procedures, thus providing limited capability to prepare combat ready crews for joint and coalition operations.

Large-scale 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. A significant gap exists between training obtained using stand-alone simulators and training obtained during live flying training exercises for the RAAF fighter combat crews. Alternative training methods, such as MTC training, should be considered to maintain crew readiness.

Figure 5. A L-3 Communications, F/A-18 Simulator.

MTCs allow multiple players at multiple sites to participate in synthetic environment training exercises ranging from individual and team participation to full theatre-level battles. Advantages arise such as increased value and efficiency of actual flying hours, along with improved communication skills in a joint and coalition environment, and an increased sense of trust and confidence amongst participants [Cochrane].

The Australian Government is to purchase 24 F/A-18F Super Hornet aircraft (initial delivery 2010) including a local aircrew training capability. L-3 Link has also announced contracts for the delivery in 2008 of the first US Navy Aviation Simulation Master Plan compliant, F/A-18E/F Tactical Operational Flight Trainers (TOFTs) that will enable aircrews to undertake networked mission training. The current synthetic range concept work could provide assistance in the specification of interoperability options for the Super Hornet local training capability to enable these systems to form part of an enhanced RAAF Air Battle Management Mission Training Centre.

JOINT AND COALITION INTEROPERABILITY

The FFG, ANZAC and FFG Up ship team training systems at the RAN HMAS WATSON MWTC are already synthetic range compliant. These MWTC ship team training simulation systems already support;

- all the DIS PDUs in the synthetic range distributed simulation standard;
- Link-16 J-series or Link-11 M-series messages; and
- DIS Radio communications.

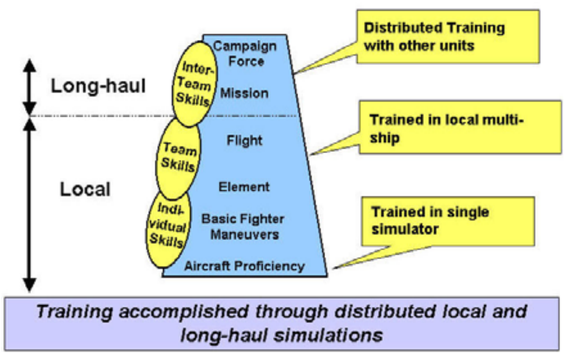

Figure 6. USAF DMO Training Focus

These synthetic range compliant MWTC systems have participated in regular experimental, coalition training exercises with the synthetic range compliant USN **B**attle **F**leet **T**eam **T**rainer (BFTT) systems including real USN ships [Ryan] for several years. Over a period of several years all major operational USN platforms have had synthetic range compliant, BFTT On-Board-Training-Systems fitted.

The RAN FFG Up operational platform (ie ship) is synthetic range compliant. The MWTC FFG Up trainer uses the same equipment as is found on the FFG Up ship and the FFG Up architecture is basically identical to that of the USN BFTT systems.

Synthetic range compliance should be considered for the new RAN Air Warfare Destroyer system.

The USN is the sole operator of F/A-18E/F aircraft and therefore the RAAF will most likely be interested in future interoperability with USN (Air Force) systems.

CORPORATE INTEROPERABILITY STANDARDS

Once synthetic range compliant, ADF corporate interoperability standards have been developed they should be mandated for every ADF distributed simulation system acquired that may require LVC interoperability. Where such (COTS) systems do not comply (eg HACTS) appropriate gateways should be procured as part of the original system acquisition. This would enable interoperability between all synthetic range compliant systems once these systems have been acquired and accepted by the ADF.

Complimentary synthetic range system interoperability test and acceptance procedures need to be developed.

Base test and acceptance procedures for the synthetic range distributed simulation (DIS) interoperability standard systems have already been developed by DSTO [Ross]. The tactical data link test and acceptance procedures developed by ADFTA should be used as the tactical data link interoperability requirements for the synthetic range and for ADFTA are identical. Tactical data link interoperability must be accredited by ADFTA to enable a synthetic range compliant system to interoperate on any ADF tactical data link network. Synthetic range compliant DIS radio/intercom communications interoperability test and acceptance procedures need to be developed.

