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The Royal Australian Air Force, Virtual Air Environment, Interim Training Capability

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Air Operations Division
Systems Sciences Laboratory

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ABSTRACT

Currently some Australian Defence personnel train using live assets. This may be prohibitively expensive and some of these assets have very short lifetimes before a major overhaul is required. DSTO has participated in a series of concept demonstrations showing the potential of synthetic, virtual environment technologies to support such operational training. These demonstrations showed both Joint and Coalition interoperability. A Distributed Interactive Simulation (DIS), virtual environment, training system known as the Air Defence Ground Environment Simulator (ADGESIM) has been developed and delivered. A mix of Commercial-Off-The-Shelf (COTS) products and customized, "thin client" applications where required, approach has been adopted. This system is now being used by Air Defence Operators and Fighter Controllers, at RAAF Williamtown, for real operational training. This paper describes some of the distributed, virtual, simulation concepts and technologies used, in DSTO's Advanced Distributed Simulation Laboratory at Fishermans Bend, Melbourne, to develop this training system.

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The Royal Australian Air Force, Virtual Air Environment, Interim Training Capability

Executive Summary

Currently some Australian Defence personnel are trained using live assets. In some situations not only is this prohibitively expensive but these assets may have very short lifetimes (eg approximately 5000 flying hours for a F/A-18 aircraft).

DSTO has participated in a series of concept demonstrations showing the potential of synthetic, virtual environment technologies to support operational training. These concept demonstrations showed Joint interoperability between Australian Air Force, Army and Navy training simulator systems. Other demonstrations, carried out between Australian and USA Navy training simulators, showed virtual interoperability between coalition force training simulators.

Further research and development in the DSTO's ADSL has culminated in the delivery of an IEEE standard, Distributed Interactive Simulation (DIS), virtual environment, training system known as the Air Defence Ground Environment Simulator (ADGESIM). An architecture, which uses a mix of Commercial-Off-The-Shelf (COTS) products and customized, "thin client" applications where required, has been adopted. This training system is now being used by F/A-18 Air Defence Controllers, at RAAF Williamtown, for real operational training.

This paper describes some of the distributed virtual simulation concepts and technologies used in DSTO's Advanced Distributed Simulation Laboratory at Fishermans Bend, Melbourne, to develop this training system.

Authors

Mr Jon Blacklock
Air Operations Division

Jon Blacklock joined the Royal Australian Air Force in 1978 and trained as an Air Defence Officer. Following postings as a Fighter Controller he was posted to the Joint US/Australia facility Nurrungar in South Australia. After training in the US in space systems and space operations he worked as a Senior Director, Space Operations and as a combat crew commander in the US Defense Support Program supporting the missile early warning and nuclear non-proliferation mission. Later, he had postings as a staff officer in Defence Headquarters responsible for aerospace control and battlespace management, as Project Manager for Air 5077 AEW&C for the Australian Defence Force, and as Commanding Officer, No.3 Control and reporting Unit. Jon holds post-graduate qualifications in management and was appointed to the position of Head, Air Projects Analysis in Air Operations Division DSTO in 2001. His recent activities have revolved around task management of analytical activities supporting replacement of Australia's Fighter and Strike forces, and in the development of synthetic environments for training, experimentation, and Force development in aerospace control and battle management

Dr Lucien Zalcman
Air Operations Division

Dr Lucien Zalcman graduated from Melbourne University with a BSc (Hons.) in 1973. He was awarded a PhD in Physics from Melbourne University in 1980. He also completed a Graduate Diploma in Computing Studies at RMIT graduating in 1987. During the period 1980 - 1984 he worked as an Experimental Officer at the CSIRO Division of Mineral Chemistry carrying out research into lead acid batteries for electric vehicles. He joined DSTO in 1984 as an Information Technology Officer in the Computer Centre at the Aeronautical Research Laboratory. In 1992 he was employed as a Senior Professional Officer in Air Operations Division of AMRL specialising in the field of Distributed Interactive Simulation. He was promoted to Senior Research Scientist in 1998.

Contents

Glossary

AADS	ADF Air Defence System
AAR	After Action Review
ACSS	Air Command Support System
ADGE	Air Defence Ground Environment
ADGESIM	Air Defence Ground Environment Simulator
ADF	Australian Defence Force
ADS	Advanced Distributed Simulation
ADSL	Advanced Distributed Simulation Laboratory
AEW&C	Airborne, Early Warning & Control
AOD	Air Operations Division
ARSR	Air Route Surveillance Radar
API	Application Programmers Interface
BFTT	Battle Force Tactical Training
CGF	Computer Generated Forces
COTS	Commercial-Off-The-Shelf
DDG	Guided Missile Destroyer
DIS	Distributed Interactive Simulation
DMT	Distributed Mission Training
DoD	US Department of Defense
DSTO	Defence Science & Technology Organisation
DTE	Digital Target Extractor
FFG	Guided Missile Frigate
FOM	Federation Object Model
GUI	Graphical User Interface
HLA	High Level Architecture
EASTROC	Eastern Region Operations Centre
IEEE	Institute of Electrical and Electronic Engineers
IFF	Interrogate Friend or Foe
IST	Institute of Simulation and Training (US)
ITC	Interim Training Capability
JCC	Jorn Co-ordination Centre
JOANNE	Joint Air Navy Networking Environment
JORN	Jindalee Operational Radar Network
LAN	Local Area Network
MWTS	Maritime Warfare Training System
MSCT	MultiSource Correlator and Tracker
OBTS	On-Board-Training-System
OCD	Operational Concept Document
ONION	Orthographic Network Input / Output Node
OTHR	Over The Horizon Radar
OTW	Out The Window
PIE	Plug-In Event
PDU	Protocol Data Unit
RAAF	Royal Australian Air Force
RAN	Royal Australian Navy
RAP	Recognised Air Picture
RFP	Request For Proposals
RPR-FOM	Real-time Platform Reference Federation Object Model
SACTU	Surveillance and Control Training Unit
SCG	Surveillance Control Group
SOM	Simulation Object Model
TDF	Tactical Display Framework
TNA	Training Needs Analysis
USN	United States Navy

VAE	Virtual Air Environment
WAN	Wide Area Network

1. Introduction

In some situations, the Australian Defence Force (ADF) has no option but to use operational assets to support training and development. The use of live assets can be expensive [1] and will normally lead to increased fatigue-life accrual with resultant increase in maintenance and support costs. Reduced operating budgets over the past decade have impacted on both asset availability and the frequency and scale of joint and combined exercises. At the same time, the ADF continues to introduce a range of complex systems that must coalesce into a coherent network of sensors, processing systems, weapons and people. This is particularly true of the aerospace battle management system operated by the RAAF Surveillance Control Group (SCG) on behalf of the ADF. The Air Defence Ground Environment (ADGE) has undergone a rapid evolution in the last three years to support comprehensive sensor integration, data fusion, and knowledge management required to solidify Australia's wide area surveillance and control capabilities. Past reliance on the availability of fighter aircraft for the conduct of fighter control and battle management training in SCG is no longer viable and enterprise level exercises that provide live training for all areas of the ADGE are virtually non-existent.

Where practical, the RAAF and wider ADF are seeking to adopt advanced simulation technologies, such as Distributed Interactive Simulation (DIS) and High Level Architecture (HLA), to enhance training capabilities, increase training opportunities, and reduce costs [2,3]. To support this thrust, DSTO has a number of sponsored tasks and research projects to achieve the following outcomes:

- Define the effects of simulation on current and future Defence capability;
- Explore simulation technologies and methods, and assess the viability of legacy simulation systems in connected simulations;
- Identify candidate areas for simulation use and the specific training and development needs of various groups within the ADF [4-11];
- Demonstrate concepts and technologies for simulation, stimulation of operational systems, operational research, operational analysis, and Force development [2,3,12-15]; and
- Highlight the value and cost of simulation and inform investment decisions [8, 16-19].

The Australian Defence Simulation Office (ADSO) is responsible for simulation policy and guidance for the ADF. DSTO maintains a strong relationship with ADSO to provide advice when required, and has several projects sponsored by ADSO and the Services to develop specific capabilities for the ADF.

2. Related Advanced Distributed Simulation Projects Within the ADF

DSTO simulation activities cover all three environments (Air, Land, and Maritime) and also contribute in the areas of Joint operations and intelligence. However, this report will deal only with the Virtual Air Environment (VAE) and a few other projects that have had a direct bearing on the development of the Air Defence Ground Environment Simulator (ADGESIM) as the Interim Training Capability (ITC) for SCG.

2.1 RAN Project SEA 1412

The objective of the initial phases of this project was to add DIS interfaces to the RAN ANZAC and FFG/DDG simulators at the Maritime Warfare Training Centre at HMAS Watson in Sydney. The aim was to share simulator resources to enhance command team training and tactical development [20-21]. During the development cycle, the potential benefits of distributed simulation were recognised and the scope of work expanded to link RAN simulators around Australia through a Wide Area Network (WAN). Synergies with the US Navy (USN) Battleforce Tactical Training (BFTT) Program that aims to install DIS training and stimulation in their surface combatant vessels were identified. A study is underway through Project JOANNE to identify how a similar capability can be achieved in the RAN Fleet.

SEA 1412 has progressed in parallel with research and development by DSTO, Army, RAAF and, under international program arrangements, the US Navy and Air Force into synthetic environments. Striving for interoperability between systems has resulted in significant changes to the scope of development and the scale of the required capabilities. There have also been significant gains through sharing of development and the reuse of components.

