A LOW-COST SIMULATION ENVIRONMENT
FOR PORT SECURITY EXPERIMENTATION AND TRAINING

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ABSTRACT

An immersive simulation environment has been developed to support the exploration of new technologies and concepts in a port security operations center, where operations focus on the monitoring and protection of people and property in a harbour (e.g., investigating boats or passengers portraying unusual behaviour). The simulation environment includes four main components: an operations center, response boats, a naval vessel, and potential waterborne threats, each requiring input and control from two or more human operators. Each component was constructed as simply and inexpensively as possible, while still providing operators with information, communication, and control capabilities consistent with their expectations. Virtual BattleSpace2 (a commercial-off-the-shelf video game), High Level Architecture federates, and real-world tracking software have been integrated and paired with consumer-level electronics to produce an inexpensive experimentation environment. Components of this flexible and adaptable simulation are also being exploited as a tactical training capability for port security boat operators.

Keywords: port security, game-based simulation, human-in-the-loop simulation, simulation-based experimentation

1. INTRODUCTION

Port security operations centers revolve around incoming and outgoing information. Information comes in through various mechanisms: cameras, radar, radio, phone, online communication tools, etc. If issues of concern are identified, they are communicated up the chain of command and decisions are relayed back down to the relevant stakeholders. As years pass, more and more opportunities to collect and disseminate data become available (e.g., consumer-level availability of GPS systems, cell phones and smartphones), and the management of the breadth of information becomes more complicated. It is not immediately clear that the addition of a new data source, a new display for multiple data sources, or a new communication pathway will improve the performance of operations overall.

The motivation for developing the simulation environment discussed in this paper came following the observation of port security exercises, and identifying the potential for the use of incident management system (IMS) software to manage and track the details of incidents and resources. Since IMS systems typically run independently of other software and data sources found within an operations center, they can be easily added to a baseline simulation without integration concerns. By running through a selection of scenarios with the baseline capability alone (i.e., no software added) and alternatively with the addition of the proposed software solution, experimenters can capture data on the performance of the system as a whole as a result of the augmented setup. While the exploration of IMS systems was the impetus for developing the baseline simulation, the setup is easily adapted to explore other capabilities or ideas that could likewise improve operations.

This simulation environment discussed in this paper is referred to as Virtual Harbour, or simply vHarbour. vHarbour is comprised of a combination of commercial gaming software and input devices, off-the-shelf computers and displays, custom-built software, simulation-based communications, and real military kit. Basing the environment on extendable gaming software and consumer electronics limits the overall cost of the setup.

2. HARBOUR PROTECTION

The operations center focussed on in this paper is a military operations center, responsible for the protection of people and property in a harbour. The team in the operations center is supported by multiple small boat teams on small, fast, rigid-hulled inflated boats (RHIBs). The RHIBs work in teams, monitoring designated portions of the harbour and relaying issues back to the operations center. RHIBs may be required to investigate suspicious boat behaviour, protect vessels entering the harbour, monitor controlled access zones, etc. In addition to receiving reports from the RHIBs, the operations center team monitors cameras and other sensors.

In order to guide the focus of simulation development, it was necessary to identify some scenarios early on that the simulation would be able to handle. All scenarios are presumed to take place in Halifax Harbour (Nova Scotia, Canada) on a sunny, summer day when active pleasure-based traffic in the harbour is at its peak. Three scenarios are fictitiously built upon prior conditions that have caused the Canadian Forces Base (CFB) Halifax to adopt a Force Protection (FP) state of yellow (i.e., a medium threat level). Each scenario involves five FP RHIBs, where two of the five RHIBs are escorting a foreign vessel into the harbour for a port visit. There are three Canadian Navy ships already in the harbour; which ship is an active part of the scenario will depend on the location of the potential incident described in the scenario.

The first scenario involves two small high speed boats approaching the escorted foreign vessel on a direct path. The second involves a fishing boat that stops briefly alongside a barge and leaves again with two people on its deck, getting into diving gear. When the boat nears one of the naval ships, the two divers jump in the water and head for the ship. The third scenario involves a small powerboat with two men on board that continually shadows the escorted warship; as a force protection boom is opened to allow the warship to be escorted inside, the small boat speeds up and attempts to enter the boomed area.

