The COA-Sim JSAF Environment in Support of Joint Military Training and Exercises

Mr. Carsten Gabrisch; Mr. Glenn Burgess
Command and Control Division, Defence Science and Technology Organisation
Edinburgh, SA 5111, AUSTRALIA
Carsten.Gabrisch@dsto.defence.gov.au; Glenn.Burgess@dsto.defence.gov.au;

Abstract. Course Of Action Simulation (COA-Sim) is a simulation based Research and Development (R&D) program in support of joint military operations training, exercises and planning. As part of the COA-Sim program a prototype environment, incorporating the Joint Semi-Automated Forces (JSAF) constructive simulation, has been developed and demonstrated in support of the training and exercise capability of the Australian Defence Force Warfare Centre (ADFWC) Simulation Section. The COA-Sim JSAF environment also contains a number of technical components, including various graphical user interfaces, intelligent software agents, and Commercial Off The Shelf (COTS) data logging software. Prototype user interfaces include ones for runtime data and analysis. Behaviours represented by the intelligent software agents include scheduling of tasks and group embarks, moves and disembarks. For JSAF to play a role in the COA-Sim JSAF environment, modifications were necessary to both the JSAF user interface and the publishing and subscribing of objects. This paper describes the COA-Sim JSAF environment, details of the user interfaces and intelligent software agents, modifications made to JSAF and the role of JSAF within the environment.

1. INTRODUCTION

Course Of Action Simulation (COA-Sim) is a simulation based Research and Development (R&D) program in support of joint military operations training, exercises and planning. As part of this R&D program, Command and Control Division (C2D) of the Defence Science and Technology Organisation (DSTO) has developed a prototype environment in support of the training and exercise capability of the Australian Defence Force Warfare Centre (ADFWC) Simulation Section.

The ADFWC Simulation Section provides simulation support during Command Post Exercises (CPX) in order to stimulate an operational HeadQuarters (HQ). They currently use the Joint Semi-Automated Forces (JSAF) constructive simulation for this purpose. The COA-Sim program has developed and demonstrated a prototype environment that incorporates JSAF. As well as JSAF, the COA-Sim JSAF environment includes a number of technical components that have been purchased and developed. These technical components include various graphical user interfaces, intelligent software agents, and Commercial Off The Shelf (COTS) data logging software.

User interfaces developed include ones for runtime data and analysis. Intelligent software agents developed include behaviours for the scheduling of tasks and group embarks, moves and disembarks. For JSAF to be integrated into the COA-Sim JSAF environment and interact with the other technical components modifications were necessary to both the user interface and its object and interaction publishing and subscription capability.

This paper describes the COA-Sim JSAF environment, details of the user interfaces and intelligent software agents, modifications made to JSAF and the role of JSAF within the environment. The experiences are relevant to the development of an Australian JSAF capability.

2. COA-SIM

COA-Sim is a collaborative program between DSTO C2D and the ADFWC Simulation Section. The ADFWC supports the operational level of command through simulation-based training and exercises. The COA-Sim JSAF environment is of immediate benefit to the existing ADFWC training and exercise capability by reducing the number and workload of Exercise Control (EXCON) staff required for the provision of simulation support during a Command Post Exercise (CPX).

3. JSAF

Joint Semi-Automated Forces (JSAF) is a simulation system used to generate entity level units such as tanks, ships, aircraft, and individual combatants, including their associated sensor systems and munitions. The individual units are organized within appropriate command structures that may be controlled as collective units. JSAF units execute tasks and behaviours appropriate for the type of unit simulated and users may override or interrupt many of the automated behaviours [1].

JSAF provides a graphical user interface (GUI), referred to as the JSAF Plan View Display (PVD), that enables operators to create, task and interact with units in a JSAF scenario.

JSAF is a High Level Architecture (HLA) compliant federate that publishes battlefield states and events. JSAF has various Federation Object Models (FOMs)
and an internal Simulation Object Model (SOM) that describe the objects and interactions that are published through HLA.

4. COA-SIM JSAF ENVIRONMENT

The COA-Sim environment aims to assist EXCON staff in the use of JSAF in an operations training environment. This is being addressed through the development of intelligent software agents to automate some of the most frequent and laborious tasks that must be performed, and GUIs that provide situational awareness and analysis functions that remove the need to have constant observation of the simulation by EXCON staff.

A prototype COA-Sim JSAF environment (see Figure 1) has been developed and demonstrated in support of the training and exercise capability of the ADFWC Simulation Section. The COA-Sim JSAF environment contains a number of technical components. These technical components include:

- A COTS data logging application namely hlaResults®.

- A modified JSAF that enables issuing of operational level orders and external unit control.

- Intelligent software agents that provide behaviours such as scheduling of tasks and group embark, move and disembark.

- JSAFReports: a GUI that provides the ability to view the status and interactions of units within a JSAF scenario.

- JSAFAnalysis: a feature available under JSAFReports, which provides the ability to analyse scenario interactions, both during and after the running of a scenario, and view them in a graphical form.

