Defence Research and Development Canada | Recherche et développement pour la défense Canada

DEFENCE R&D DÉFENSE

Simulation-Based Training for IED Awareness

Best Practices and Experiences

Jerzy Jarmasz
Dorothy Wojtarowicz
Jason Dielschneider
Ken Ueno

Defence R&D Canada
Technical Memorandum
DRDC Toronto TM 2013-027
March 2013

Canada

Simulation-Based Training for IED Awareness

Best Practices and Experiences

Jerzy Jarmasz
Dorothy Wojtarowicz
Jason Dielschneider
Ken Ueno

Defence R&D Canada – Toronto

Technical Memorandum
DRDC Toronto TM 2013-027
March 2013

Principal Author

Original signed by Jerzy Jarmasz

Jerzy Jarmasz

Defence Scientist

Approved by

Original signed by Linda Bossi

Linda Bossi

Head, Human-Systems Integration Section

Approved for release by

Original signed by Dr. Joseph V. Baranski

Dr. Joseph V. Baranski

Chair, Knowledge and Information Management Committee, Acting Chief Scientist

The work reported here was performed under Project 12rr03, IED Awareness Training (Counter-IED TDP).

Abstract

Improvised Explosive Devices (IEDs) have been major threats to CF soldiers in recent conflicts (e.g., in Afghanistan) and will likely continue to be a threat in the foreseeable future. Accordingly, Defence Research & Development Canada - Toronto (DRDC Toronto) has been investigating training methods and technologies to better prepare soldiers to detect and assess IED threats in theatre. One of these tools, the IED Awareness Simulator, was designed by DRDC Toronto around the "serious games" Virtual Battle Space 2 (VBS2) platform, for the purpose of training the team aspects of IED detection in convoys. This report describes the design requirements for the IED Awareness Simulation, the procedures we developed for using it during counter-IED training events, and our "lessons learned" about what works well and what doesn't in the simulator, in particular regarding its core application, VBS2. We conclude with recommendations for the development of future synthetic training environments for teamwork and command-and-control in tactical asymmetric conflicts.

Résumé

Les dispositifs explosifs de circonstance (IED) ont constitué un grand danger pour les soldats des FC au cours des conflits récents (p. ex. en Afghanistan) et continueront probablement de poser un danger dans un avenir rapproché. Recherche et développement pour la défense Canada (RDDC) Toronto étudie donc des méthodes et des technologies d'instruction pour mieux préparer les soldats à détecter et à évaluer les dangers que présentent les IED dans le théâtre. Un de ces outils, le simulateur sur la lutte contre les IED, a été conçu par RDDC Toronto en se servant du jeu sérieux Virtual Battle Space 2 (VBS2) comme plateforme afin d'enseigner à une équipe les particularités de la détection des IED dans un convoi. Le présent rapport décrit les exigences de conception de la simulation sur la lutte contre les IED, les procédures que nous avons élaborées pour les instructions sur la neutralisation des IED, et les « leçons retenues » sur ce qui fonctionne et ce qui ne fonctionne pas dans le simulateur, notamment en ce qui a trait à son application principale, soit VBS2. Pour conclure, nous formulons des recommandations sur la mise au point future d'environnement d'instruction sur simulateur pour le travail en équipe et le commandement et contrôle dans les conflits aux tactiques asymétriques.

This page intentionally left blank.

Executive summary

Simulation-Based Training for IED Awareness: Best Practices and Experiences

Dorothy Wojtarowicz; Jason Dielschneider; Ken Ueno; Jerzy Jarmasz; DRDC Toronto TM 2013-027; Defence R&D Canada – Toronto; March 2013.

Introduction or background: The ongoing threat of Improvised Explosive Devices (IEDs) to Canadian and Allied troops in recent conflicts presents major force protection and training challenges. Defence Research and Development Canada (DRDC) Toronto has been investigating a number of Counter-IED (CIED) training technologies to help the Canadian Forces (CF) better prepare troops for the IED threat. This report focuses on DRDC Toronto's investigations of simulation-based training for IED awareness in convoys.

Results: We developed a CIED team training environment, the IED Awareness Simulator, built around a commercial simulation platform, Virtual Battle Space 2 (VBS2). A consideration of the requirements for a synthetic CIED training environment showed that VBS2 could not meet all the requirements alone, and thus a system that integrated new or existing components with VBS2 had to be developed to create a CIED training platform. Despite these additions, IED Awareness Simulator is still limited by certain features (or lack thereof) of its central component, VBS2. Thus, we also developed systematic procedures and "work-arounds" for CIED training with the IED Awareness Simulator, which are also documented in this report.

Significance: As VBS2 is now widely used for small-team tactical land forces training, in the CF and in allied countries, there is a large user community encountering issues similar to ours with VBS2. Thus, we feel that many of our insights are relevant to other users of VBS2-based training systems and could provide input for the development of standard procedures for using VBS2 for training, as well as inform acquisition decisions related to simulation-based training in the CF and allied military forces. We also identify areas of research that should be addressed for the acquisition or development of future simulation-based, small-team, tactical training systems.

Future plans: As the project under which this work was conducted is wrapping up, there is limited scope to continue the development and experimental evaluation of the IED Awareness simulator. However, we expect that our insights will serve to inform future research into simulation-based training at DRDC Toronto and elsewhere.

Sommaire

Simulation-Based Training for IED Awareness: Best Practices and Experiences

Dorothy Wojtarowicz; Jason Dielschneider; Ken Ueno; Jerzy Jarmasz; DRDC Toronto TM 2013-027; R & D pour la défense Canada – Toronto; mars 2013.

Introduction ou contexte: Introduction ou contexte : Le danger actuel que présentent les dispositifs explosifs de circonstance (IED) pour les troupes canadiennes et alliées dans les récents conflits représente un important défi en matière de protection des forces et d'instruction. Recherche et développement pour la défense Canada (RDDC) Toronto étudie donc plusieurs technologies de formation sur la neutralisation des IED pour aider les Forces canadiennes (FC) à mieux préparer les troupes pour les dangers des IED. Le présent rapport se concentre sur les études de RDDC Toronto sur l'instruction par simulation sur la lutte contre les IED en ce qui concerne les convois.

Résultats: Nous avons mis au point un environnement d'instruction d'équipe sur la lutte contre les IED, soit le simulateur relatif aux IED, lequel est basé sur la plateforme de simulation commerciale Virtual Battle Space 2 (VBS2). Lorsque les exigences d'un environnement d'instruction sur simulateur sur la lutte contre les IED ont été prises en compte, il a été déterminé que VBS2 ne pouvait pas respecter seul les exigences, donc un système intégrant des composants nouveaux ou existants à VBS2 a dû être mis au point pour créer une plateforme d'instruction sur la neutralisation des IED. Malgré ces ajouts, le simulateur sur la lutte contre les IED est toujours limité par certaines caractéristiques (ou l'absence de caractéristiques) de VBS2, son principal composant. Ainsi, nous avons également élaboré des procédures systématiques et des « solutions de rechange » pour l'instruction sur la neutralisation des IED à l'aide du simulateur sur la lutte contre les IED. Les procédures sont également décrites dans le présent rapport.

Importance: VBS2 est actuellement largement utilisé pour l'instruction tactique de petites équipes des forces terrestres tant dans les FC que dans des pays alliés. Il y a ainsi une grande communauté d'utilisateurs confrontés à des problèmes dans VBS2 semblables aux nôtres. Nous estimons donc que beaucoup de nos idées sont pertinentes pour les autres utilisateurs de systèmes d'instruction fondés sur VBS2, et que nous pourrions contribuer à l'établissement de procédures normalisées sur l'utilisation de VBS2 pour l'instruction. Nous pourrions également éclairer des décisions d'approvisionnement liées à l'instruction axée sur la simulation dans les FC et les forces armées alliées. Nous avons également identifié des domaines de recherche dont il faudrait tenir compte dans l'approvisionnement ou la mise au point future de systèmes d'instruction tactique de petites équipes axés sur la simulation.