Figure 1 provides a visual of the entities involved in each scenario and their anticipated interactions (data sharing and/or communication).
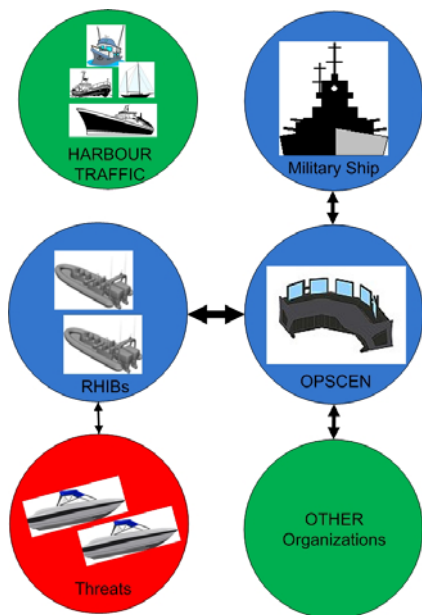

Figure 1: Scenario Entities

The heavier lines indicate that more interaction is anticipated between these elements. The absence of connecting lines does not indicate that entities could not conceivably communicate or share data with each other.

Rather, it means that such interactions are not expected to directly influence the outcome of experiments focussed on the operations center.

The simulation was developed to handle (at a minimum) the three scenarios that have been described. Some scenario-specific elements influenced the development efforts (e.g., the third scenario requires that a force protection boom be in place and that there be an opening for the warship to enter through), but the simulation is flexible and can be adapted to handle alternative scenarios as well.

3. vHarbour SIMULATION COMPONENTS

The simulation environment focuses on the operations center since this is where new technologies or concepts will be trialed. All other simulation components are included simply to enhance the realism of the experience of those in the operations center. The other human-controlled components include two RHIB response boats, a naval vessel with a sentry and force protection officer, and up to two human-controlled (potential) waterborne threat boats. A naval vessel is included in each scenario primarily to stimulate the need to share and track information between multiple locations, creating a better testing environment for new software.

This section briefly describes the requirements for the core components of the simulation environment (i.e., the 'what') as determined by real-world observation of port security exercises; as much as possible the simulation environment mimics what was observed. The following section (section 4) will describe the software and electronics used to create the environment to handle these requirements.

3.1. Operations Center

The operations center includes all of the information feeds available in an actual operations center: video feeds of numerous cameras on the harbour, each adjustable in direction and zoom, radar and Automatic Identification System (AIS) tracks of ships/boats in the harbour (when available), and a map showing response boat positioning and communication options. This 'map' is an Electronic Chart Precise Integrated Navigation System (ECPINS) chart with an Asset Control and Tracking (ACT) add-on for RHIB position-tracking and communication between the RHIBs and the operations center.

Other tools are also available within the center, such as a whiteboard, phone lists, and Microsoft Office software. Communication occurs via radio, chat, e-mail and phone to military ships in the harbour as well as any other ships/boats and organizations that would typically be engaged with during harbour monitoring and protection.

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3.2. Response Boats

RHIB (response) boats need to communicate their position to the operations center. To some extent, their position may be observed through cameras (or eyes) on the harbour, however, verbal reports are also called in over radio at fixed intervals. In addition, some of the boats on duty are fitted with a commercial ACT RHIB-based unit which provides automated position reports to the operations center's ECPINS display at regular intervals using a secure AIS channel. RHIBs with ACT have a small monitor mounted near the boat coxswain (driver) that shows the location of other ACT-fitted RHIBs as well as AIS and radar tracks on a harbour chart. ACT can also receive textual messages as well as map overlays from the operations center (e.g., exclusion areas, or points of interest) and can be used to return primarily preset messages. In addition to ACT, RHIB boat operators can (obviously) use their vision to see what is happening on the harbour, and this is a key source of day-time data collection which must be replicated in the simulation environment.

3.3. Red Team

While a variety of threats can exist in a harbour environment, the scenarios designed for this simulation focus on small boat threats. The boats are assumed to have no sensor feeds beyond operator vision. They have access to radios, but would be unlikely to use the radio to communicate ill-intended plans; they may use cell phones to speak with each other or communicate simply through verbal cues.