The addition of a WAN capability at HMAS Watson and the signing of a Project Arrangement between the US Navy (PMS 430) and DSTO/RAN have facilitated a series of training exercises that are intended to enhance warfighting readiness through the development of a combined coalition team training and mission rehearsal capability [14]. Brief descriptions of the distributed training demonstrations and exercises are at Section 4.

As an extension of the SEA 1412 and work between the RAN and USN, a study has been carried out by DSTO and RAN, in conjunction with industry and academia, to investigate the concept of a Distributed Simulation, Maritime Warfare Training System (MWTS). The MWTS will comprise both shore-based training facilities and On Board Training Systems (OBTS) embedded in RAN combatant platforms, suitable debriefing and analytical tools and a communications infrastructure to provide the bandwidth required and nodal connections. The objective of the MWTS is to provide a WAN capability to simulate a realistic threat of any type, size and capability, anywhere in the

(virtual) world independent of the ship or shore facility real world locations. Such a capability would offer enterprise-wide facilities for training from basic operators through to task group command teams [22].

2.2 The DSTO Project JOANNE

DSTO's Air Operations Division has initiated development of the Joint Air Navy Networking Environment (JOANNE) Project [2,3,12-15]. JOANNE will develop a prototype synthetic environment for ADF training through the connection of existing simulation assets, and will also spawn a R&D testbed for distributed simulation research. JOANNE is a bridging mechanism for projects such as SEA 1412 and the VAE, and seeks to facilitate collaboration with the US Navy's BFTT Program and the US Air Force (USAF) Distributed Mission Training (DMT) Program. USAF DMT is designed to enhance Expeditionary Air Forces readiness by linking tactical aircraft simulators with AWACS and major C4I simulation nodes.

DSTO views JOANNE as demonstrating prototype functionality and standards for an ADF joint synthetic environment for training. Research and development, product evaluation and testing of tools for distributed simulation systems will take place on the JOANNE testbed in the DSTO Advanced Distributed Simulation Laboratory (ADSL) at Fishermans Bend in Victoria. Where practical, future ADF simulation systems should comply with the appropriate JOANNE standards to ensure the maximum probability of interoperability and scalability [23].

2.3 The DSTO Aerospace BattleLab Capability

The DSTO Aerospace BattleLab Capability (ABC) will be developed at Fishermans Bend as an integration facility that brings together a range of evolving simulation capabilities. Components with varying levels of fidelity, function and resolution will be co-located and technologies applied to allow reuse of systems and software developed separately for training, operational analysis, operations research, and visualisation. Systems outside the ABC will be integrated remotely as required. The ABC will provide an environment in which many current systems can be migrated towards common standards for connectivity, capability modelling and representation, data sharing, and post activity assessment and analysis. Initial installation will comprise VAE ITC, JOANNE, Virtual Air Commanders, SEA 1412, virtual aircraft (AEW&C, F111, Hornet), Intelligent Agent, and other components.

2.4 The DSTO Virtual Air Commander Task

Virtual Air Commanders is a cooperative arrangement with the USAF for the development of future concepts in C4I. Work centres on cognition and perception, and the development of methods and technologies that optimise warfighter effectiveness in complex, information rich environments.

3. The RAAF VAE

The planned introduction of new air defence and air traffic sensors, communications and processing systems, Jindalee Operational Radar Network (JORN), and Airborne Early Warning and Control (AEW&C) aircraft pointed to significant expansion of the RAAF SCG operations and personnel base. This expansion could not be supported by reliance on live exercises and operations, nor were the existing outdated simulators in SCG useful for meeting the challenge.

In 1998 the need for study into advanced simulation tools to support initial and advanced training within SCG was recognised by the RAAF and led to the establishment of the RAAF VAE Project. The project initially had three main goals:

- Define the need for a future project to develop a comprehensive simulation environment to support RAAF training, planning and experimentation;
- Investigate the specific needs of SCG for integrated simulation to support training and operational development; and
- Identify options to replace ageing air defence simulators in RAAF SCG units with an Interim Training Capability to bridge training needs until delivery of new simulators under Defence Major Project Air 5333 *Vigilare*.

The objectives were met for the initial phase of study and a second phase was funded to extend knowledge and move to the development of recommendations for RAAF simulation development, and to procure the Interim Training Capability (ITC) for SCG. Several key studies, activities and demonstrations now form the basis of recommendations to be made to the RAAF in mid-2003 including:

- **Technology Demonstrations**. Four VAE demonstrations, discussed at Section 4, allowed the collection of data on distributed network performance, training effectiveness, interoperation between Land, Sea, and Air synthetic environments, and the potential for a future ADF Joint Synthetic Environment;
- **Training Needs Analysis (TNA)**. RAAF Training Command completed an initial TNA that highlighted the need for additional studies for aircrew (particularly fighter aircrew), and a separate detailed study for air defence personnel. Contracts for these studies were let and three reports were written to support future planning for the VAE;
- **Operational Concept Document**. Following on from research conducted by DSTO, Boeing Australia was contracted to compile an integrated view of how the ADGE would be structured after the integration of new systems under Air 5333. The resultant Operational Concept Document (OCD) [1] identifies relevant C4I nodes and functions that are crucial to the operation of the ADGE as a component of the ADF Air Defence System (AADS). The OCD provides a partial template for design of an integrated simulation network to replicate real-world functions in the synthetic battlespace. In conjunction with SCG, a

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prioritised list of simulation functions, from those listed in the OCD, is under development to guide continuing evolution of VAE capabilities; and

- **ITC Design, Development and Installation.** A Request for Proposals (RFP) for the ITC was sent to Industry seeking cost and schedule information. However, flaws in the specification of requirement sent to Industry by the Commonwealth, combined with major changes to real-world operational tempo in SCG, meant that neither the functionality nor the schedule specified in the RFP have met operational and training needs. Redevelopment and issue of a new RFP to industry was considered unlikely to produce results within required timescales. A decision to allow DSTO to develop and field an "in-house" ITC solution was made by the RAAF in late January 2002 and the first system was installed in October 2002 at the SCG Surveillance and Control Training Unit (SACTU).

4. Advanced Distributed Simulation Concept Demonstrations in Australia So Far

Technology demonstrations over the last four years have highlighted the value of simulation, and contributed to the delivery of simulation products to the ADF. The demonstrations/exercises are outlined below.

4.1 VAE Demonstration One

Demonstration One [8,9,16] linked a piloted dome simulator and desktop scenario generators in AOD Laboratories in Melbourne to the 3CRU (Duckhole Hill) site at RAAF Williamtown using commercial ISDN lines. Fighter control was provided by 3CRU, and preliminary gateway technologies converted simulation entity state data messages into pseudo-radar data to stimulate operational C4I display and processing systems.

4.2 VAE Demonstration Two

Demonstration Two [8,9,17] saw the first use of artificial agents to represent enemy forces. Artificial agents, piloted simulators, and desktop scenario generators shared the same synthetic space and interacted with each other to produce realistic tactical training and show the reduced level of supervision and "driving" that might accrue to agent technologies. Significant data on network performance and limitations over wide areas was collected and analysed.
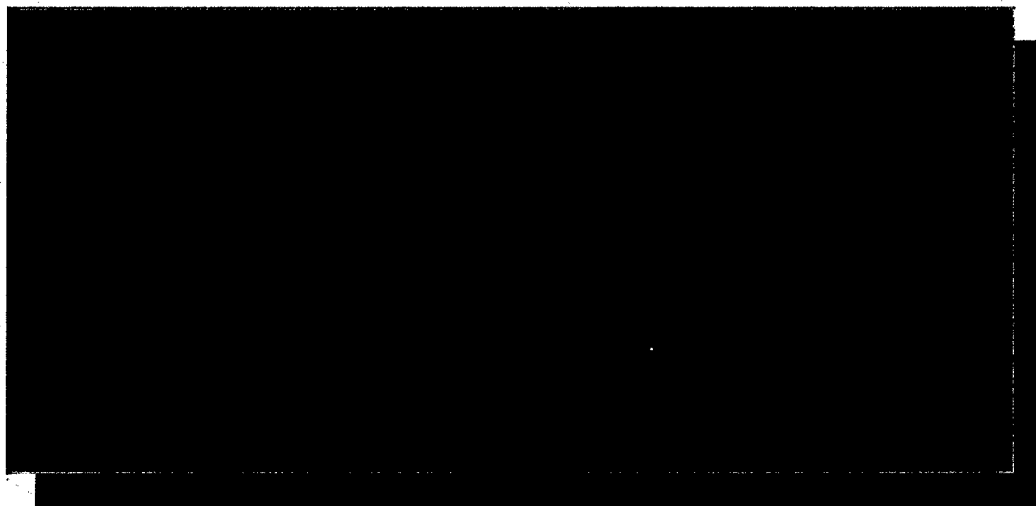
Figure 1. A Scene From VAE Demonstration One

4.3 VAE Demonstration Three

Demonstration Three extended scenario sharing to 2CRU at RAAF Darwin, NT and the JORN Coordination Centre (JCC) at RAAF Edinburgh, SA. 2CRU systems were stimulated using gateway data to generate a microwave radar picture while the JCC was stimulated using an OTHR gateway (developed under VAE) to build an OTHR picture. The two pictures were merged in the 2CRU Regional Coordination Centre and transmitted to Air Command at RAAF Glenbrook, NSW, as the Recognised Air Picture (RAP). Simulated data was co-processed and presented alongside the real-world RAP.