Perspectives: Le projet pour lequel les présents travaux ont été effectués se termine, donc il y a peu de marge de manœuvre pour continuer la mise au point et l'évaluation expérimentale du simulateur sur la lutte contre les IED. Toutefois, nous nous attendons à ce que nos idées soient utilisées pour éclairer la recherche future sur l'instruction axée sur la simulation tant à RDDC Toronto qu'ailleurs.

Table of contents

List of figures

List of tables

Acknowledgements

The authors would like to thank the many Defence Research & Development Canada (DRDC) staff, Canadian Forces (CF) personnel and contractors who have contributed to the work described in this report, and without whom this work would not have been possible.

The following were instrumental in conceiving of, designing and producing the Actions-On training videos: Mr. Matt Lamb, Cpl Ryan McHugh, Mr. Jim Clarke and MCpl Scourtoudis, from DRDC Toronto; Dr. Phil Eles and Sgt Gerald Darcy, from DRDC Centre for Operational Research and Analysis (CORA), providing information on Improvised Explosive Device (IED) attack patterns in theatre for the scenarios; Area Training Centre Meaford for providing voice actors, simulation "actors" and facilities for the recording of the videos; 2 Combat Engineer Regiment (CER), 32 Combat Engineer Regiment, the Counter-IED (CIED) Task Force and the CIED cell of the Tactics School, Combat Training Centre (CTC) Gagetown, for providing subject matter experts during the scenario development process; the Army Learning Support Centre (CTC Gagetown) for assistance with the video production. Special thanks go to Capt Fox from the Tactics School for his unwavering support of the project, helping to liaise with personnel at CTC Gagetown, and for integrating the final products into the Army's library of electronic teaching materials.

The following were key in supporting our work with the IED Awareness Simulator: Dr. Alexandra Muller-Gass, Dr., Vladimir Zotov (DRDC Toronto), assessors from 32 CER and the Advanced Warfare Training Team (32 Canadian Brigade Group), and the Land Software Engineering Centre (Director of Land Command Systems Program Management) supported our training trials at DRDC Toronto, which involved the Governor General's Horse Guards, 25 Service Battalion and Psychological Operations TF1-10; Capt Jerome Robin-Theriault and personnel from the Simulation Centre at Canadian Forces Base (CFB) Valcartier supported our training study with the Royal 22e Régiment. HumanSystems Inc. (Guelph, Ont.) supported our studies both at DRDC Toronto and CFB Valcartier. Special thanks go to Capt Chris Taff and Mr. Don MacQuarrie of the Land Software Engineering Centre, who supported our simulation-based CIED training work throughout the project by giving us access to technical support, software development resources, contracting vehicles and their extensive experience in military modeling and simulation.

This page intentionally left blank.

1 Introduction

1.1 Background

Improvised Explosive Devices (IEDs) continue to pose a significant threat to the safety of Canadian Forces (CF) personnel currently deployed in combat and peace support operations, and are expected to continue to do so into the future (Army Lessons Learned Centre, 2010). Efforts are ongoing throughout the CF and the Department of National Defence to mitigate the IED threat and protect troops. Due to their improvised nature, it is difficult to identify and predict patterns in IED attacks. Technology helps but often the naked eye is still the best sensor for IEDs (Zorpette, 2008) and recent research suggests that cognitive skills play an important role in detecting IEDs (Murphy, 2010). Thus, there is a need to train soldiers to become proficient at visually detecting and identifying signs of an imminent IED attack. One area the CF is interested in improving is simulation-based training of counter-IED (C-IED) skills.

The nature of IED threats as well as the "irregular" conflict context pose quite a training challenge. IEDs by design are meant to not be found, or to be so obvious that they distract attention from the real threat. Furthermore, as coalition forces learn to counter specific types of IEDs, insurgents quickly adapt (Eles, 2009). This cycle of deception and adaptation places great pressure on military doctrine and training systems to adapt to new adversary tactics and integrate lessons learned from theatre into pre-deployment training. However, it also requires specific skills by insurgents, the coordination (willing or not) of many people (insurgent networks and financiers, as well as local inhabitants), and opportunities to stage the attacks. Thus, a successful IED attack is difficult and the process can leave a number of cues (“combat indicators” in doctrinal terms), both physical and behavioral (e.g., overt observation by insurgents), which might alert coalition forces or local inhabitants.

While detecting IED indicators is possible in principle, doing so in practice is difficult. Indicators can be understood as alterations of the physical and social environment in which they are emplaced. Thus, effective IED detection requires a good understanding of “normal” environmental conditions, in order to then determine the “alterations” due to IED emplacement activity. Also, indicators may be spread out over time and space, and may change as the IED attack progresses from emplacement to detonation, making associations difficult. This spatio-temporally distributed nature of IED attacks means that integrating multiple indicators into a coherent picture would likely require a team effort between the members of tactical units, allied security forces, the supporting headquarters and intelligence elements. This assessment of IED threat awareness as a team cognition task is supported by a Cognitive Task Analysis (CTA) of IED detection in Canadian Forces convoys (Bruyn Martin & Karthaus, 2009) that identified “judg[ing] whether an object, behavior or pattern of life is atypical,” “interpret[ing] potential IED indicators” and “develop[ing] and maintain[ing] a shared situation awareness” as some key skills underlying IED detection within convoy operations.

Simulation-based training is emerging as a cost-effective way of providing training for team skills in military contexts (Roman & Brown, 2008; National Research Council of the National Academies, 2008; Zachary, Scolaro, Stokes, Weiland & Santarelli, 2004). However, military simulations have traditionally focused on conventional force-on-force scenarios, whereas recent military operationshave become more “asymmetric” or “irregular” in nature. Such missions usually involve interaction with civilian populations (e.g., providing humanitarian assistance, coordinating activities with local authorities) to a higher degree than the conventional force-on-force scenarios, while also conducting combat operations against non-state actors in complex terrains, often using improvised weapons such as the above-mentioned IEDs. As noted in relation to IEDs above, this type of mission emphasizes team and cultural skills, and a need to adapt to rapidly developing adversary tactics, in a manner that conventional force-on-force conflicts do not. Accordingly, simulation-based training platforms and methods for irregular warfare capabilities, such as counter-IED skills, are still very much an area under development (National Research Council of the National Academies, 2008).

Thus, DND is interested in developing and evaluating simulation-based training for “irregular” warfare, including preparing soldiers to detect, avoid and neutralize IEDs. Accordingly, DRDC stood up the CIED Technology Demonstration Project (TDP), which includes a number of training sub-projects. One of these sub-projects, the IED Awareness Training project led by DRDC Toronto, has been working to develop a range of training tools for training IED detection and threat assessment skills. The various tools developed by the project target a range of skills and contexts (from individual to small team training), and include a variety of technologies, from video-based training packages to 3D, multiplayer, “serious game” simulations (see overview in Jarmasz et al., 2010).

Two of the project’s training tools were developed using the same core simulation technology, namely Virtual Battle Space 2 (VBS2, Bohemia Interactive). These are the CIED “Actions-On” Training Videos and the IED Awareness Simulator. The focus of this report is the IED Awareness Simulator, a synthetic training environment that is based on “first-person shooter,” 3D, multiplayer, gaming technology. Specifically, the report discusses the “concept of employment” and procedures we developed for the employment of the IED Awareness simulator, as well as the lessons learned about its limitations and how to work around them. However, before discussing the IED Awareness Simulator, we will briefly describe the “Actions-On” videos, as their development also contributed to our understanding of VBS2 as a training tool within the IED Awareness Simulator.