In the COA-Sim JSAF environment a JSAF operator would construct an operational level order, or High Level Order (HLO), through the JSAF PVD. This HLO is passed to the intelligent software agents via HLA. On receipt of this HLO an intelligent software agent will decipher the contents, obtain situational awareness from the runtime database and compose and issue a series of tasks associated with the appropriate JSAF units.

For the COA-Sim environment to achieve this, a number of modifications to JSAF were required. These modifications included the ability for operators to send HLOs through the JSAF PVD, JSAF to publish the current taskframe associated with units and the ability for external federates to create, control and delete JSAF units. These modifications are described in more detail in Section 4.2.
The runtime database, or situational awareness, is provided through the logging of the JSAF FOM by hlaResults®. JSAFReports and JSAFAnalysis provide the operator an ability to observe and analyse JSAF unit states and events through queries to the runtime database.

4.1 hlaResults®

A key requirement for the COA-Sim R&D was access to a runtime database for situational awareness by the intelligent software agents. This runtime database also would provide the means for JSAFReports and JSAFAnalysis to display and analyse JSAF unit states and interactions. Therefore a suitable HLA logging and replay capability was required. Under initial consideration to provide this capability was Caber, provided with JSAF, and hlaResults®, provided by the Virtual Technology Corporation. hlaResults® is an HLA federation and DIS exercise runtime tool for the data collection, analysis, and playback of any HLA federation’s or DIS exercise’s data. With this tool, data can be collected and analysed during execution so that results can be examined and reported immediately, rather than waiting until the execution has completed [2].

The hlaResults® product was chosen primarily because of its ability to record HLA data using a variety of widely available commercial software products. These included the ability to record in text file, Microsoft Access, Oracle and MySQL formats. All of these recording formats are of a textual basis that is easily accessed by other COA-Sim components such as intelligent software agents, JSAFReports and JSAFAnalysis.

In addition, some changes needed to be made to JSAF. Specifically the cardinality of attributes or parameters that contain an array of values were changed in order to enable JSAF data to be logged more easily and in an appropriate format. A change to the JSAF reader file format was also necessary to make JSAF publish the number of elements within these arrays and not the total byte size of these arrays.

4.2 JSAF Developments

To enable the issuing of HLOs and the control of units by external federates JSAF required modification and new developments. For JSAF to achieve this, a number of objects and interactions were added to the JSAF SOM and FOM. The objects and interactions added include a UnitTaskReport object and HighLevelOrder, UnitCreate, UnitTask and UnitDestroy interactions.

UnitTaskReport is a JSAF publishable object that provides the current taskframe associated with a JSAF unit. This object was added to enable the intelligent software agents to decipher the current tasking of units within a JSAF scenario.

HighLevelOrder is a JSAF initiated interaction that is sent once a JSAF operator has completed a HLO through the JSAF PVD. The HighLevelOrder interaction is deciphered by the intelligent software agents and decomposed into a series of existing JSAF unit tasks. This decomposition is explained further in Section 4.3.

The UnitCreate interaction is one that JSAF reacts to on reception. UnitCreate enables external federates to create units within JSAF. These units can then be either tasked through the JSAF PVD or by external federates, such as intelligent software agents.

The UnitTask interaction is again one that JSAF reacts to on reception. UnitTask enables external federates to task internal JSAF units. The external federate can only apply internal JSAF tasks to units. The tasks available correspond to those visible through the PVD task frame. Through the UnitTask interaction, tasks are either appended onto the end of the existing task frame or the entire task frame can be replaced.

The UnitDelete interaction is an interaction that JSAF reacts to on reception. UnitDelete enables external federates to delete units from within the JSAF scenario.

Software libraries were developed and added to handle the publishing and subscription of these object and interactions. The software library that handles the HighLevelOrder interaction also adds the ability to construct and send a HLO within the JSAF PVD. In Figure 2 an “Interdict Air Lines Of Communication (ALOC)” HLO is displayed within the JSAF PVD. This provides the operator the ability to interact with all JSAF units while constructing a HLO.

4.3 Intelligent Software Agents

Intelligent software agents decompose a HLO into a number of primitive simulation operations (unit task frames). These intelligent software agents typically perform some reasoning or labour-intensive task. EXCON staff can enter a HLO directly from the JSAF PVD (Figure 2). The HLO are then forwarded to the appropriate intelligent agent via HLA.

An example of an intelligent software agent which has already been developed is one to Interdict ALOC, which is primarily the automatic scheduling of fighter aircraft for combat air patrol (CAP). Another example which is under development is the automated movement of multiple units, using available land, air or surface transport assets.