4.4 VAE Demonstration Four

Demonstration Four was conducted in conjunction with Army and DSTO's Land Operations Division (LOD) under Exercise Prowling Pegasus and highlighted the future of joint synthetic operations at all levels from the tactical through to National control. Preliminary VAE infrastructure elements were combined in a shared battlespace with Army Synthetic Environment components. A Regimental HQ, staffed by Army and RAAF personnel managed warfighting over a period of several days to conduct airspace management, ground warfare, close air support, air transportation, surface to air engagement, fire support and helicopter operations. In this demonstration, human-in-the-loop (HiL) simulators (F/A-18 Dome and the F/A-18 Low-cost Demonstrator Cockpit at AOD Melbourne, and two multi-crew helicopter simulators at LOD Edinburgh) shared the simulation space with a range of other synthetic aircraft (including C-130), armoured vehicles and ground forces.

4.5 The I/ITSEC 2001 US Navy / Australian Navy Coalition Training Exercise

The main objective of the RAN/USN Coalition Readiness Management System Preliminary Interoperability Experiment (CReaMS PIE) is to enhance warfighting readiness through the development of a coalition team training and combined mission rehearsal capability [12-14,24]. The first such distributed training exercise was carried out by linking RAN operational team training simulators at HMAS Watson with USN training simulators located at Dam Neck, Virginia and the I/ITSEC 2001 Conference floor at Orlando, Florida. The Royal Netherlands Navy also participated with simulators at the TNO in the Netherlands. DSTO provided technical assistance and analysis of the data recorded from this (unclassified) coalition training exercise.

Connectivity between these locations was established using commercial ISDN WAN service providers (eg Telstra in Australia). DIS Entity and DIS radio communication interoperability were achieved. A video conferencing capability was provided to assist set up and the After Action Review process. Learning methodology research was also carried out during these exercises [15].

4.6 The SimTecT2002 Synthetic Environment Demonstration

The SimTecT 2002 (Melbourne, Australia) Joint / Coalition Synthetic Battlespace Demonstration brought together simulators/simulations from the Australian Army, Navy and Air Force. A USN simulation system (Battle Force Tactical Training Operator Processor Console – BOPC) also participated. Simulators running both DIS and HLA scenario and entity management software interoperated during the exercise using gateway technologies. Defence and Industry resources combined to showcase this demonstration. Current and future operational capabilities including the new Australian Armed Reconnaissance Helicopter, Global Hawk UAV, and *Wedgetail* AEW&C aircraft were represented to highlight the training, research and acquisition support potential of such synthetic environments.

4.7 The February, 2003 US Navy / Australian Navy Coalition Training Exercise

A second USN / RAN CReaMS exercise (in February, 2003) continues the development of coalition team training and mission rehearsal. This classified exercise, using certified secure WAN technologies and data encryption, paves the way for a future Coalition mission rehearsal capability. The security and encryption infrastructure and procedures developed for this exercise (the I/ITSEC 2001 exercise was unclassified) will provide a template for future ADF and coalition connectivity and become part of the JOANNE standardised environment.

A TADIL (eg Link 11/Link 16) capability (eg network centric warfare) were also implemented in this exercise - a pivotal technology for all future ADF distributed simulation.

The February 2003 RAN/USN training exercise is an important milestone for the ADF. On completion of this exercise, coupled with all the other demonstrations and exercises already carried out in Australia, most/many of the relevant distributed simulation technologies required during a typical classified, joint/coalition, WAN training exercise will have been researched, evaluated and/or installed.

Because the USN/RAN simulators (BFTT/FFG Upgrade) used (or to be used) in these exercises will be the same as the real on-board training systems, for coalition Navy training, the laboratory to laboratory and shore trainer to shore trainer exercises could now start the shift to one of the main objectives of the CReaMS project - ship to ship training for coalition mission rehearsal on operational platforms – train as we (and where we) fight. This will require that an additional set of WAN communication issues be researched.

5. The DSTO Advanced Distributed Simulation Laboratory

DSTO's Advanced Distributed Simulation Laboratory (ADSL) was set up to explore the use of Commercial-Off-The-Shelf (COTS) technologies to support ADF simulation and has, for the most part, been funded by the RAAF VAE Project.

The approach currently used by most ADF simulation projects has resulted in one-off, highly specialised, monolithic, large software applications. These large software projects are high risk and usually end up being delivered over time, over budget and not providing the full functionality tendered for. In addition these large one-off projects are expensive to maintain.

The ADSL promotes the use of modular, cost-effective, COTS ADS applications. However it is most unlikely that an operational simulator can be completely created from available COTS applications and *customised thin-client* applications have been developed where no commercial equivalents exist. Because the in-house development focus is on these customised thin-client applications, which when compared to the COTS applications used only require a relatively small amount of code to be developed, a simulator application can be delivered quickly and reliably when compared to highly specialised, monolithic, large one-off software ADF simulation applications mentioned above.

Integrating COTS products using thin-client applications allows large-scale simulation systems to be developed with relatively low risk and cost. A low-cost and cost-effective hardware and software development environment based on COTS (corner store) PC

hardware, Microsoft Windows (2000 and XP) operating systems and Visual Studio.NET compilers is mandated in the ADSL for the development of software.

This philosophy of integrating well-developed COTS applications with in-house developed, customised thin-client applications, that have no commercial equivalent, into a cost-effective and low-cost environment should reduce considerably the purchase, development and maintenance costs of a simulator and increase the probability that project functionality is delivered on time, on budget and according to specifications. This approach is a risk reduction strategy.

6. The Interim Training Capability

As discussed in section 3, one of the required outcomes of the VAE is the delivery of operational mission simulators for RAAF SCG units at various locations in Australia. The background to the decision to provide an "in-house" solution to the ITC was discussed at section 3. Candidate COTS components and applications in use or under evaluation in the ADSL were assessed for their usefulness in meeting the RAAF's functionality and timescale requirements.

Core components from MäK Technologies in the US, *VR-Forces* and *VR-Link*, were selected as having the architecture required to support development of an ITC application suite. VR Forces heritage in land operations required adaptation and modification of the core application to provide capabilities needed for air operations. MäK Technologies provided strong technical support and help in evolving their product and giving advice on interfacing VAE's unique control and management applications to their architecture.

Development of the ITC began in March 2002 using VR-Forces and VR-Link with customised thin-client applications on ADSL mandated hardware and software development infrastructure. The ITC software and hardware (collectively called ADGESIM – Air Defence Ground Environment Simulator) were delivered and installed at RAAF Williamtown and became operational in October 2002. This six to seven month development cycle time compares more than favourably with industry estimates of between three and five years in the original Request For Proposals (RFP) responses.

The Air Defence Ground Environment Simulator is comprised of three customised thin-client applications developed in the DSTO ADSL interoperating with five (Solipsys back and front ends, VR-Forces back and front ends and VR-Link toolkit) COTS products. The thin client applications are the ADGESIM Pilot Interface, the ADGESIM Airline Scheduler, and the ADGESIM Orthographic Network Input/Output Node (ONION) Application.

6.1 The ADGESIM Pilot Driver Interface

The Pilot Interface Application allows simulator operators to create and fly multiple simulated aircraft entities generated in the VR-Forces [25] back-end. Functionality provides for situation awareness and has features that allow the operator to respond in a way that approximates the behaviour of real-world pilots and formations of aircraft.

Aircraft position, performance and system information is presented in a custom Graphical User Interface (GUI) and derived from information broadcast by VR-Forces. Each Pilot Interface can control up to twelve such VR-Forces back-end entities at any one time (although entities can be released and captured for control as required) and works by calling VR-Forces back-end functions over the network to control entity and environmental behaviour. Several custom VR-Forces controllers were developed as part of the Pilot Interface client application to achieve more realistic aircraft control.

The Pilot Driver Interface code is extensible and can be modified quickly to increase or change functionality. Multiple Pilot Interfaces can concurrently communicate (using UDP port numbers) with a single VR-Forces back-end. Minor modifications will allow a Pilot Driver Interface to communicate with one of several VR-Forces back-ends on the network to make the ADGESIM architecture highly scalable.

Pilot Interfaces communicate with each other, as well as with the VR-Forces back-end, to provide electronic warfare indicators such as radar "spikes", radar mode changes, and weapon launch indications and, in later versions, pseudo-data link for cooperative engagement of targets. Through VR-Forces the Pilot Interface controls IFF (Interrogate Friend or Foe) Modes 1, 2, 3/A, 4 (both original and coded), and Mode S for all entities and manages weapons employment. The interface allows aircraft to be grouped and flown as formations, and also provides automated manoeuvres such as heading snaps, postholes, navigate to a point, and follow or patrol a route that reduces operator workload.

Although not absolutely necessary, because the ADGESIM Pilot Driver Interface application has been designed to work with several windows open at the same time, the application is most effectively run on a high-end personal computer with a modern dual channel video card such as a nVidia GeForce4 Ti series video card with the nVidia nView multi-display technology enabled. The multiple window ADGESIM Pilot Driver Interface is shown in Figure 2.