3.4. Ship

All military vessels in the harbour that are of relevance to any of the prescribed scenarios are stationary. With a force protection state of yellow, a Force Protection officer (FPO) and upper deck sentries can be expected on each ship. FPOs have chat, phone and/or radio communication pathways to the operations center, other organizations and to boats on the harbour. The sentries would have visuals on the harbour and radio communication with the FPO.

3.5. Other Ships and Agencies

The operations center staff may need to communicate with other ships/boats in the harbour (e.g., a small boat that is too close to a commercial shipping lane) or other military or non-military agencies via phone, e-mail or radio. It is difficult to predict which other agencies might be engaged; it depends on the scenario and the decision maker's interpretation of the events. However, likely candidates are the military and civilian police, local fire and emergency services, Halifax Port Authority (HPA), etc.

4. SIMULATION COMPONENTS

At this point the simulation requirements have been identified. This section focuses on the software and hardware components used or developed in order to meet those requirements, providing simulation fidelity sufficient for experimentation with new technologies or concepts.

4.1. Virtual BattleSpace 2 (VBS2)

VBS2, developed by Bohemia Interactive (www.bisimulations.com), is an immersive 1st person virtual environment (which is also referred to as a 'serious game') and is at the heart of vHarbour. It is used for scenario generation and editing, exercise control, and after-action review of operator decisions. All operator-controlled entities (RHIBs, threat boats, the sentry and also the cameras in the operations center) in the simulation are created through VBS2 at scenario design time and controlled through VBS2 instances at run time. One instance of VBS2 is used to simulate each of the cameras in the operations center; four are run on each of two computers and the windows are tiled 2x2 onto two 52" TV monitors. Each camera provides a different view of the harbour, and allows the operator to do basic panning and zooming as required. VBS2 also provides the visual environment (i.e., what the operator sees in the harbour) for each of the operator-controlled RHIBs and threat boats, as well as a visual display for the sentry onboard the ship. VBS2 terrain for Halifax harbour with geo-specific (e.g., key buildings, the dockyard, and bridges) and geo-typical elements was built for vHarbour. As well, it was necessary to build additional VBS2 models for a variety of vessel types including jet skis, fishing boats and other small water craft.

4.2. High Level Architecture (HLA) federates

Defence Research & Development Canada – Atlantic (DRDC Atlantic) has been developing HLA-based federations for over eight years, with most work based on the Virtual Maritime Systems Architecture (VMSA) (Canney 2002). Thus, core federates related to simulation control already existed. Other federates needed to be developed, including the following:

- A Scenario Editor and Visualizer (ScEr-V) for generating and directing harbour background traffic (Gaudet 2009),
- A radar federate that produces VMSA radar tracks for all entities in the simulation (generated by ScEr-V and/or VBS2) within size and range limitations and not blocked by obstacles or masked by shadow zones (Hackett 2009),
- An Automatic Identification System (AIS) federate that simulates the behaviour of AIS transponders, producing VMSA AIS tracks (and necessitating a custom addition to the VMSA Federation Object Model (FOM)) (Gaudet 2009),
- A National Marine Electronics Association (NMEA) federate that receives radar and AIS data from the simulation, formats it according NMEA standards and passes it over a serial connection to NMEA-compliant listening devices (thus bridging the simulation to real-world equipment) (Campaigne 2009), and

- A software bridge for exchanging data between simulation components using the High Level Architecture (HLA) and others using the Distributed Interactive Simulation (DIS) protocol; this DIS-HLA bridge (named 'Charon') supports the passage of simulation data between VBS2 (which supports DIS) and VMSA (which is based on HLA).

ScEr-V was used to generate the background traffic in Halifax Harbour for each scenario, including commercial shipping vessels, fishing boats, pleasure craft, and the Halifax-Dartmouth ferry (which follows the real-world schedule). It was also used to create three simulation-controlled RHIBs for each scenario. The radar and AIS federates produced tracks for both ScEr-V-generated and VBS2-generated entities, as appropriate. These tracks were picked up by the NMEA federate and passed to chart displays on the RHIB and in the operations center. Charon allowed VBS2 to 'see' the VMSA entities and vice versa.