Other intelligent software agents that are being considered include ones to help plan an air strike package, wide area surveillance, anti-subsurface warfare, amphibious operations, embark/disembark and air mobile operations. Common features of these tasks are scheduling, ensuring doctrinal constraints on the behaviour of units and adhering to complex conditions for successful execution.
4.3.1 Interdict ALOC
Interdiction of air lines of communication is a task designed to prevent adversary air assets entering or passing through an area of operations. It is closely related to local air superiority. The key requirements for this task are the abilities to detect and engage air tracks. This is typically achieved by a combination of continuous airborne surveillance and fighter assets either on active patrol or standby. In the absence of more capable air surveillance assets such as an airborne early-warning (AEW) radar, fighters might be used to perform the dual role of detection and engagement of air tracks. But compared to typical AEW aircraft, fighters have a very short endurance (a few hours), so scheduling CAP for extended periods (days to weeks) becomes an essential logistic issue.

The Interdict ALOC intelligent software agent is designed to assist EXCON staff to perform this common operational task by balancing the need for airborne fighters against the availability of high-quality air surveillance, and by automating the scheduling of surveillance patrols, CAP and air-to-air refuellers when available. Presently it only schedules CAP and ignores any available AEW and refuelling aircraft.

The intelligent software agent responds to an order of Interdict ALOC by querying the simulation database to discover the available assets and their locations. It then uses a batched search-based scheduling algorithm to find a semi-optimal allocation of assets to satisfy the overall mission requirements. This schedule is then converted into a set of missions for individual aircraft in JSAF which can be modified, approved or rejected, as desired, by the EXCON staff.

4.3.2 Group Embark Move Disembark
Another ubiquitous operational task is the movement of numbers of units on transport assets. This is a generic problem, although the actual implementation depends greatly on the type of units to be moved and the chosen mode of transport. A number of issues are independent of these details however, such as the need to protect the transport assets in transit and the need to send units in batches whose size depends on the number of assets to be moved, the number and capacity of the transport units and the distance to move.

The most challenging aspects of this problem, when using JSAF, is coordinating the loading, movement and unloading of units on transport assets and estimating their transit times. Transit times are required to perform accurate scheduling and to satisfy arrival time constraints. For example, when all units should arrive before a given time. But the transit time depends on the exact route chosen and the nature of the terrain along the entire route.

4.4 JSAFReports
JSAFReports provides to EXCON staff a dynamically-updated view to the states and events of JSAF units in one convenient interface (see Figure 3). This reduces the need for EXCON staff to constantly monitor JSAF. The interface is divided into three sections. The top
section provides the latest status information of a unit. Units are either individuals or grouped by an aggregate unit. Aggregated units can be expanded and contracted as needed. Status information displayed includes unit identification, type and force, location, elevation, speed and heading, and time of status information. Also displayed is whether the unit has detected or engaged adversary units or received damage.

The middle section provides a history of any detections, damage or engagements associated with a selected unit. Detection information includes time of detection, target type, force, location, elevation, speed and heading and sensor mode, function and type. Damage information includes time of damage, damage state, firing unit identification, type and force, damage reason, and munition name and type. Intercept information includes time of intercept, firing location and elevation, target unit identification, type and force and munition type used.

The bottom section provides a textual summary of a unit status, a detection, damage received or an engagement depending on which is selected at the time. This textual section enables EXCON staff to copy and paste this information into messages for stimulating the HQ during a CPX.

All this data is obtained from queries to the runtime database provided by hlaResults®.

4.5 JSAFAnalysis

JSAFAnalysis takes the JSAFReports interface one step further by allowing EXCON staff to analyse the history with simple manipulations and view it in graphical form. Users are able to perform analysis on several predefined groups of units or define their own named groups. Examples of predefined groups include All Friendly Units, Friendly Air Units, Hostile Land Units and All Surface Units.

Supported analysis includes various standard metrics used for after-action review (AAR) including losses, loss exchange ratio, strength, direct fire shots and force exchange ratio. Thus JSAFAnalysis can be used in an AAR role, or during simulation execution as a further diagnostic tool.

For example Losses would show a count of the lost platforms from multiple selected groups as separate lines. While Loss Exchange Ratio (see Figure 4) shows a single ratio of percentage losses for two selected groups.
5. SUMMARY

Development of the COA-Sim JSAF Environment has delivered tools for a foundation ADFWC Simulation Section JSAF capability. The tools delivered include JSAFReports and JSAFAnalysis. Although these tools have provided immediate benefit to EXCON staff further developments could include the automatic generation of reports, after the completion of unit missions, and periodic report generation of the force nature and size. These enhancements would further reduce the workload and number of EXCON staff required during a CPX.

Also demonstrated has been the benefit of intelligent software agents for the implementation of laborious tasks associated with providing simulation support to a CPX. By implementing these intelligent software agents as external federates their reuse with other simulations is greater. This has been demonstrated with the CAP agent as this was originally developed to control Joint Theater Level Simulation (JTLS) units and through minimal modification performs the same functionality with JSAF. The development of these intelligent software agents is still a software engineer intensive task. Research and development of a simpler process for agent implementation needs to be explored. This process should provide the ability for military Subject Matter Experts (SMEs) to describe the Standing Operating Procedures (SOPs) in a form that could be interrogated by intelligent software agents for implementation within a simulation.

REFERENCES
1. JSAF User Guide.
2. hlaResults® Version 2.2 User’s Guide.