Operator response to the interface has been very positive with confidence and proficiency in use of all functionality in around two hours of supervised use. The ADGESIM Pilot Driver Interface in use at RAAF Williamtown is shown in Figure 3. A detailed screen shot of the main ADGESIM Pilot Driver Interface window is shown in Figure 4.
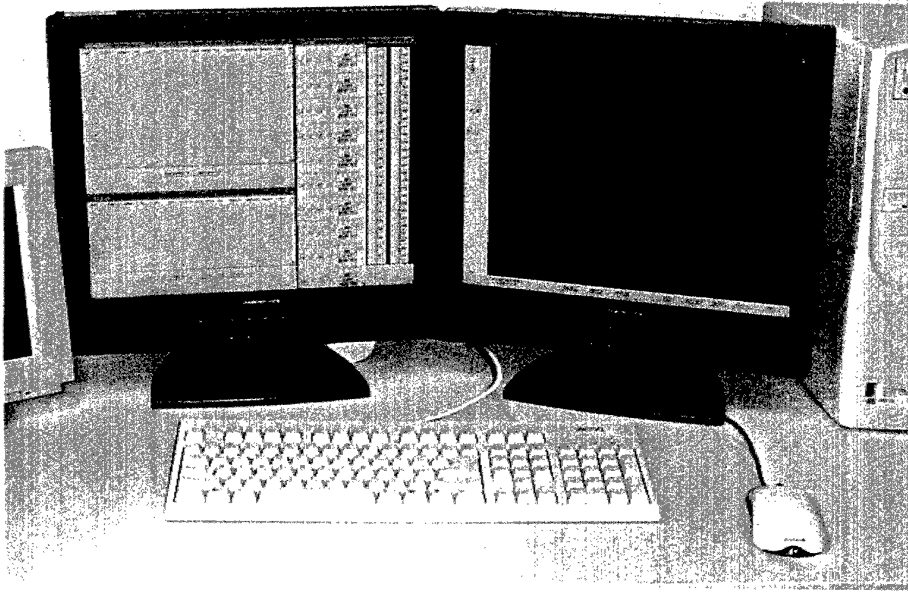
Figure 2. The ADGESIM Multiple Window Pilot Interface
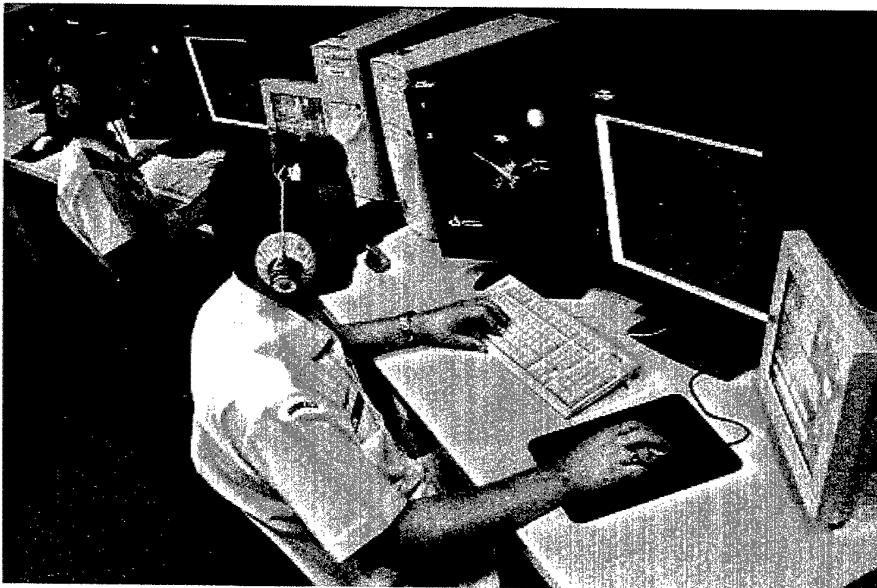
Figure 3. The ADGESIM Pilot Interface in Use

Figure 4. A Typical ADGESIM Pilot Interface Screen Shot

6.2 The ADGESIM Airline Scheduler Thin-Client Application

ADGESIM is required to provide both air control, and wide area surveillance training for the SCG. Air control operations require high resolution and high fidelity that is computationally intense, and subsequently expensive on a large scale. For a reliable depiction of large volumes of air traffic over wide areas, a lesser level of fidelity and resolution is acceptable.

The ADGESIM Airline Scheduler (shown in Figure 5) provides a way to populate the synthetic environment with large numbers of "background" entities that are not dynamically controllable by ADGESIM Pilot Drivers or VR-Forces itself, and which conform to predetermined behaviours such as airline schedules or simple scripts. Whereas the ADGESIM Pilot Driver Interface Application communicates with the MÄK Technologies VR-Forces back-end, which then produces IEEE standard DIS Protocol Data Units (PDUs), the Scheduler application makes use of a MÄK Technologies COTS library of DIS functions, called the *VR Link* Toolkit [25], to generate Entity State and IFF PDUs.

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The Airline Scheduler is a stand-alone DIS application whereas the ADGESIM Pilot Driver Interface Application cannot function without a VR-Forces server back-end. As the VR-Link Toolkit provides no performance or physical attribute modelling of entities, the Scheduler performs calculations required to direct entity takeoff/start, navigation, height changes etc. Multiple scripts can be run simultaneously and many entities may be airborne in the Scheduler at any one time, at any location on the planet. The Scheduler is being updated to manage surface and space traffic. This will be important for wide area surveillance training where simulated space and OTHR sensors are required. Testing has shown that with around one thousand entities airborne simultaneously the processor load on a 2GHz Pentium 4 PC remained steady at about two percent, indicating scalability well beyond ten thousand simultaneous entities.

Data on air routes, waypoints and airfields are held in configuration files compiled from standard aviation publications. Aircraft attributes, DIS enumerations, and flight schedules are also kept in configuration files. SCG will gradually add the entire schedules for QANTAS and other Australian airlines [26] into the application for domestic use and, over time, schedule libraries will be created for other world airlines and various "interesting" surveillance scenarios.
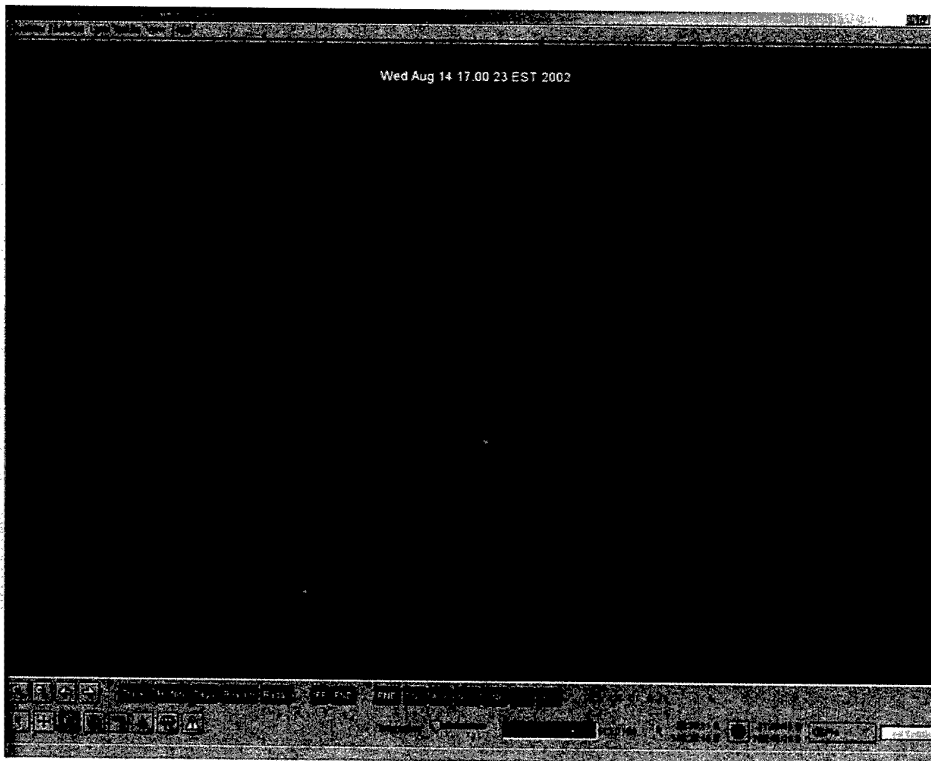

Figure 5. ADGESIM Airline Scheduler Entities Displayed in the Solipsys TDF

6.3 The ADGESIM Sensor ONION Thin-Client Application

A Sensor ONION (Orthographic Network Input / Output Node) acts as a gateway between the *ADGESIM* synthetic environment and operational systems. DIS provides a network environment within which participants share information using protocols and message formats that are generally not used by operational systems. DIS also provides a 'perfect' picture of scenario activity. In the real world, operational systems are constrained by sensor capabilities and the performance of other systems to which they are connected and do not have a 'perfect' view. ONIONs are software applications that emulate (ie simulate) the performance of real world sensors and systems. ONIONs listen to the DIS environment, apply a sensor detection model to determine whether a simulated event should be detected, and then format messages about that event that resemble the output streams of real-world sensors. These streams of simulated sensor data are received and processed by operational systems in the same way as 'live' sensor data, with the exception that simulated sensor data will usually have an indicator flag of some kind that identifies it as synthetic. The ADGESIM Sensor ONIONS also filter out any inappropriate DIS entity information eg dismounted infantry.

A number of sensor ONIONs, with differing performance attributes, can be run simultaneously to replicate a multi-radar or multi-sensor operational environment to stimulate operational systems. Generic sensor ONIONs have been produced for 2D and 3D radars. Rotation rates, detection probabilities, clutter performance, IFF range, primary range, and various other attributes are maintained in XML-based configuration files on a sensor-type-by-type basis. Each instance of a sensor type can also have magnetic variation, location, altitude and identity label assigned.