4.2.1. Scenario Editor and Visualizer (ScEr-V)
ScEr-V provides a graphical interface (Figure 2) for building scenarios by dragging and dropping entities onto a map image, adding waypoints, paths, areas of operation (e.g., fishing grounds) or exclusion (e.g., controlled access zones), and specifying the types of behaviour each entity should perform. Behaviour options include: moving to an absolute or relative point, operating within an area (fishing, sailing, etc.), following a path, and drifting. It allows for specification of entity speed and duration of each behaviour, and supports switching from one behaviour to another after a pre-set amount of time or the completion of a task (e.g., after fishing an entire area, return to port).
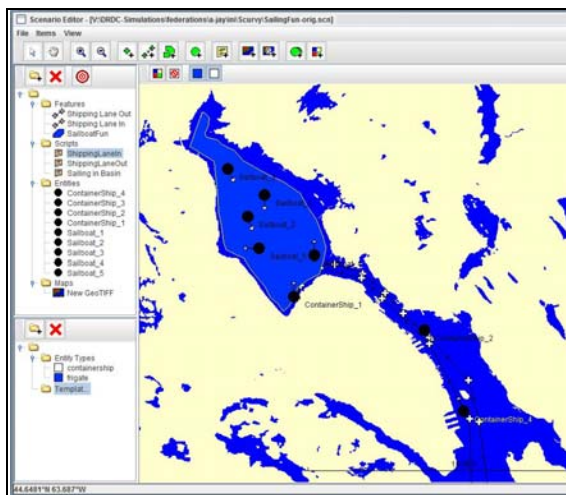

Figure 2: ScEr-V Graphical Interface

The ScEr-V scenarios are recorded as script files that are exported to an agent-based navigation federate that ultimately controls entity movement at run-time. The navigation federate also handles the priority of behaviours for each entity. For example, a fishing behaviour will be suspended if a munitions detonation occurs near that entity since escaping from a threat is more important than fishing. A ScEr-V viewer is also available at run-time to monitor entities and take control of them as needed. For vHarbour, an additional 'white cell' player was assigned to monitor the radio for requests issued to neutral traffic and to modify behaviours as necessary. In short, ScEr-V creates computer generated forces (CGFs) capable of controlling their own behaviours. In contrast, VBS-2 is used in vHarbour to create entities requiring/supporting human input throughout scenario execution.

4.2.2. DIS-HLA Bridge (Charon)
VBS2 and VMSA need to be able to exchange entity-related information with each other (type of boat, location, speed, etc.) so that VBS2 can properly display entities created and controlled by ScEr-V and the VMSA sensor federates can produce tracks for VBS2-based RHIBs. The VBS2 licence purchased by DRDC included LVC-Game by Calytrix Technologies (www.calytrix.com) that allows VBS2 to participate in DIS exercises. VMSA is based on HLA, so a DIS-HLA software bridge is required to exchange data between VBS2 and VMSA.

While it would have been possible to purchase a commercial product to perform this translation between DIS and HLA, the choice was made to develop this bridge in-house. A commercial solution would have required considerable configuration, been less flexible, and have taken additional time and money to procure. The bridge built in-house, Charon, was programmed using the Open Source DIS project as well as a DRDC-written HLA toolkit known as "Polka" and took approximately four weeks to build. Charon's core responsibility is to translate identification and spatial information for all VMSA entities into information that can be understood by VBS2 and vice versa.

4.3. Real Military Kit
ECPINS software was purchased for the operations room and ACT software was likewise purchased for one simulated RHIB station, both from OSI Geospatial Inc. (www.osigeospatial.com). This is the actual software used in the operations center and onboard the RHIBs and can run on any modern Windows-based computer. It provides blue force tracking of all ACT-fitted RHIBs (i.e., knowledge of where they are) to the operations center and the RHIBs themselves. It also allows the operations room staff to send instructions to the ACT-fitted boat, such as new exclusion zones drawn on a map, or textual instructions and warnings. An operator on the RHIB can return similar messages, typically by selecting phrases from a preset list rather than typing from scratch.