1.2 Overview of the “Actions-On” Videos

Our first use of VBS2 as a synthetic environment for simulating CIED procedures was for creating synthetic demonstration videos called Actions-On videos. Using an “authoring as acting” method (Fu, Jensen & Hinkelman, 2008), infantry soldiers acted out drills appropriate to five CIED scenarios in the VBS2 environment. The VBS2 animation was captured as video files and subsequently edited into instructional videos. At the time, we only used the VBS2 platform, and the additional capabilities described in the next section were added later, partly as a result of our experiences producing the videos. Notably, audio communications functions were not used, and the sound tracks for the videos were recorded separately from the VBS2 action.

It is beyond the scope of this report to describe in detail the production process of the Actions-On videos. Here we will briefly discuss the aspects of the process that were relevant to working with

VBS2 and the subsequent IED Awareness Simulator. To conduct the simulation events during which we captured the video "footage" that was used to make the videos, we:

- Developed five CIED scenarios and validated them with SMEs from the CF CIED training community;
- Implemented the scenarios in VBS2, which involved choosing appropriate terrain maps, player, vehicle and IED models, positioning them appropriately to start the scenario, programming some simulation events using the VBS2 scripting language, and planning some events to be triggered or executed by a system administrator during the simulation events;
- Put together a hardware setup that allowed multiple players to carry out the drills set out in the scenarios and to record their actions in VBS2; this involved one computer acting as a central server, connected to a number of client computers (one for each "player" as well as a few stations dedicated to video capture for specific scenes) and a networked external hard drive for data storage via a high-speed (1 Gigabit per second) Ethernet network switch;
- Had the soldiers perform the drills, with a "director" coordinating the actions as would the case in producing a conventional video, while commercial video capture software (FRAPS, from Beepa Pty Ltd, Albert Park, Australia) recorded the VBS2 action frame-by-frame.

We developed five scenarios (described below) of increasing complexity with regards to the IED attacks and the response required from the "players." The scenarios were developed and storyboarded with CIED instructors from the CF. This set of scenarios were intended to provide a progression of mission complexity in order to ease the training audience into CIED training. At the same time they were designed to meet key teamwork training objectives in convoy operations in IED environments. Thus they formed the basis of the scenario progression we applied in subsequent training studies with the IED Awareness Simulator, described below. This first experience with VBS2 also taught us a number of things about the platform's capabilities, which shaped our employment of it in later studies. In particular, we discovered that the artificial intelligence (AI) capabilities available in the VBS2 scripting language for controlling human and vehicle entities was rudimentary and inadequate for automating most of the actions required in the scenarios. Thus, human actors were required for controlling each human or vehicle entity in the simulation, rather than automating some of them via scripts. The limitations of the AI in VBS2 were a recurring limitation in our studies with VBS2.

From the action recorded in VBS2, we produced five training videos with the help of the video production section at DRDC Toronto. The titles and run times of the videos are as follows:

1. IED Find (7:00 min);
2. QRF & EOD Response to an IED Find (14:30 min);
3. IED Strike, Convoy Speed Through (06:00 min);
4. Vulnerable Point Search, IED Strike, Vehicle Mobility Kill (10:00 min); and
5. IED Strike, Mass Casualties, Medical Evacuation (10:30 min).

The videos were accepted into the repository of electronic CIED training materials at the Tactics School, Combat Training Centre (CTC) Gagetown. They are available only either online on CTC

Gagetown's Documentum portal (accessible on DND's intranet) or by request from the authors. The concept of employment of the videos is to serve as supplementary classroom materials during CIED courses, or as preparation for convoy drills practice in field or computer-assisted exercises. While we have not had the opportunity to assess the effectiveness of the Actions-On videos as preparation for conducting field or computer-assisted exercises, we conducted a study evaluating user impressions of one of the videos in a classroom setting during a CIED course. An overview of that study is provided in Jarmasz et al. (2010).

1.3 Overview of the IED Awareness Simulator

The IED Awareness Simulator is an interactive, multiplayer virtual environment for small-team tactical operations (both mounted and dismounted) designed to allow small teams to practice convoy procedures in an IED threat environment. At its core is the VBS2military training simulation, which supports primarily the simulation of land operations at the small team (generally company level and below) level. Other capabilities (voice communications, data logging, crowd simulation) have been added to VBS2, some of which are still under development, and which are described in more detail in Section 2.

The intent of the IED Awareness Simulator is to provide a virtual environment where small units can practice CIED Tactics, Techniques and Procedures (TTPs; Department of National Defence, 2006) and the teamwork aspects of IED awareness and effective CIED drills that were identified through our CTA (Bruyn Martin & Karthaus, 2009) and in discussions with SMEs. The focus on convoy operations was chosen because, for most of the CF's combat mission in Afghanistan (specifically in Kandahar province), the main CF targets of IEDs have been convoys (Eles, 2009). Rather than replace live field exercises, our intent is to provide an environment for soldiers to practice or "shake out" their drills before engaging in a live exercise, in order to make the live exercise more effective. In one of the few known reports in the open literature assessing training effectiveness with VBS2, Hill (2008, cited in Roman & Brown, 2009) describes a successful example of combining simulation-based and live training in the CF. VBS2 was used to replace part of the life training component in the Troop Warrant Officers course, which is a 6 week, mostly hands-on course given regularly at CTC Gagetown. The study compared, among others, the student pass rates at the end of the course and the cost savings between the last serial of the course, which used no VBS2, and the first two serials to use VBS2 (1 day and 2.5 weeks of VBS2 training respectively) prior to the live training component (which was commensurately scaled back). The pass rate at the end of the course for the last serial with no VBS2 was 72%, whereas it was 83% and 100% for the serial with 1 day and 2.5 weeks of VBS2, respectively. At the same time, the costs to run the course decreased by 33% between the last all-live scenario and the serial with 2.5 weeks of VBS2 training. While the study had a number of limitations (different instructors for each course, no assessment of transfer-of-training, etc.), it made a compelling case for the effectiveness of VBS2 as a complement to live training for at least some Army applications.

The above considerations resulted in the following initial requirements for the IED Awareness Simulator:

- Simulate CF convoy missions of different types (Combat Logistics Patrol, mechanized infantry show-of-force patrol, reconnaissance mission, etc.), and a range of dismounted operations, which implied the ability to simulate appropriate vehicles and equipment, including communications network and weapons;

- Create IED events that involved a number of elements distributed in space and time; that is, not just the device, but also the insurgents involved in the attack (e.g., triggermen or spotters), and combat indicators that may have been created by the IED emplacement (disturbed earth, piles of rocks, etc.; a more complete list can be obtained in Department of National Defence, 2006);

- Terrain detailed enough to allow for realistic attack patterns, such as those identified by Eles (2009), to be implemented; primarily this requires simulated dirt and paved roads, hills, roadside ditches, 'wadis' (i.e., dried-up riverbeds), culverts, and would ideally involve terrain that is "geotypical" of (similar in appearance to) the Kandahar region in Afghanistan;

- Record simulation data (player actions, simulation events, the occurrence of certain conditions such as vehicles passing certain landmarks, etc.) and voice communications for later analysis;

- Provide a virtual after-action review (AAR), including the voice communications, to the primary training audience (PTA) at end of event;

- Support easy scenario development by instructors;

- Represent non-combatant civilian activity, as SMEs and the CTA we performed showed that civilian activity patterns or "pattern of life" to be a key source of information for decisions by soldiers in IED and other threat contexts.