An ONION GUI, shown in Figure 6, has been developed for run-time management of sensor operations. Sensor performance and attributes can be managed in real-time to enable and disable functions such as primary and secondary radar operation, clutter profile and detection probability. Future development will manage EW operations. Current radar data output is Westinghouse TPS-43 Digital Target Extractor (DTE) format. However, the modular nature of the application allows for additional data output formats to be added simply.

ONIONs for ESM, OTHR, AEW&C, ship-based radar, and space-based sensors (Infrared and Elint) are planned in the near term. Performance of the application is very good with ten simultaneous sensor instances on a single 2GHz Pentium 4 PC producing an approximate processor load of thirty percent with three hundred radar targets (many being detected by several sensors simultaneously). Performance may be impacted in the future as more complex detection and electronic warfare functions are added. Figure 7 shows the functional relationship of the ADGESIM thin-client applications to the MäK Technology components and the operational ADGE Solipsys C4I display and processing network.

Sensor Management Interface

File   Sensor

- Mil ATC 2D ADATS (DTE)
  - Radar 101 - RAFF Williamtown ATC
  - Radar 109 - RAFF Darwin ATC
- Civil ATC terminal RASSP (DTE)
  - Radar 102 - Sydney Airport
- Civil ATC enroute RASSP (DTE)
  - Radar 103 - Mount Boyce
  - Radar 104 - Round Mountain
- Mil ATC 2D Alenia (DTE)
  - Radar 105 - Tindal
- Air Defence 3D TPS43 (DTE)
  - Radar 106 - Williamtown
  - Radar 107 - Lee Point
  - Radar 108 - Mobile Unit
- Generic
  - Radar 1 - live

Radar 108 - Mobile Unit   Rename

Radar Position

Latitude 12 20 60.0 S
Longitude 130 52 60.0 E
Altitude 0   (feet)
Magnetic Variation 0.0   (degrees)

Radar Modes ON/OFF

☑ Primary
☑ IFF Master
☑ Mode 1 IFF

Program output

c:\winnt\system32;c:\winnt;.
c:\Sensor\
c:\Sensor\gateway.exe
<?xml version="1.0"?>
<Sensor name="Radar 108 - Mobile Unit" type="TPS43">
    <ParamLat name="latitude" val="-12:21:0.0"/>
    <ParamLon name="longitude" val="130:53:0.0"/>
    <ParamUint32 name="altitude" val="0"/>
    <ParamFloat64 name="magVar" val="0.0"/>
    <ParamBool name="primaryOn" val="true"/>
    <ParamBool name="iffMasterOn" val="true"/>
    <ParamBool name="iffMode1on" val="true"/>
    <ParamBool name="iffMode2on" val="true"/>
    <ParamBool name="iffMode3Aon" val="true"/>
    <ParamBool name="iffMode4on" val="false"/>
    <ParamBool name="iffMode5Con" val="true"/>
    <ParamBool name="noiseOn" val="true"/>
    <ParamUint32 name="noiseBand1Amount" val="15"/>
    <ParamFloat64 name="noiseBand1MinRange" val="0.01"/>
    <ParamFloat64 name="noiseBand1MaxRange" val="0.25"/>
    <ParamUint32 name="noiseBand2Amount" val="15"/>

Stop
Apply
Revert to Instance
Revert to saved

start   sensorGUI   Sensor Management ...   EN   2:28 PM

Figure 6. Sensor ONION GUI Showing Available Sensor Types

Driver Workstations

VR Forces Engine
Models synthetic vehicles, weapons and environment in real-time. Controls broadcast of entity state data as DIS messages. Maintains points, routes etc.

Provides a front-end to the VR Forces Engine and allows control of VR Forces entities.

DIS Network

Creates bulk aircraft traffic from airline schedules etc. and broadcasts them on the DIS Network

ONIONS watch the DIS Network, "detect" entity activity, and produce data messages that look like real-world sensors.

AADSLINK Tracks

TPR1000 Tracks

ASTERIX Tracks

ASTERIX Tracks

Sim SIS Box

DTE Plots

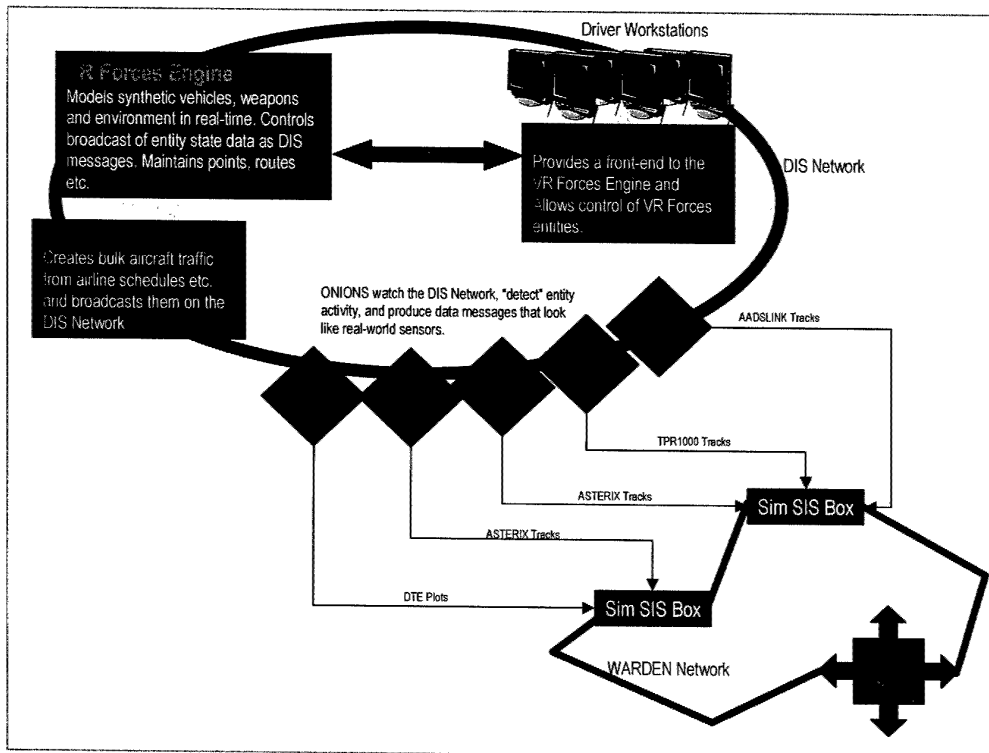Sim SIS Box

WARDEN Network

Figure 7. Functional Relationship of ADGESIM Components

6.4 The Solipsys, COTS, Back-End, Multisource, Correlator and Tracker Application

The Solipsys [27] Multisource, Correlator, Tracker (MSCT), back-end, server, application processes radar plot, contact and track data from multiple sources to produce a composite track database for display and dissemination. The Solipsys MSCT application allows data from dissimilar, real and non-real-time, local and remote, sources to be collected, correlated and fused into a single, integrated picture, at both the radar contact, track and plot level, for display and dissemination.

The MSCT accepts data from various (industry standard) sources including :

- COTS radar systems ;
- Link 11/16 Tactical data links (TADIL); and
- DIS and HLA simulation systems.

ADGESIM compliance with the OCD System Interface requirements is achieved through the Solipsys MSCT. The Solipsys MSCT application supports direct connection to all US Federal Aviation Administration Air Route Surveillance Radar (ARSR) systems and US military radars.

The Solipsys MSCT application is a modern architecture, distributed, networked enabled, application. The MSCT can run on either COTS (corner store) PC hardware or Sun SPARC processor-based computers. The MSCT can reside on one computer and communicate its correlated and fused data, single integrated picture to a variety of (client) applications that can reside on other computers on the network.

6.5 The Solipsys, COTS, Front-End Tactical Display Framework (TDF) Application

Multiple front-ends are available to display / manipulate this correlated / fused information generated by the MSCT back-end server. The Solipsys Tactical Display Framework (TDF) is the Graphical User Interface application used to present information obtained from the MSCT to RAAF Air Defence Controllers. The Solipsys Tactical Display Framework in use at RAAF Williamtown is shown in Figure 8.

The TDF application is highly configurable and the look and feel of the application can be radically modified through the choice of application and configuration preferences.

Many industry standard image/map formats are supported. A track scenario record and playback capability, which can be used during an After Action Review, is included and a plug-in capability is available to allow additional functionality to be added by users at any time.

To support portability the TDF has been written in Java and can run on many computing platforms including COTS (corner store) PC hardware and software (ie Microsoft Windows). The TDF is multi-threaded and appears to be a responsive application on a single processor computer.
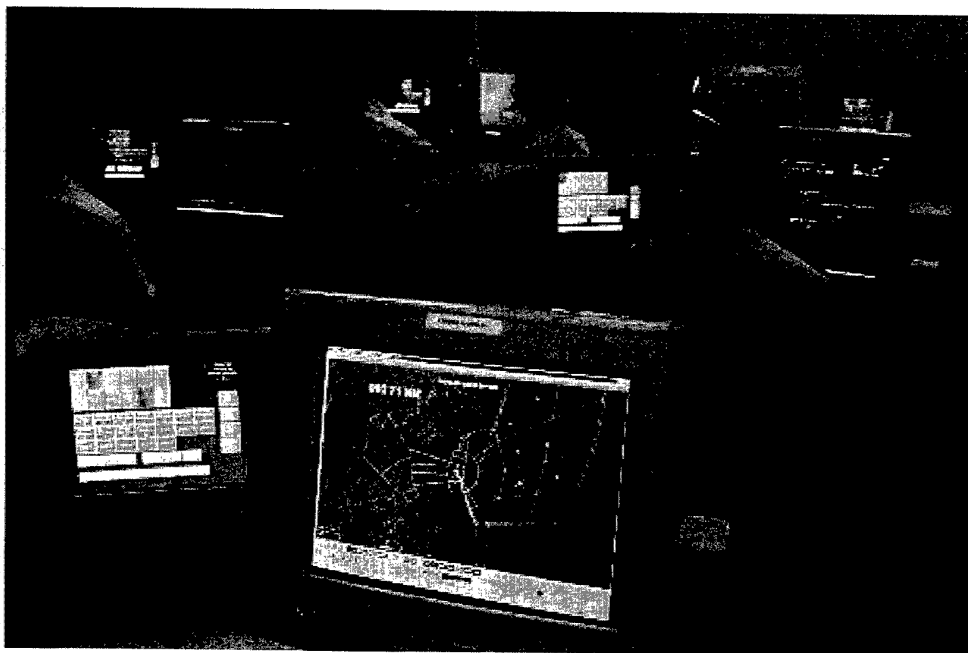

Figure 8. The Solipsys Tactical Display Framework in Use

6.6 The MÄK Technologies, COTS, Back-End, VR-Forces Application

VR-Forces is a COTS simulation application developed and marketed by MÄK Technologies in the United States. VR-Forces is a Computer Generated Forces (CGF) simulation software tool for generating and executing battlefield scenarios.