In the real world, positions and messages are passed via an encrypted AIS channel. In the simulated world, there are two challenges: passing data from the simulation to

the ECPINS and ACT software and exchanging information between ACT (on the RHIB) and ECPINS (in the operations room). The latter was straightforward as an AIS Network Simulation came with the ECPINS and ACT software for exactly this purpose and it was simply a matter of configuring it according to the documentation. The former requires the passing of AIS and radar tracks from the VMSA simulation to the ECPINS and ACT software, as well as truth-based GPS data to both ECPINS and ACT so that they would know where their host (i.e., the operations center and the RHIB, respectively) is located.

One instance of the NMEA federate and two computers are required for each NMEA-compliant listener since data are passed via a serial connection. Thus, pushing VMSA tracks to both the ECPINS and ACT software requires two instances of the NMEA federate, each running on different computers, and two additional computers to run the ECPINS and ACT software. In the future, the design of this federate could be modified to work via TCP/IP and remove the device dependency.

Any VBS2 data required by ECPINS and ACT is routed through the bridge and the VMSA simulation, so there is no direct connection between VBS2 and ECPINS and ACT.

Given the use of the NMEA standard to pass data to a NMEA-compliant listener (such as ACT), it is now possible to share VMSA simulation data with *any* real-world device that is NMEA-compliant (e.g., a GPS system).

4.4. Radio Simulator
The idea of using real radios to support the simulation was explored, but difficulties in obtaining an adequate number, their inflexibility, and limitations on where they could be used led to the selection of a simulated radio network setup. SimSpeak, developed by the Canadian Forces (CF) was used for this purpose, and is similar to other Voice Over Internet Protocol (VOIP) systems used by gamers. Microsoft Life-Chat gaming headsets were used for monitoring and broadcasting on a single radio channel via SimSpeak.

4.5. Telephone Simulator
A commercially available telephone line simulator (Teltone TLS-5 (www.teltone.com)) was used to program the phone lines for the operations center, the ship, and 'all other organizations'. At simulation execution time, a single human actor must take responsibility for acting as any organization/agency that the operations center staff or military ship decide to contact (via phone or radio). A single phone line is assigned to represent all such organizations for a couple of reasons. First, the telephone simulator can only handle four simulated lines, and there are more than two potential agencies that could be called. Secondly, even if adding more lines was possible, the actor would need

to answer all of those phone lines. Instead, there is a single line 'to all', and callers are instructed in their pre-experiment briefing to always identify themselves and who they are calling so that the actor knows what organization he/she is representing at any given time.

4.6. E-mail/Chat Service
A Linux-based virtual appliance was freely downloaded from VMWare and used for the e-mail server. E-mail addresses could then be provided to the operations center staff, the FPO on the ship, and the multiple organizations handled by the actor. A similar process is expected to be used to provide a chat service, although this has not been thoroughly explored to date.

5. RHIB Station
From an experimentation point of view, the operations center is the focus of vHarbour. However, the heart of vHarbour from a simulation perspective is the small boat station set-up.

There are four of these stations in the vHarbour set-up. Two stations are used for RHIBs that work together under the instruction of the operations center; one of these is fitted with ACT. The other two stations are used for the red team. They are identically configured (with no ACT) in terms of their hardware and software; however, settings in VBS2 are modified according to the type of threat boat(s) in the scenario.

The technical integration for the RHIB/small boat set-up has already been discussed – VBS2 supplies the visuals and control of the RHIBs and a headset is used with SimSpeak to supply radio communications.

Figure 3 shows a RHIB station that is configured with ACT.

Figure 3: RHIB station with ACT

5.1. Hardware and Structural Components
A small Anthrocart desk was configured to make the driving podium. A 52" TV was used to display the operator's view of the harbour via VBS2 and was

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mounted such that the average operator's sight would center on it while in a standing position. Its large size means that it is capable of filling most of the operator's field of view and gives a sense of immersion in the environment.