VBS2 was chosen because it is already widely in use in the CF and allied militaries, despite the fact that there are few commonly accepted standards for the use of serious games and a lack of objective training effectiveness evidence, with the exception of rare studies such as Hill (2008) reported above (Roman & Brown 2009). VBS2 comes close to meeting many of the requirements set out above. However, it has a number of limitations which prevents it from fully meeting our objectives. Namely: the terrain and object models are not realistic enough to implement all desired scenarios; the default in-game audio communications are impractical and limited; the AI for controlling entity behaviour is rudimentary (as discussed above); the AAR functionality is unreliable and does not support integration with voice communications "out of the box;" and the options for capturing data from the simulation are very limited. VBS2 by itself was not sufficient to fully support CIED training, thus a number of additional capabilities were (or will be) integrated with VBS2 into the IED Awareness Simulator. At the same time, not all limitations could be addressed this way, and thus the employment of the IED Awareness Simulator required the careful scoping and management of training scenarios in order to make most effective use of the platform's strengths while avoiding its weaknesses. Perhaps most importantly, it became clear to us early on, even at the stage of producing the Actions-On videos described above, that VBS2 does not provide the visual realism and level of detail required for accurately simulating emplaced IEDs or detailed indicators of such emplacements, such as disturbed earth. Thus, we made the strategic decision of employing the IED Awareness Simulator specifically for training team coordination and team cognition (i.e., team situation awareness of "coarse" IED threats), while addressing the training of detailed IED cues and indicators using a different training tool. This tool, Environment Familiarization and Indicator Trainer (EFIT), uses real video from an operational environment, rather than computer-generated visuals, and thus is better suited to training the recognition of detailed IED indicators and environmental patterns that can be related to IED attacks. An overview of our approach of using different training tools for different aspects of IED awareness training is given in Jarmasz et al. (2010).

The next section of this report discusses a “system architecture” of software components for the IED Awareness simulator we have designed to meet the requirements set out above and the technical set-up we have actually used during various simulation events. Next we discuss our approach to scenario development, the procedures and the technical “work-arounds” we developed for employing the simulator for CIED training events. Finally we review outstanding technical issues with the IED Awareness Simulator as a training tool suited to the CF’s needs and work we consider should be carried out in order to address them.

2 System Architecture and Technical Set-Up

2.1 Intended System Architecture

As discussed in the introduction, the VBS2 platform does not meet all the requirements for the IED Awareness Simulator on its own. We have thus designed a system architecture that integrates other software components to provide all the required functionalities. The components involve a mix of commercial software, applications developed on contract to the Crown for other projects, and some custom software currently under development. In this architecture, VBS2 handles the majority of the scenario generation, in-game action, and AAR functionalities, while other functions are performed by other modules as follows:

- Voice communications, via one of two applications: CNR Sim (Calytrix Inc, bundled with VBS2 by Bohemia Interactive), or SimSpeak (radio net simulation developed for the Crown). These also support playback of voice communications during the AAR.
- Crowd behaviour simulation, via the Civilian Activity Modelling for eXercises and eXperimentation (CAMX) application (also developed for the Crown, described in Levesque, Cazzolato & Martonosi, 2009)
- Data collection and logging (in progress, likely to involve the use of the Virtual Command and Control Interface (VCCI) database framework developed for the Crown (MacQuarrie, Taff, Asselstine, Hans & Reid, 2008)
- Scenario generation module (in progress, at this point likely to be limited to a system that models insurgent activity patterns to automate the emplacement of IEDs in a given scenario).

The intended final system architecture is shown in Figure 1. To date, the only components that have been integrated at DRDC Toronto are VBS2 and the voice communications software (Comm Net Radio (CNR) Sim or SimSpeak have both been used, with SimSpeak eventually chosen due to its IP belonging to the Crown). The CAMX system for crowd modeling has been under constant development during the life of IED Awareness Training project, and while early iterations have been used by certain CF units in conjunction with VBS2 already, it was not available to us during our studies to date. Similarly, the database application upon which the data collection capabilities will be built (VCCI) has been in use at the Directorate of Land Synthetic Environments (DLSE) for some time, but has not yet been integrated into the IED Awareness Simulator because our data collection activities to date have not required its capabilities yet. The scenario generation capability, in the form of an automated system for IED emplacement in VBS2, is in early stages of development and is not expected to be ready for use for some time.

It is our intention to conduct further training studies with the IED Awareness Simulator once most or all of the capabilities called for in its intended architecture are available. The following sections describe how we used the components available to us during the studies we have been able to conduct, including how we mitigated the lack of the above capabilities through certain procedural and scenario design choices. These mitigating strategies, and the ways in which they sometimes failed to meet our initial requirements, reveals a number of shortcomings of the VBS2 platform. Our proposed architecture for the IED Awareness Simulator is one way in which VBS2 can be augmented by other tools to ensure the CF gets full value from VBS2 as a small-teams training tool, particularly for “irregular” warfare missions such as CIED.

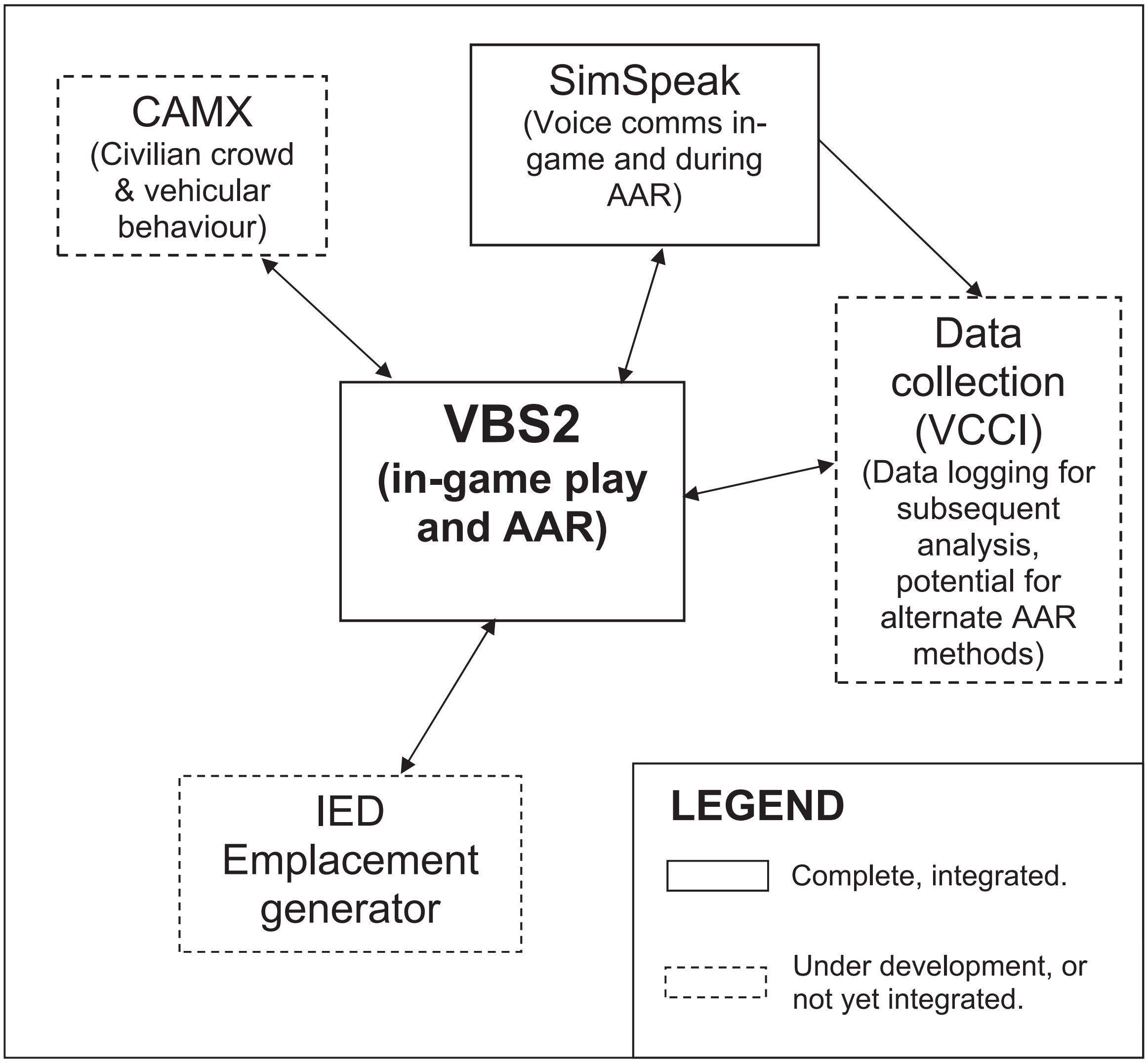

Figure 1 : Proposed architecture for the IED Awareness Simulator.