VR-Forces has a client-server architecture. A VR-Forces GUI front-end (discussed below) is used for set-up and control. The VR-Forces back-end server is a simulation engine used to simulate the properties of fixed and rotary wing aircraft, ground vehicles, surface and subsurface naval craft, weapons, and humans in the ADGESIM synthetic battlespace. Models created by the VR-Forces simulation engine approximate the performance, shape, visual attributes, and electronic properties of entities required in a simulation. This engine also provides mechanisms by which entities are aware of each other and of the terrain in which they are operating. Such detail as the change in speed and acceleration performance for a vehicle on paved, dirt and mud surfaces, and the articulation of control surfaces on aircraft wings and the turrets of armoured

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vehicles can also be modelled. Such complex calculations require significant, dedicated computational support to maintain the timeliness of simulation and to cater for large numbers of entities in the simulation environment. Therefore in ADGESIM, VR Forces is hosted on a dedicated server where it communicates with other networked ADGESIM components and external DIS compliant simulators.

The VR-Forces back-end functions as a programmable CGF toolkit. It has an Application Programmers Interface (API) that has been designed to be controlled over the network from a customised user interface. The ADGESIM Pilot Driver Interface application uses the VR-Forces back-end (through its remote control API) as its simulation engine. Currently communication between ADGESIM Pilot Driver Interface applications and the VR-Forces back-end occurs via a customised UDP messaging mechanism. This will be modified to use the DIS Set Data PDU. Using this Simulation Management PDU mechanism to communicate between Pilot Driver Interface applications and VR-Forces back-ends will allow the use of (COTS) DIS Data Loggers (and DIS After Action Review tools) to record and playback scenarios in the ADGESIM. Therefore using such a DIS Data Logger to replay all recorded DIS PDUs will enable all ADGESIM Pilot Driver Interface to ADGESIM Pilot Driver Interface interactions (eg spiking) and all ADGESIM Pilot Driver Interface to VR-Forces back-end interactions to be reproduced.

As per the Solipsys applications, the VR-Forces components are modern architecture, distributed, networked enabled, applications. VR-Forces components can run on either COTS (corner store) PC hardware or Sun/SGI workstations.
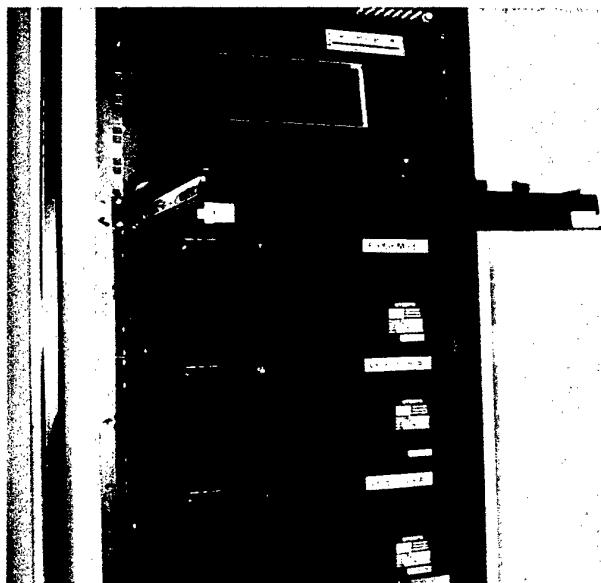

Figure 9. The ADGESIM VR-Forces Server with Shared Keyboard, Mouse and Display

6.7 The MÄK Technologies VR-Forces Front-End COTS Application

A front-end client GUI application is provided by MÄK Technologies for starting and managing VR-Forces simulation sessions and for interacting with entities and the synthetic environment inside the VR-Forces battlespace.

Originally it was intended that the VR-Forces front-end client GUI application would be used as the Pilot Driver Interface. However limited functionality in the VR-Forces GUI front-end required the development of a customised thin-client application (the ADGESIM Pilot Driver Interface) for use by SCG personnel for management of air defence training operations.

6.8 The MÄK Technologies VR-Link COTS Toolkit

The MÄK VR-Link Toolkit is an object-oriented library of C++ functions and definitions that minimise the effort required to create networked simulators and virtual reality applications [11]. VR-Link's protocol-independent API enables the user to simulate local entities, set their state and automatically send entity information to other network applications either through DIS PDUs or HLA's Runtime Infrastructure (RTI). VR-Link simplifies the receiving and processing of information from other applications handling dead reckoning, thresholding, responding to attribute requests, filtering, and other tasks.

Because VR-Link supports both DIS and HLA through the same API, applications can be switched between the two by changing just a few lines of initialisation code and recompiling [11] the application. Thus VR-Link based applications can maintain DIS compliance vital to ongoing projects, while migrating to HLA in the longer term.

VR-Link's default functionality can also be extended to work with user-defined DIS PDUs and new HLA objects or interactions. VR-Link is the simulation industry de-facto standard simulation protocol toolkit and has been used successfully in the ADSL for many years.

6.9 Summary of the Air Defence Ground Environment Simulator

The block diagram architecture of the Air Defence Ground Environment Simulator (with some of the proposed future enhancements discussed in section 7) is shown in Figure 10.

ADGESIM has been designed to provide Air Defence Controller training on operational equipment using simulation (and stimulation). The Air Defence Controller undergoing training will normally not be able to differentiate between real live entities and ADGESIM simulated entities. It should be noted that Air Defence Controllers are not trained on live systems but on an alternate, fully functioning training system.
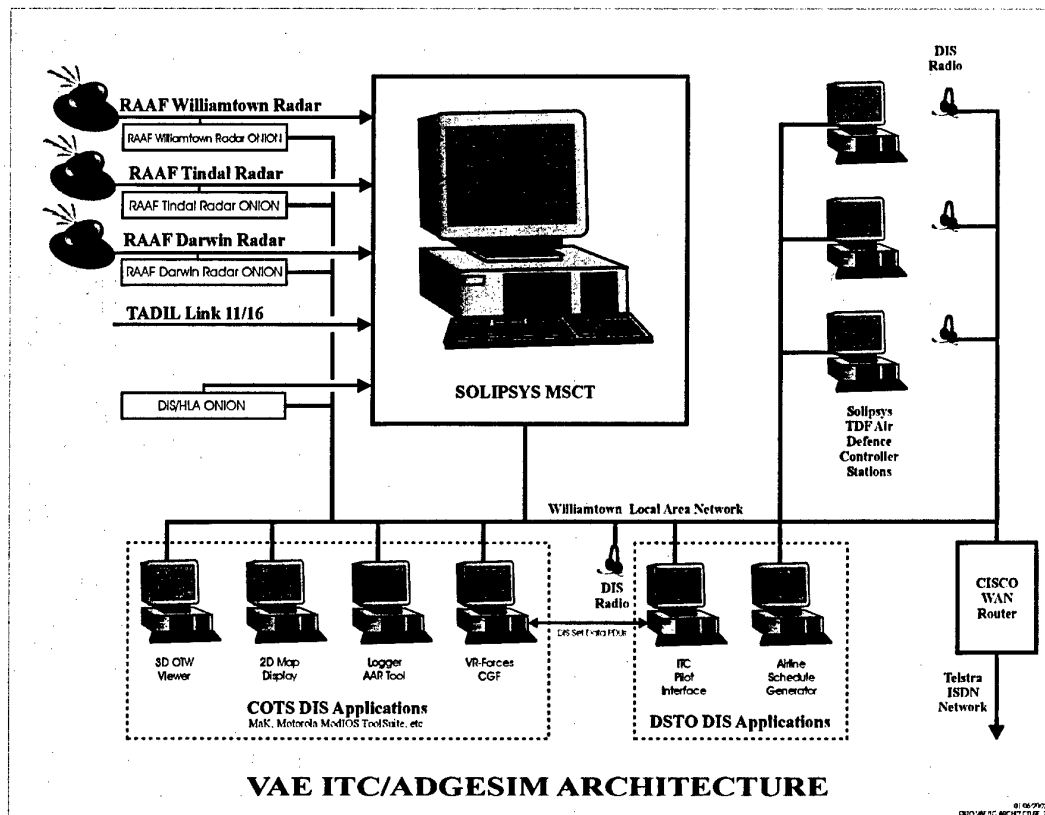
Figure 10. The VAE ITC/ADGESIM Architecture

The Solipsys Multisource, Correlator and Tracker (MSCT) and Tactical Display Framework (TDF) applications are used by Air Defence Controllers at RAAF Williamtown. The ADSL has access to the full functioning Solipsys TDF application but has a subset MSCT known as MSCT Lite. The MSCT Lite is sufficient for ADGESIM development so far, but is deficient in several critical areas.