Once an ADF standard Entity Set has been developed, other associated standards (entity visual and behavioural models, emission databases, etc.) should also be developed leading to further cost reductions. A draft Standard Entity Set has been developed for the RAAF - this will be tendered to the ADF.

The more corporate interoperability standards are used, the less simulation systems will need to be modified once they have been procured thereby reducing risk and cost to the ADF.

If synthetic range interoperability (including appropriate gateways) is not acquired with the original system, additional justification, funding and acquisition processes may be required. This could delay synthetic range interoperability of a system for several years.

CONCLUSIONS AND SUMMARIES OF LESSONS LEARNED

An overview of some of the research work carried out and the lessons learned, upon which the RAAF Simulation Roadmap is based, has been presented.

The synthetic range concept, architecture and interoperability model, have been discussed.

A synthetic range interoperability model, based on Advanced Distributed Simulation interoperability, tactical data link interoperability, and real and simulated radio communications interoperability, has been developed. Simple synthetic range interoperability model standards have been recommended.

ADF corporate interoperability standards, based on these synthetic range interoperability model standards, need to be developed and their use mandated otherwise simulation systems may have limited interoperability.

The synthetic range concept allows operational platforms, high-fidelity training simulators and experimentation systems to interoperate with each other.

COTS products may come with DIS, HLA or TENA distributed simulation protocol interfaces. Although DIS is the recommended distributed simulation protocol of choice, the synthetic range interoperability model has been designed to enable interoperability regardless of which distributed simulation protocol is used. However, where a system is not delivered with the appropriate DIS interoperability, gateways will be required to achieve compliance with the recommended synthetic range compliant, corporate, interoperability standards.

Where appropriate, Live, Virtual, and Constructive systems should be acquired with synthetic range compliant, interoperability capabilities. Such systems will then be able to participate in LVC exercises with less modification to their interoperability gateways thus reducing risk and cost.

If synthetic range interoperability is not included as part of the original system acquisition an additional set of justification, funding and acquisition processes may be required. This could delay corporate synthetic range interoperability of a system for several years.

Some key RAAF modeling and simulation components, including the DSTO RASEC and Net Warrior projects and the RAAF ADGESIM, AEW&C OMS and F/A-18 simulators, have been described.

ADGESIM will be synthetic range compliant (ie compliant with the recommended synthetic range interoperability model standards) once the DSTO ADGESIM Link-16 capability is developed.

The AEW&C OMC ECP-80 needs to be implemented to make the AEWC OMS synthetic range compliant.

Additional gateways will be required to make the RAAF HACTS F/A-18 simulators synthetic range compliant. However some of these gateways may be developed as part of the work carried out for the ADF Joint Combined Training Centre TS07 exercise.

A RAAF, Air Battle Management, Mission Training Centre, based on synthetic range interoperability between the ADGESIM, ECP-80 AEW&C OMS, and the HACTS F/A-18 simulators, has been proposed. This system will provide the RAAF with a new capability to conduct large scale, theatre wide (air force, joint and coalition) NCW force development and training.

To enhance this Air Battle Management MTC further synthetic range compliant interoperability should be developed and specified for the current F/A-18C and AEW&C, and the future F/A-18F Super Hornet and JSF aircraft and training systems.

Legacy air platform (current F/A-18 and AEW&C aircraft), synthetic range compliance can be achieved through the use of add-on ACMI pods.

The synthetic range interoperability model proposed will provide Joint and Coalition LVC interoperability between RAAF, RAN and USN synthetic range compliant systems.

In summary the synthetic range concept, and its associated interoperability standards, will enable the RAAF to carry out research and development, and experimentation (as described in the RAAF Simulation Roadmap) that will help transform the RAAF (and the ADF) from a platform based, network aware force to a seamless Network Centric Warfare force over the next 10 to 15 years.

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