2.2 Actual Setup-up

The set-up we used for the IED Awareness Simulator during our studies varied somewhat. The set-up we arrived at after a few iterations was as follows:

- We used VBS2 (versions 1.21 to 1.23), running on a central server desktop computer running the Windows operating system (Microsoft Inc.) , and a number of client machines (either laptops or desktop Windows computers), networked using a fast (1 Gigabit per second) Ethernet network switch. The central server machine was used by the system administrator to set up the scenarios and control them in real-time during simulation events. The client machines were used by the players or by observers wishing to monitor gameplay from "within" the simulation. A stand-alone desktop computer was also used to run VBS2 for the purposes of replaying the AAR after training events.

- For voice communications, either CNR Sim or SimSpeak, described above, were used, also running in a client-server architecture on the same machines as VBS2. The CNR Sim or Simspeak servers recorded voice communications during gameplay and synchronized them with VBS2 during AAR playback.
- The players used standard computer keyboards, but 6 stations also had a Universal Serial Bus (USB) driving peripheral (a steering wheel and pedals), to provide a more realistic control interface for the players who were in the role of vehicle drivers in the game.
- Analog headsets with microphones were used to ensure a more realistic experience for the radio voice communications.

Technical details of our set-up are provided in Annex A. Using this set-up, we conducted four training events. These events have allowed us to provide CIED training to CF troops while at the same time developing procedures for the following: employing the simulator, assessing performance of the PTA, and assessing the effectiveness of the simulator. These events also helped us understanding the simulator's limitations as a training environment and to suggest improvements to it. The trials we conducted involved the following units:

1. Governor General's Horse Guards (Primary Reserve reconnaissance unit), Unit Training, 20-22 February 2009 at DRDC Toronto;
2. Royal 22^{e} Régiment (Regular Force infantry unit), Pre-Deployment Training (Operation ATHENA Task Force 3-09), 9-13 March 2009 at CFB Valcartier;
3. 25 Service Battalion (Primary Reserve combat services support unit), Unit Training, 8-10 May 2009 at DRDC Toronto;
4. Task Force 1-10 Psychological Operations Platoon, Pre-Deployment Training (Operation ATHENA), 20-24 Jul 09, DRDC Toronto.

While all of the events were conducted as training events for the benefit of specific units, the first three were also conducted as experimental studies. Data were collected in conformity with the DRDC guidelines on research with human participants (Defence Research & Development Canada – Toronto, 2003). The fourth event was not a formal training study but nevertheless allowed us to continue to refine our procedures and develop our understanding of the strengths and weaknesses of VBS2 combined with SimSpeak or CNR Sim as a training platform. An overview of our training studies with this system is given in Jarmasz et al. (2010). The following sections describe the strategies and procedures we developed for employing this system while attempting to satisfy our original set of requirements for the IED Awareness Simulator. While our lab set-up has continued to evolve, and we now have VBS2 version 1.45 and CAMX installed, we feel that the vast majority of the observations and insights we report in the following sections still hold.

3 Scenario Development

3.1 General considerations

"An IED attack is the result of a planned tactical operation with several key elements that work in a coordinated and synchronized manner to attain a desired result." (Department of National Defence, 2006)

Training effectiveness and transfer are primary concerns with any training system. What is less clear is how to ensure that a given system is effective for training the tasks it is targeting. Simulation systems have traditionally focused on replicating the physical aspects of the target task environment in order to ensure transfer, aiming for what is often called "physical fidelity." This approach assumes that the non-physical (e.g., the knowledge or teamwork) aspects of the task are implicitly captured by replicating the physical aspects of the environment (Elliott, Dalrymple, Schiflett & Miller, 2004). However, there is a growing recognition that, for many tasks, particularly those with a significant cognitive or teamwork aspect, simply aiming for high physical fidelity is not enough, and that care must be taken to explicitly build the more psychological aspects of the task into the synthetic environment. That is, it is often important for simulations to explicitly aim for so-called "psychological fidelity" as well (Elliott et al., 2004; Kozlowski & DeShon, 2004).

The key to ensuring psychological fidelity in a simulation-based training system is to design training scenarios for the system that are explicitly guided by the cognitive skills and information requirements uncovered by an analysis of the target task, as well as fundamental principles from instructional design (Elliott et al., 2004; Kozlowski & DeShon, 2004). Thus, we developed a systematic approach to designing IED Awareness training scenarios that explicitly supported the individual and collective cognitive aspects of IED Awareness. These were determined by the CTA we conducted (Bruyn Martin & Karthaus, 2009) and the analysis of IED attack patterns by Eles (2009). The key findings of these analyses were as follows: soldiers operating in an IED threat environments develop a tacit (i.e., intuitive and difficult to verbalize) understanding of the "logic" of IED attacks. In particular, they develop an intuitive understanding of how different environments support or favour different types of attacks. Soldiers also develop a tacit understanding of the patterns of human activity in a given area (often called "pattern of life" by soldiers), thereby learning to distinguish "normal" (presumably statistically regular) patterns from anomalous activity which may indicate that an IED attack is imminent. Finally, effective avoidance and responses to IED threats in convoy missions requires effective coordination and communication between team members, especially with respect to perceived threat cues.

Thus, our intention when designing training scenarios was to support the skills and knowledge uncovered by our analyses by designing sets of incidents that progressed the PTA through a variety of IED events of increasing complexity (a well established principle of instructional design) that conformed to the logic of IED attacks described by Eles (2009). As one key skill in IED Awareness is to be able to detect anomalies, and by implication to understand what counts as "normal," in a given environment, we allowed the PTA to develop a familiarity with the terrain by situating all the scenarios for a given training event on the same VBS2 terrain map. The progression in IED attack complexity was based on the sequence of scenarios designed for the Actions-On training videos described above, and which was vetted by C-IED and training SMEs.

Unlike the intended sequence for the Actions-On videos, we chose to place the IED find scenario at the end of the scenario sequence. We also included scenarios that did not involve an IED event (i.e., the PTA was given a primary, convoy-related task, and the secondary task of scanning for IEDs, but no actual IED events were built into the scenario).This allowed the PTA to become familiar with what counts as "normal" in the synthetic environment before being required to detect the "anomalies" that indicate a possible IED emplacement. It also allowed the PTA to learn that not all convoy missions are associated with IED events. We speculated that including an IED event in every scenario would leave the PTA with the impression that every convoy mission necessarily involves IEDs, which might lead some PTA members to adopt a fatalistic or "learned helplessness" (Seligman, 1975) mindset. (Unfortunately testing this hypothesis was beyond the resources available to this project). A sample of a typical scenario progression that we used is given in Annex B.