In operation the Air Defence Controller trainee sits at the Solipsys TDF console on the alternate, fully functioning, training system.

The ADGESIM Pilots sit in front of the ADGESIM Pilot Interfaces that can control up to 12 simulated aircraft entities. Currently ADGESIM Pilots provide both the simulated blue force aircraft controlled by the Air Defence Controller trainee and the opposing red force aircraft. In future, opposing red force entities may be controlled by Artificial Intelligence computer controlled software agents.

At the start of a training session the instructor would instruct the opposing red force ADGESIM Pilot to create simulated aircraft entities which would either come into or be

in range of a relevant radar sensor. The Air Defence Controller trainee communicates with a blue force ADGESIM Pilot. The training exercise would then begin.

The ADGESIM Pilot Interface does not model any aircraft entities – it communicates with the MÄK Technologies back-end VR-Forces server that models all Pilot Interface controlled entities.

In the current ADGESIM configuration all Pilot Interfaces communicate with a single back-end VR-Forces server application. The VR-Forces server application injects DIS PDU packets onto the ADGESIM Local Area Network. These DIS PDUs describe the behaviour of the simulated entities to any IEEE DIS compliant, distributed simulation application listening on the network.

The Sensor ONION application is such an IEEE DIS compliant application. Sensor ONIONs detect DIS PDU information on the local area network and apply their radar detection and aberration models to determine whether and how a simulated event should be detected. The ONION then formats an appropriate message, which looks like the output stream of a real-world sensor, that is sent to the Solipsys MSCT. The ADGESIM Sensor ONIONS also filter out any inappropriate DIS entity information (eg. dismounted infantry PDU data) that could otherwise saturate either the MSCT or the TDF processor. One sensor ONION application per radar sensor system is used.

The MSCT then presents the correlated and fused data to the trainee Air Defence Controller through the TDF application. Unless specifically shown how, the trainee Air Defence Controller cannot differentiate between data created from real-world radar sensors or data originating from the ADGESIM Pilot Interface.

The trainee Air Defence Controller can then communicate with the ADGESIM Pilot as if the ADGESIM pilot was a real F/A-18 pilot, directing the simulated blue force aircraft to interact with the simulated opposing red force aircraft as required.

Because ADGESIM uses IEEE complaint DIS PDUs other COTS applications such as Data Loggers, 2D Map Displays, 3D OTW Stealth viewers, DIS Radio Communication systems, etc. can also interoperate on the network at the same time. Some of these COTS DIS applications are discussed in detail in section 7.

7. Future ADGESIM Enhancements

ADGESIM can be further enhanced as described in the following sections.

7.1 A DIS Data Logger

A DIS data logger is a tool used to record and playback DIS PDU simulation data generated by simulation applications and tools distributed over a simulation network.

Such a tool allows controlled and repeatable playback to perform data analysis and After Action Review.

A modern data logger tool should allow users to quickly and easily record and playback DIS data using GUI VCR-like controls. Playback should be able to be started and ended at any two time points within the logger file, occur at multiple speeds faster and slower than real-time, be paused, and the logger should include a fast forward and rewind capability.

As previously mentioned the ADGESIM uses a proprietary communication protocol to communicate both between Pilot Driver Interfaces and between the Pilot Driver Interface and the VR-Forces back-end. When this proprietary communications protocol is replaced by the DIS Set PDU mechanism a COTS DIS Data Logger should then be able to fully functionally replay recorded ADGESIM scenarios.

Currently the ADGESIM does not have such a capability although Solipsys has its own record/replay capability but this will not replay the scenario on the DIS network. The DIS Data Logger will replay the scenario over the DIS network and this will simultaneously replay the scenario through the Solipsys applications.

The ADSL uses the MÄK Technologies Data Logger. This is a simple, reliable application but it does not allow playback from any point in time within a recorded logger file.

The ADSL has purchased the General Dynamics ModIOS Toolsuite [28]. This set of applications includes an event driven Data Logger application and an event driven After Action Review application. The ModIOS Data Logger graphically indicates the timeline presence of (user programmable PDU detection) events such as the detection of a DIS Fire PDU etc. The user can then replay the DIS data from the time when a particular DIS Fire PDU was detected. The user can rapidly jump from one detected event to the next to replay any required data. The ModIOS Logger appears to be more comprehensive than the MÄK Technologies Data Logger.

7.2 An Event Driven After Action Review Tool

The ModIOS After Action Review (AAR) tool appears to be a considerably more capable version of the ModIOS Logger. Recorded DIS data files are interchangeable between the Logger and After Action Review applications. The ModIOS Logger can only graphically display (ie event detect) when particular user defined PDU types have been detected. The AAR has a considerably more comprehensive event detection timeline reporting capability.

Event detection is controlled via Plug-In Event (PIE) and Report modules. Several PIEs are provided with the AAR tool and the user can also write their own PIE. PIEs allow events to be detected depending on data extracted from DIS PDU data fields. For

example the provided Transmission Event PIE allows DIS Transmitter PDU data to be detected (ie graphically displayed) when Signal PDU data is transmitted (Transmitter PDU State = ON_AND_TRANSMITTING) on a chosen frequency. Provided PIEs can generate events, charts and/or reports for Fire, Detonation, Kill, Bookmark and Radio Transmission events.

DIS PDU filtering can be applied to both record and playback functions.

The AAR tool can generate a *Take Home (Debriefing) Package* containing charts, reports, snapshots and movies of the ModIOS 2D, 3D and radio Toolsuite components in HTML format. The AAR tool can also be remotely controlled using the DIS Set PDU mechanism.

The ModIOS After Action Review application appears to be a very comprehensive tool worthy of further investigation. The ModIOS AAR tool may already be fully compliant with the record and replay requirements as specified in section 4.5.2 of the VAE OCD.

The objective of a DIS compliant AAR tool is to easily and quickly identify and replay areas of interest from the recorded training exercise data. If required, other DIS complaint COTS applications, such as 2D and 3D display applications, can then be used to enhance the overall After Action Review process.

7.3 DIS Radio Communications

Radio / Intercom communication systems on ADF training simulators are generally expensive (many millions of Australian dollars) and are usually proprietary and thus completely incompatible. When networking (DIS'ed) ADF training simulators together the simulators may be interoperable from the entity point of view, so that one simulator will correctly see entities generated on another simulator and vice-versa. However the simulator communications systems (most likely) will not interoperate because they were never designed to be compliant with any acceptable standard such as an IEEE DIS (Communications) standard.

The ADGESIM currently has no radio communications system capability. Work has been carried out in the ADSL testing available DIS compliant radio communications systems.

The RAN FFG and ANZAC ship simulators at HMAS Watson have been retrofitted with IEEE 1278.1a DIS compliant interfaces - including DIS compliant radio communications systems. Achieving interoperability between USN Battle Fleet Tactical Training (BFTT), RAN ANZAC and RAN FFG/DDG ship simulators, including these DIS compliant radio communications systems from different manufacturers, was one of the main objectives in the I/ITSEC 2001 USN / RAN coalition training exercise (discussed in section 4.5).

Interoperability between these different I/ITSEC 2001 exercise, DIS compliant, radio communication systems and the ModIOS (software only) DIS radio communication system has been achieved and demonstrated in the ADSL.

Using an IEEE DIS complaint (simulated) communication system (almost!) ensures interoperability eg. an entity on one simulator communicating on a specified (frequency etc.) channel should be able to interoperate (ie interact _and_ communicate) with another entity on another simulator communicating on the same (simulated) communications channel. In addition to processing normal DIS (non-communications) data, any appropriate DIS Data Logger should also be able to record and replay DIS compliant radio communications traffic.

All major ADF simulators, without DIS compliant communications systems, should investigate being retrofitted with such systems if those simulators are to be used in joint / coalition, Wide Area Network (WAN), distributed simulation training exercises such as that demonstrated at I/ITSEC 2001.

8. Out-The-Box Joint and Coalition Interoperability

Connecting DIS compliant simulators onto the same network does not automatically guarantee interoperability. Common DIS interoperability parameters (individual DIS PDU support, entity sets, entity set visual models, terrains etc.) need to be agreed on. However once these parameters have been agreed on a greater degree of interoperability can occur.

Because the ADGESIM is a DIS compliant simulator and the DIS PDU data fields themselves are standardised by the IEEE, any DIS application software should interoperate as long as the same version of DIS is used.

8.1 Interoperability With Australian Navy ANZAC, FFG and DDG Simulators

Phase 2 of the Royal Australian Navy Project SEA 1412 recently completed the addition of IEEE 1278.1A DIS interfaces onto the ANZAC, FFG and DDG ship simulators at HMAS Watson in Sydney. DSTO has provided considerable assistance to this project over a period of many years.

Because the ADGESIM is a 1278.1A compliant simulator and is thus capable of sharing the same common DIS interoperability parameters, the ADGESIM should fully interoperate with the HMAS Watson simulators. Therefore the ADGESIM should be able to interoperate as a fixed wing aircraft asset station in distributed simulation exercises carried out at HMAS Watson.

With some minor modification the ADGESIM should also be able to interoperate as a subsurface, surface and rotor-wing asset station.