A Track-IR (www.naturalpoint.com/trackir) gaming peripheral was used to control the operator's point-of-view in VBS2. It achieves this by amplifying head movements such that an operator can look all the way over one shoulder by turning the head slightly away from centre. It uses an Infrared camera on top of the TV and a reflective target attached to the operator's hat to detect head position and orientation. The setup also uses a Saitek throttle quadrant and a Logitech force-feedback steering wheel (both found commercially in the gaming sector), so that the control of the boat is achieved in a manner similar to the real world. The ACT software is displayed on a small monitor and controlled by a joystick (both identical to those used on actual RHIBs) which are mounted next to the driver providing blue force tracking and communication with the operations center.

5.2. Motivation for Human-Controlled RHIBs
The choice to develop immersive RHIB stations may seem extreme, given that the focus of experimentation was meant to be in the operations room. However, the information detected visually by the RHIB operators and communicated to the operations center is critical to operator decision making. Thus, it is important to make these inputs as realistic as possible.

In past simulation-based experiments, DRDC scientists have attempted to give white cell players a god's-eye-view of the simulation (showing the position and identity of all entities) and lists of rules about what information they could release to the rest of the team (in this case, the operations center) based on certain conditions. For example, as they got closer to an entity, they could reveal more and more details about what they saw (e.g., a small boat, or, a small fishing boat with two people onboard). Obviously this is simple to implement in terms of simulation requirements; in this case, the hardest part is creating reasonable rules and scripts for the white cell players to use. Yet, even with well developed instructions, the white cell players had difficulty not releasing too much information too soon, and in some cases missed information that they could have provided. It was clear that for future studies it would be better to eliminate this uncertainty by providing a first-person viewpoint through a visual display that would only allow the individual to learn the appropriate level of detail at the appropriate time. This is exactly what VBS2 does for the RHIB drivers.

It is also possible to have scaled back the hardware set-up, but given the use of readily available consumer-level components, the additional expense is easily justified by the increase in realism for the RHIB and small boat drivers. Further, it's a logical assumption that a better, more realistic experience for the boat operators will translate to increased realism for the simulation overall.

Figure 4 provides a high level conceptual overview of the vHarbour simulation components and the links between them.
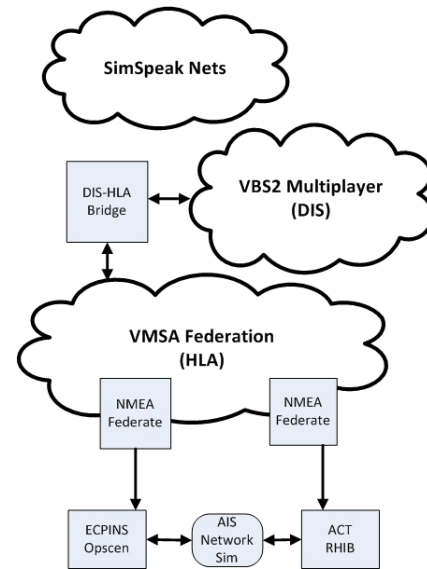

Figure 4: The vHarbour Simulation

6. vHarbour-ASSOCIATED COSTS
In 2010, the Canadian Army bought an Enterprise license of VBS2 so there was little cost associated with DRDC's use of VBS2 licenses. Contract support was used to assist with VBS2 model and terrain development as well as the development of the ScEr-V, radar, AIS and NMEA VMSA federates. These are now Crown IP and are reusable and applicable to future work efforts. ECPINS and ACT are COTS products that were purchased at a reduced price for simulation use only. SimSpeak is 100% Canadian Crown IP and available to DND users at no cost. The telephone line simulation is an inexpensive, commercially available product. The e-mail server was downloaded freely from VMWare. Headsets and all RHIB station components are commercially available and aimed at the entertainment industry thus making them affordable to the average person. Not including the initial costs of software development and integration, it is estimated that all of the components (including three computers) of a RHIB station without ACT can now be purchased for approximately $3500, including the VBS2 licences for those without access to an enterprise agreement. The remainder of the vHarbour setup was run on basic modern computers with desktop displays and keyboards.