Before discussing some aspects of our scenario design in more detail, we acknowledge that scenario-based training per se is common practice in CF simulation centres, and our intention with this work is to supplement and enhance current practice within CF simulation-based training. Our informal observations of CIED training at CF simulation centres suggests that while simulation centre staff are often very experienced with simulation systems and with designing generic Army training scenarios, they often did not have the operational experience or access to information that would have allowed them to support a high degree of psychological fidelity for IED Awareness training. Also, current procedures in effect at CF simulation centres, to our knowledge, do not mandate the use of operational analysis or recent lessons learned about the most recent IED threats in theatre, nor the systematic use of front-end analysis, to identify the specific skills and knowledge that troops needs to develop for mission-specific training. This is a particular problem when doctrine for mission-specific training is very much in flux, as it was for CIED TTPs during the CF's combat mission in Afghanistan. Thus, despite the staff's best efforts, we observed uneven quality of CIED training scenarios in sim centres, with some scenarios representing the "logic" of IED attacks quite well, while others representing IED attacks in a very unrealistic manner (relative to what had been observed in theatre by analysts and SMEs). Thus, we present our scenario design approach here with the intention of supplementing current CF simulation-based training practices and to provide an example of a systematic approach to mission-specific training for future CF missions.

Finally, we note that note that supporting psychological fidelity in CIED training goes beyond the design of specific VBS2 scenarios. The manner in which the scenarios are presented to the PTAs and in which the training event itself is conducted by the training cadre can also have a major effect. Section 4 describes the overall procedures we developed for the conduct of simulation-based IED Awareness training. In the remainder of this section we give more detail on specific aspects of our approach to scenario development.

3.2 Generating content for training scenarios

Creating training scenarios in VBS2 generally involves the creation and management of specific content (maps, vehicle and equipment models, human entities and scripting events) using the VBS2 content management facilities. It is possible to automate some events in VBS2 scenarios using scripts (simple programming commands). However, VBS2's scripting capabilities are limited, and thus we often found it more convenient for the events in the scenario to be triggered or carried out in real time by human "players," be they the PTA itself or enemy or neutral role player, and by the system administrator, during the simulation itself. In the following sections we will discuss some of our insights and experiences pertaining to the technical aspects of creating and managing content, for training scenarios in VBS2 for the IED Awareness Simulator.

3.2.1 General considerations – managing content

VBS2 provides models for terrain, environment features, vehicles, equipment, weapons, and living entities (human and animal), as well as a few generic training scenarios, "out of the box." However the system is customizable to a degree, and it supports the addition of user-created or third-party content packs as well as custom scenarios or maps. Managing this content can become onerous and confusing if it is not organized in a systematic or rational manner. A technical discussion of this is provided in Annex C.

3.2.2 Choosing a Terrain

IED attacks patterns depend heavily on the opportunities for emplacement, concealment, overwatch and escape provided by the environment (Army Lessons Learned Centre, 2010; Eles, 2009). Terrains in VBS2 must be carefully selected, because the choice will constrain the type of scenarios that can be implemented. At the same time, more complex and realistic terrains make more demands on the system, which can lead to poor computer performance during a training event. Thus, choosing a terrain involves making trade-offs between scenario objectives and system limitations; in some cases, the scenarios and training objectives may need to be revised due to terrain considerations.

VBS2 maps and terrain content are paged (that is, only relevant parts of the terrain map are activated in memory at a given time), and can therefore in theory be of unlimited size. In practice however, maps generally represent less than a 50 km × 50 km area in the virtual "world." There are two considerations when choosing between maps of different sizes. The first is that the simulation uses a number of topographic markers (called 'posts') to represent the elevation of the terrain in a map. That is, instead of representing elevation data for the whole map, elevation is represented to the simulation only at the posts. As VBS2 uses a limited number of posts for each map, the larger the map area, the larger the area that each post must cover, and therefore, the lower the terrain resolution and complexity that is achievable. The second consideration is that entity density (buildings, vehicles, trees, roads, clutter, characters, etc), rather than map size per se, is the main constraint on system performance. Small maps tend to result in good performance (i.e., fast and fluid gameplay) by virtue of the limited number of entities that can be placed in the "virtual space," but larger maps will vary widely in their effect on performance, depending on how many entities are added to the map for a scenario.

Bohemia Interactive supplies a number of pre-built maps with VBS2 that represent a variety of environments, from temperate to tropical to desert, most of which contain both urban and rural areas, complete with buildings, roads, clutter, and other environmental objects. A list and description of maps provided "out of the box" with VBS2 is given in Annex D. While there are some shortcomings in the pre-built maps, there is enough variety available to support most kinds of training. To date, DRDC has been able to conduct all exercises with the pre-built maps (with individual scenarios customized as needed via the Real-Time Editor). However, some of the limitations in the maps constrained our scenario designs. For instance, the difficulties with representing terrains that are both complex and large resulted in the use of large but relatively flat terrains, limiting our ability to model some IED attack scenarios that depend on complex terrains. Also, by limiting the number of entities that we placed in large maps in order to maintain system performance, we were forced to simplify some scenarios.

3.2.3 IED Placement

IEDs should be placed in tactically correct positions (e.g., sites with canalizing terrain, locations identified as previous IED strikes to the PTA in their orders), as per the attack patterns identified by Eles (2009) and the Army Lessons Learned Centre (2010). The type of IED used should be consistent with the types of IEDs typically used by insurgents in the terrain selected for the scenario (e.g., pressure plate IEDs are common in rural areas, whereas vehicle-borne IEDs are mainly used in urban areas). While reports from theatre and discussions with SMEs suggest that many IED attacks did not have associated indicators (at least none detectable by humans), many others do. Thus, depending on the scenario and training objectives, it will also be appropriate to emplace IED indicators along with the IED (or in some cases, instead of an IED). The indicators should be consistent with the type of IED in the scenario (e.g., an aiming marker present for a command initiated IED). In our scenarios we have striven to emplace IEDs and associated elements (indictors, adversary characters such as spotters, etc.) as much as possible in accordance with known IED attack patterns as determined by Eles' (2009) analysis of IED incident reports from the CF area of operations in Kandahar Province. Technical aspects of emplacing and controlling IEDs in VBS2 are discussed in Annex E.

3.2.4 Choosing other entities

The majority of the vehicle and equipment supplied with the versions of VBS2 we used for the work reported here are from American and British forces, as these are the largest customers for the VBS2 product. Some vehicles used by the CF are available in these foreign inventories, but they are often variants that lack certain features (e.g. turrets, hatch placement, armour configuration, paint scheme, etc). Thus, in our training events we often had to make use of allied vehicles or pieces of kit that most closely matched CF equipment, and sometimes adapt vehicle crew SOPs accordingly. A list of currently available entities out-of-the-box that are most relevant to CF operations is given in Annex F. As of VBS2 version 1.6, which was delivered in December 2011, a number of CF vehicles and objects have been included in VBS2, built by Bohemia Interactive to specifications provided by both DRDC Toronto (IED Awareness Project) and the CF (Directorate of Land Synthetic Environment).

3.3 Programming events (scripting) vs executing scenario elements in real-time

VBS2 has a scripting functionality which allows scenario designers to pre-program certain events in a scenario (e.g., events such as IED detonations can be programmed to take place when certain criteria are met, such as a specific vehicle in a convoy passing a certain waypoint). It also has a Real-Time Editor (RTE) that allows system administrators to control aspects of the game (e.g., create, delete, revive entities or trigger events) in "real-time" while the game is being played.The scripting functionality is limited, and in particular, scripted human or vehicle entity movements often seem unrealistic and are unreliable. Controlling events or entities in the RTE can overcome some of these issues, and also allow unscripted events to be injected as deemed appropriate by the exercise controllers (e.g., the scenario fails to challenge the PTA, or scripted events fail to occur for technical reasons). But doing so imposes an extra load on the administrator, and requires good planning and an experienced administrator and training cadre during a training event.