8.2 Interoperability With Australian Air Force AEW&C Onboard Mission Simulator and US Air Force AWACS

DSTO ADSL staff have been part of the team specifying interface standards for the AEW&C Onboard Mission Simulator (OMS). The AEW&C OMS has not yet been delivered, however if it is delivered with the interfaces as already specified (DIS including radio communications) it should be interoperable with the ADGESIM.

The next Block 40/45 upgrade of the USAF AWACS aircraft will use the Solipsys MSCT and TDF products [36-37]. Therefore ADGESIM is already interoperable with this future version of the US AWACS platform. This is actually development/acquisition by simulation. Because the Solipsys MSCT and TDF products will be used by future USAF AWACS aircraft (and presumably their equivalent simulators) ADGESIM could provide simulated, fully Human-In-The-Loop entities to both the future AWACS real aircraft and the future AWACS simulator, compared to the Semi-Automated Forces entities currently provided by the US developed ModSAF Computer Generated Forces software application. Therefore ADGESIM could be used to provide, en-route, mission rehearsal capabilities to the real USAF (upgraded) AWACS aircraft.

Ignoring its deficiencies, ModSAF can also do this but the entities generated would be detected via the perfect-world Solipsys MSCT DIS/HLA interface compared to the real-world sensor ONION approach used by ADGESIM unless the USAF have an ADGESIM ONION equivalent. Recent DSTO/USAF Virtual Air Commander (AWACS Block 40/45 development team) interchanges did not report such a capability.

8.3 Interoperability With USAF DMT Simulators

Interoperability with the USAF DMT AWACS simulator has been discussed above. Other US Air Force Distributed Mission Training (DMT) simulators (eg F-15, F16 simulators) are both DIS and HLA compliant. Again, once common DIS interoperability parameters have been agreed, the ADGESIM should be interoperable with DMT cockpits.

8.4 Interoperability With US and Australian Navy Ships

The US Navy PMS 430 Program is in the process of upgrading all major combat ship on-board training systems to be DIS (US Navy BFTT) compliant.

Similar to the Solipsys MSCT system, real USN systems, such as radar systems, weapon systems, navigation systems, tactical data link systems, chaff launchers etc. [38], can all be stimulated by DIS PDUs to provide enhanced training. If training is

required for a system that is not used on that ship, an equivalent system simulator can be used.

In a typical training exercise sailors perform detection, controlling and engagement processes while operating combat system controls and tactical displays. Task and team skills are developed and refined. Operator performance data is collected for post-exercise reconstruction, evaluation and feedback. Most importantly, because the same systems are used (stimulated) the skills that are derived from precision training are directly transferable to "real world" tactical operations.

A ship may train in stand-alone mode or be integrated with other ships, joint platforms, or other designated allies in the BFFT network in a common synthetic environment. Combat system operators may be trained individually or as a team on board any ship. Training capabilities may be added to any ship at any time by simply adding a simulator or stimulator to the on-board training network. Training configurations can be changed quickly and easily to meet emerging training needs. Training scenarios are controlled locally using a desktop or laptop computer operating in a Windows environment or externally when training across ships. Master/slave controller arrangements permit scenario control and monitoring anywhere within reach of the on-board trainer network.

The USN BFTT system achieves combat readiness through effective, high fidelity on-board training. Training at the BFTT level uses DIS and HLA to form a network that interconnects battle forces across the synthetic theatre of war (STOW). Ships react as a co-ordinated team in a common interactive environment, training together on an integrated tactical strategy [38].

This stimulation / simulation system is being provided by the US AAI Corporation [39]. AAI Corporation is also providing a similar capability to the Australian Navy FFG Upgrade Program. Six FFG ship systems and two land based (Garden Island and HMAS Watson) systems will be provided [40].

Therefore the ADGESIM will be able to be connected either to an on-board US Navy or Australian Navy FFG ship system to act as an asset station. ADGESIM will also be interoperable with the FFG Upgrade training simulator (it is the same equipment as on the ship) at HMAS Watson.

8.5 Radio Communications Interoperability

The RAN FFG and DDG ship simulators at HMAS Watson use ASTi DIS communication systems [41]. The ANZAC ship simulator at HMAS Watson uses a DIS compliant communications system designed, built and installed by CSC Australia.

The FFG Upgrade system (on the FFG ships) will utilise spare communications capability and add ASTi DIS communications systems to allow multi-ship, mission

rehearsal training exercises using DIS radio communications. Therefore the FFG Upgrade training simulator to be installed at HMAS Watson will (ie should) be supplied with an ASTi DIS compliant communications system.

The US DMT systems have ASTi DIS radio communications systems [42-45]. The US Navy (BFTT) training simulators have a US Navy developed DIS communications system.

As already mentioned in section 7.3, the ADGESIM currently has no radio communications system capability. However DIS radio communications interoperability between all these systems (and the ModIOS DIS radio software) has already been demonstrated in the ADSL. Therefore adding any COTS DIS radio communications capability to the ADGESIM should provide DIS radio communications interoperability between the ADGESIM and any or all of these Joint and / or Coalition training simulator systems.

9. Conclusions and Recommendations

Advanced Distributed Simulation concept demonstrations have shown the value of simulation to the ADF. Candidate technologies and methods, capability areas for simulation use, the viability of connecting and using new and legacy training simulators, and the specific training and development needs of various ADF groups have been developed, evaluated and investigated.

The VAE Project has funded the DSTO Advanced Distributed Simulation Laboratory in Fishermans Bend, Melbourne. After an abortive attempt by the Commonwealth to obtain the required capability from industry, the ADSL produced the VAE Interim Training Capability (ADGESIM) in a highly timely (6 months compared to industry estimates of 3 to 5 years) and cost-effective (more than an order of magnitude less than industry estimates) manner.

The VAE ITC/ADGESIM is now being used for operational training by the Surveillance and Control Group at RAAF Williamstown and has been very well received.

A minor modification to the ADGESIM to incorporate the DIS Set Data PDU method of communicating between distributed applications will allow the use of COTS Distributed Simulation Applications such as a DIS Data Logger or a DIS After Action Review tool.

Adding a DIS radio communications system to ADGESIM should enhance its capabilities whilst still retaining complete interoperability with joint / coalition simulation systems which also use IEEE standard, DIS communications systems.

A modern After Action Review tool should be investigated/developed for ADGESIM.

The ADGESIM is DIS compliant and with minor modification can be made HLA compliant.

Compared to other operational training simulators the ADGESIM is very low-cost and highly cost-effective.

In producing the ADGESIM the ADSL integrated simulation industry standard, COTS software applications and low cost PC hardware platforms with in-house developed, customized, thin-client applications that have no commercial equivalent. This approach (along with considerable client/developer interaction) should reduce the purchase, development and maintenance costs of any delivered systems and increase the probability that project functionality is delivered on time, on budget and according to specifications – it is a risk reduction strategy.

A modern, distributed simulation architecture coupled with widely used, simulation industry applications and standards used in the ADGESIM has resulted in a flexible, scalable and highly interoperable application.

The ADGESIM should interoperate (with little or no modification) with the:

- RAAF AEW&C OMS simulator;
- RAN HMAS Watson FFG UP, ANZAC, FFG and DDG shore-based simulators;
- USAF DMT simulators; and the
- USN BFTT shore-based simulators.

The ADGESIM will also be interoperable with platforms containing embedded DIS interfaces such as the:

- RAN FFG UP ships;
- USN BFTT ships; and the
- USAF Block 40/45 Upgraded AWACS aircraft.

The ADF is bringing Advanced Distributed Simulation into its in-service training simulators through the Navy's Project SEA 1412 and the Air Force's VAE Project. The Australian Navy is already moving towards operational coalition training through the HMAS Watson ADS training exercises carried out under the DSTO/USN PMS 430 Project Arrangement. The RAAF could carry out similar research through a Distributed Mission Training Project Arrangement currently under negotiation between Australia and the USA. Such work could make a valuable contribution to the AIR 6000/Joint Strike Fighter Project.

ADGESIM could make a valuable contribution to the USAF AWACS Block 40/45 upgrade program.

Providing real platform, OBTSs with Advanced Distributed Simulation interfaces means that an operational training simulator system can be obtained from the real platform OBTS. Thus the money usually spent on developing a one-off operational training simulator (usually many tens of millions of dollars) which are normally delivered over time, over budget and not according to specifications could be used to purchase the same (ie COTS) system as is used in the real platform which is already functioning as is required (eg as in the FFG Upgrade program).

When a flexible COTS system is to be used the already available COTS system can be used to develop the real platform system as is being done for the USAF Block 40/45 Upgraded AWACS aircraft – this is development and acquisition by simulation.

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19. ABSTRACT Currently some Australian Defence personnel train using live assets. This may be prohibitively expensive and some of these assets have very short lifetimes before a major overhaul is required. DSTO has participated in a series of concept demonstrations showing the potential of synthetic, virtual environment technologies to support such operational training. These demonstrations showed both Joint and Coalition interoperability. A Distributed Interactive Simulation (DIS), virtual environment, training system known as the Air Defence Ground Environment Simulator (ADGESIM) has been developed and delivered. A mix of Commercial-Off-The-Shelf (COTS) products and customized, "thin client" applications where required, approach has been adopted. This system is now being used by Air Defence Operators and Fighter Controllers, at RAAF Williamtown, for real operational training. This paper describes some of the distributed, virtual, simulation concepts and technologies used, in DSTO's Advanced Distributed Simulation Laboratory at Fishermans Bend, Melbourne, to develop this training system.