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7. INCIDENT MANAGEMENT SYSTEM (IMS) EXPERIMENTATION

vHarbour was developed over approximately a one-year period with three computer scientists working on it part-time in addition to the aforementioned contractor support. Given the lead time needed to prepare the simulation environment, development began based on the early premise that the port security operations center could benefit from having an IMS system. After looking at a number of commercial systems and further considering their applicability to this environment in particular, it was felt that these systems offered capabilities exceeding what was really needed. Also, many IMS systems require considerable training and frequent practice to maintain proficiency. Evaluating system usability as part of the software selection process can minimize this problem (Randall 2011). However, to date, the authors have not identified a system that they believe is appropriate enough for this operational setting to take on the effort of organizing participants and engaging in the experimental process. While the simulation environment is near completion, plans to trial IMS systems have been reconsidered.

8. vRHIB

In July 2010, Halifax hosted an International Fleet Review (IFR) in celebration of the Canadian Navy's 100th birthday. In addition to many visiting foreign naval vessels, Her Majesty Queen Elizabeth II sailed in the harbour during the review. In preparation for this visit, a major force protection exercise was conducted in early June. Naval Reserve (NAVRES) port security unit (PSU) and CF boat operators would be patrolling the harbour on RHIB boats during the IFR and lead-up exercises. Since the ACT systems were a relatively new purchase for PSUs and indeed would not be shipped to Halifax until late in the exercise period, DRDC offered to assist the operators with ACT familiarization through the provision of a reduced version of vHarbour, focusing on the RHIBs themselves. Since the two threat vessel stations were identical to non-ACT RHIB station set-ups, four RHIB stations could be offered, one with ACT. The offer was accepted and with tight deadlines, vHarbour was stripped of the then unnecessary phone simulator and ship, and the operations center was reduced to a single station running ECPINS and a radio. All of the simulation control was reduced to run on two computers: one for the VMSA federation and another to run VBS2 in administrative mode. All of the scenario generation was moved from VMSA to VBS2 alone and the four RHIB stations were configured to be blue forces (rather than two blue and two red). This entire set up was then moved to HMCS SCOTIAN, the NAVRES unit where the pre-IFR exercise was being conducted, to make the simulation more accessible to the boat operators. It was set up in two rooms, one for the operations center (i.e., ECPINS) and one for the four RHIB stations. The originally envisioned plan of training boat operators within the full simulation environment became unnecessary when the actual ACT units arrived early and became available for real-world training. However, the trainers did end up making use of the simulation in an entirely different manner. They turned one of the RHIB stations around so that operator could not see the other operators and designated that RHIB as red force. The three remaining RHIB operators practiced working together as a team to deal with the threat vessel. New scenarios were requested on-the-fly and were implemented quickly within the VBS2 environment. Thus, the simulation was used by NAVRES for training in their own way, ultimately demonstrating the flexibility of this environment now that the core pieces are in place.

As a result of the initial success with using vRHIB, a contract has been let to refine the vRHIB environment such that it can be easily maintained and used for training within NAVRES units across Canada. This contract effort will also address issues related to integrating a new training system into existing training plans.

9. OFF-THE-SHELF SOFTWARE FOR SIMULATION ENVIRONMENTS

Low cost COTS simulations, games, and peripherals continue to increase in capability while decreasing in cost. DRDC Atlantic is currently using another COTS product, Dangerous Waters, as the core simulation engine for a human factors experimentation environment for the Victoria Class submarine's operations center. Many other COTS products are available and cover numerous simulation domains. Often these products can be leveraged for experimentation or training simulations aimed at concept or tactical development, where a 'close enough' look and feel is sufficient to meet the end goals of the simulation. Investigating the low-cost and serious games marketplace before engaging in the development of a completely custom simulation environment may indeed be time well-invested.

10. CONCLUDING REMARKS

With only a year's effort from a small part-time team, a simulation environment has been created to fully simulate all relevant inputs to a port security operations center. It was created inexpensively, using VBS2 as its backbone, supported with consumer-level electronics and devices, existing software components, and a modest amount of new software development. This environment can now be used for investigating the use of new software or procedures and plans in the operations center. A simplified version of this flexible environment focusing on a team of RHIB drivers was able to support real-world tactical team training efforts. In the future, a refined version of the RHIB team simulation will be made available for training use by all NAVRES port security units in Canada.

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