If a scenario calls for a number of non-PTA actors (i.e., adversaries or neutral civilians that need to perform specific actions in the scenario), we have found that the scripting capabilities in VBS2 are generally not adequate (the pre-programmed behaviours are unrealistic and unreliable), and we have resorted to controlling those entities real-time during a training event. In such situations, role players were used to control the additional entities and reduce the system administrator's workload. The role players can control an entity either via a client terminal the same way that the PTA controls their entities, or via a RTE terminal, in which case the role player will have access to the same system functions that the administrator does (trigger events, insert or delete objects in the game, etc.) This approach requires the role players to be competent VBS2 users, especially if they are using the RTE mode, to be briefed on the scenarios and to exercise a good amount of discipline in order not to accidentally create events that will distract the PTA or derail the scenario (e.g., accidentally deleting a vehicle or object that is critical to the scenario).

A discussion of the employment and limitations of the RTE & scripting in our experiences can be found in Annex G.

3.4 Other scenario aspects: convoys and UAVs

Given our focus on training mounted operations, we became quite familiar with the technical aspects of conducting convoy operations in VBS2, such as maintaining desired spacing between vehicles or ensuring the players and administrators can determine which players are in which vehicles. VBS2 normally groups players that enter a vehicle and the vehicle itself into a single, composite entity or "group," but some bugs in the code for this function (corrected in v1.45) and the limited field of view in the simulation made taking advantage this grouping function more difficult than anticipated. We also used models of uninhabited aerial vehicles (UAVs) in some scenarios to provide commanders with more situation awareness (in VBS2, UAV models are designed to provide a "video feed" of the synthetic environment similar to the feed that real UAVs produce in a live environment). Details of our insights with respect to managing vehicles for convoy operations and UAV assets in VBS2 are given in Annex H.

3.5 Performance considerations

While VBS2 can run on a variety of platform configurations, as discussed above, the more complex the scenario (specifically, the more complex the terrain, the more entities are used, and the complex scripts are used), the more resources will be required from the system. Thus scenario complexity has to be managed according to available system resources, in particular the processing and memory capacities of the server and client workstations used. See Annex I for a discussion of these considerations.

4 Conduct of training events

4.1 General considerations

The conduct of CIED training within simulation is only part of the overall training exercise. Prior to the start of VBS2 play itself, a number of preparatory steps should be taken,the PTA's performance during the simulation activity assessed, and then reviewed with the PTA as part of the training. Soldiers must also receive proper instruction on how to operate in the synthetic environment, be given sufficient time to learn the game controls and be given orders prior to participating in any training scenario, including clear rules of engagement (ROEs).

While there is official guidance on live training within the different CF environments (e.g., the guidance on training for the Land Forces, Department of National Defence, 2010), there seems to be little or no official documentation on the conduct of simulation-based training in the CF. We feel that this lack of official documentation may be a cause of the variability in the conduct of training we observed at CF simulation events. We therefore share our experiences conducting simulation-based CIED training with the knowledge that much of what we report is common practice within the CF, but also in the spirit that some CF training personnel might benefit from such "common" experiences being documented in print.

4.2 Exercise Personnel

Simulation-based exercises usually require a cadre of personnel to run smoothly. The team that runs a simulation-based exercise is often called the "white team," by analogy with the "blue team" (a common name for the "friendly" team in an exercise or real mission) and the "red team" (a common name for the enemy or opposing force). For a simulation-based training event, the "white team" typically includes the exercise planners, an exercise "director" or "controller" who determines the actual start and stop of activities, assessors who evaluate the PTA, the technical support team running the simulation platform, role players who control non-PTA entities in the simulation (which can be friendly, enemy or neutral according to the scenario), and a member of the PTA's chain of command, who typically has the responsibility of determining the direction and overall intent of the exercise.

The main departure from common practice in CF Land Forces live training (documented in Department of National Defence), is the technical support team that manages the synthetic environment. The technical support team is comprised at minimum of a system administrator (often simply referred to as the "Admin"). The Admin sets up the synthetic environment prior to the exercise, and controls the environment in real time during the exercise, under orders from the Exercise director. The Admin's duties during the exercise include compensating for any technical malfunctions (e.g., a workstation goes down, or a simulation entity controlled by one PTA member ceases to function) that may occur, and adapting the scenario in real-time to respond to unexpected actions from the PTA. The Admin is also typically responsible for implementing the exercise scenarios in the synthetic environment, and is often involved in the design of the scenarios as well, to ensure that the events proposed by the scenario design team are realizable within the synthetic environment. In large simulation events, such as some of ours, the Admin will also be supported by other technical personnel, prior to and during the exercise. Some members of the Admin's support team might also act as role players (e.g., enemy forces, non-combatants) during the exercises, as some of the activities called for by the scenario might require advanced knowledge of the synthetic environment's functionalities.

Another change relative to live training practice is the conditions under which the assessment team evaluates the PTA. The assessors need to observe the PTA's actions within a computer-generated environment. This can be achieved by allowing assessors to observe individual trainees' workstations ("over their shoulder" so to speak), or by providing assessors dedicated workstations where they can observe the synthetic environment directly. This last option presents a few alternatives: an assessor can observe the synthetic environment from a first-person view, as though they were a participant in the exercise (ideally in a "stealth mode" that does not require an avatar to be generated for the assessor in the game), or from a third-person, map-like view. Each of these options has relative strengths and weaknesses. Allowing assessors to view the PTA's workstations provides assessors with an imperfect view of the synthetic environment, and might prove to be too intrusive for the PTA; however, it allows assessors to observe the PTA directly and note any emotional or stress reactions, as well as monitor compliance with the rules of the simulation (e.g., noting whether some PTA members are inappropriately viewing their colleagues' screens). Giving assessors access to the synthetic environment via a dedicated work station gives them a better view on the environment and allows them to observe the action in an unobtrusive manner; however, it requires extra computing resources, which are sometimes in short supply during an exercise, and it can make it harder to assessors to get a "feel" for the PTA members as individuals. In our CIED training events we used a combination of these approaches to give assessors the most flexibility and the most information possible for them to assess the PTA.. Finally, in keeping with the guidelines recommended by the Department of National Defence (2010), we strongly suggest that the assessors involved in the exercise not be drawn from the same unit as the PTA. Selecting assessors from outside of the PTA's unit helps ensure that the feedback given by them is impartial and constructive.

4.3 Exercise sequence

Below is a sequential list of tasks making up a CIED simulation-based exercise that we developed over the course of our training events. A sample schedule for a typical training day with the IED Awareness Simulator is given in Annex J.

4.3.1 CIED Theory Lecture/Review

Based on the level of the PTA's knowledge and experience either a full ETHAR lecture or a short review of CIED theory and TTPs should be conducted. Physical rehearsals of some of the drills, such as "5s&20s" might need to be carried out if the PTA is new to this subject matter to ensure the soldiers have a good understanding of the material The CIED "Actions-On" Training Videos produced by DRDC Toronto may also be used to demonstrate to the PTA the kind of actions they will have to perform in the scenarios. The videos also give the PTA a visual introduction to the VBS2 environment. We recommend that only the video or videos that are most relevant to the scenario that the PTA will experience be shown, rather than showing the full series of 5 videos all at once.

4.3.2 VBS2 Familiarization Training

It is important to ensure the PTA is comfortable with the simulation's controls and knowledgeable about the synthetic environment they will be expected to operate in prior to the start of the simulation activity. Soldiers should be taught vehicle, dismount and communication drills within the VBS2 platform. It is essential that soldiers practice those drills within the environment or "area of operations" because, as discussed above, a large part of being able to find an IED is through assessing what is "abnormal" in that environment. Certain "gameisms" or "simisms" will have to be pointed out so that they are not incorrectly interpreted in actual scenario play, such as overlapping terrain boundaries which could look like trip wires. Certain CIED TTPs and drills will have to be simulated outside of VBS2 if they cannot be simulated within the platform (such as electronic counter-measures).

In our experience, an appropriate amount of time for this portion of the exercise is one hour, but this may depend on the level and experience of the PTA with gaming in general. A detailed discussion of content that should be covered in a typical VBS2 familiarization session is given in Annex K.

4.3.3 VBS2 ROEs

Scenario-specific ROEs (i.e, ground rules appropriate to the simulation event) must be devised and enforced to ensure the smooth conduct of the exercise. The ROEs must address two areas: dealing with technical particularities and glitches within the synthetic environment, and exercise discipline. These rules must be stated prior to the start of the scenarios. With respect to technical issues, the PTA must be informed that it is it is very likely that some technical glitches will occur during play (to reduce surprise when they do occur), and instructed to not touch any controls until instructed and then only as per instruction, to ensure smooth resolution of the issues, and to reduce breaks in the PTA's sense of "immersion" (see discussion of this concept in Section 4.3.6) . More specifically: in the event of a glitch, soldiers should attempt to fight through it if possible, in that they should attempt to ignore the glitch (such as melting faces) and stay focused on the overall mission scenario. If that is not possible (such as in the case when their computer shuts down), soldiers should quietly request staff help by raising a hand without disrupting play for other soldiers who may not be aware of the problem. The PTA, however, should not attempt to resolve the issues themselves as that may cause more problems with the system (including possibly a system-wide crash). With respect to exercise discipline, soldiers must be given clear instructions on when it is appropriate to touch the workstation controls, to chat informally among themselves, and to leave the training area for breaks. And, very importantly, any and all negligent discharges (ND) within the simulation should be treated as live (i.e., NDs are to be treated as very serious violations of soldiers' duties and code of conduct). Failure to adhere to ROEs within VBS2 must be treated seriously, but only after soldiers have had sufficient time to learn and practice the button controls (in order to reduce the likelihood that non-compliance is a result from inexperience with the controls). Accidental fire must be investigated through a review of the playback, as it is in live exercises. If negligence is determined by the staff, the training unit's chain of command must choose appropriate action to deal with the incident. Ignoring such incidents will very likely lead to the PTA losing respect for the training tool and not taking future missions in simulated environments seriously (see also further discussion of this issue below).

4.3.4 Mission Orders

Planning and preparation of simulation-based training should be done with the same level of diligence as for field exercises. Soldiers must be familiar with the overall mission, be given specific task or convoy orders and clear ROEs. The ROEs must be realistic but may need to be adapted to the synthetic environment, such as using escalation distances that will work within the platform. All reports and returns formats, such as the 9 and 10 Liner reports should be made available and reviewed if necessary. Maps, aerial photographs and uninhabited aerial vehicle feeds can be simulated in VBS2 to give soldiers as much situation awareness about the theatre they will be expected to operate in. Previous IED and mine location data and intelligence and targeting information should be simulated (or real data used, if available and appropriate) to give the PTA current information on explosive threats from where patterns can be identified and learned. These data should be updated as missions are played out, for instance, new IED strikes and finds should be recorded on a mission map.

4.3.5 Battle Procedure

After task or convoy orders are issued by the exercise staff to the convoy commander, time must be allotted for them to perform their battle procedure. This includes commander's planning, writing and issue of orders to the convoy, reconstitution of teams if necessary and conduct of rehearsals (outside and/or inside the VBS2 environment). Often, the time required for this battle procedure is longest for the first mission of the day, decreasing in length for each subsequent mission.

4.3.6 Scenario/Mission Play

With the preparations described above complete, the PTA can commence the simulation activity proper. Typically, the Exercise Controller will explicitly signal the start of the activity, following which the PTA begins performing start-up procedures, supported by the technical staff on the White Team. Start up procedures should includelogging in to the VBS2 workstations, and performing communications, Global Positioning System (GPS) and Electronic Counter-Measures (ECM) systems checks within the simulation, as would be done with actual equipment prior to departing for a mission. The PTA then start conducting their mission as defined by the mission orders and preparation they previously received.

For optimal performance, a scenario in VBS2 should last approximately 30-45 minutes. In our experience, if the scenario lasts longer, computers may begin to shut down or experience technical glitches (this may vary with the specifications of the equipment used, the complexity of the scenario, and the version of VBS2 used). To avoid lengthy play, assessors may need to speed up the scenario so that the key event is reached and played out. For example, if a convoy is stopping for a VPS too often before they will reach intended site, assessors can prompt the command element to send a message over the net that the area has been recently swept by local security forces or a route-clearance package

Once the key activity and key response has been played out and assessed, an "end ex" should be called to collectively take everyone out of the mission. This can be accomplished with an assessor instructing "hands off the keyboards" while lights are being turned on. This will both help with the PTA's understanding of when they should be immersed in the activity (see discussion below) as well as protect the AAR recording from being overburdened by actions of troops after the "end ex".

A key aspect of the simulation activity itself is ensuring that the PTA have the right attitude or mindset during the activity. That is, it is important to ensure the PTA takes the simulation activity seriously, rather than treating it like a game. During the simulation events we conducted, we took steps to encourage the PTA to adopt an attitude of taking the simulation activity seriously. Prior to the simulation activity itself, the quality of the mission briefings and preparations will set the tone for the rest of the exercise. During the simulation activity, the attitude and behaviour of the White Team and PTA's chain of command will also influence the PTA's attitude; in particular, the enforcement of the scenario-specific "ROEs" discussed above will convey to the PTA that the exercise is serious business, and not just a video game. In addition to these factors, the physical setting of the training environment will play a role. Beyond the psychological realism of the scenarios themselves (also discussed above), the layout and environmental conditions can either encourage or distract the PTA from taking the event seriously. For instance, dimming the lights in the room and physically separating individuals (with dividers or purely by distance) encourages the PTA to interact with each other via the synthetic environment, as intended, rather than face-to-face, "outside" of the simulation. These elements contribute to a sense of "immersion" or "presence" (Lee, 2004; Sheridan, 1992) for the trainees. The sense of immersion is thought to be an important factor in training in synthetic environments, although conclusive evidence linking it to training effectiveness is lacking (Lee, 2004; Romano & Brna, 2001; Witmer & Singer, 1998).While we were not able to collect data examining the relationship between immersion and training effectiveness (i.e., skill development and transfer) per se, our experiences showed that encouraging immersion helped the PTA to take the exercise more seriously and comply with orders and with the simulation ROEs. Conversely, when we did not put so much effort into "immersing" the PTA, we encountered less compliance and more discipline issues during simulation events.

Technical considerations of controlling VBS2 during the "live" playtime part are discussed in Annex L.

4.3.7 AAR Preparation

As mentioned above, VBS2 can record all the events within a given simulation event and replay them at a later date, from any point of view within the synthetic environment, thereby providing a computerized AAR function. Because VBS2's AAR functionality is slow and computationally demanding, it is best if assessors and technical team members personnel select what parts of the simulation event they want replayed, and from what point of view, prior to conducting the AAR. Assessors should confer to compare notes and any performance measures (e.g. checklists) and identify a maximum of 3 key issues to be addressed by the training staff prior to starting the next scenario. This will allow the PTA to have their say during the AAR and not have the assessors take up all their time. The length of AAR is usually equal to the length of the mission/scenario play. During these preparations the PTA should be taking a break outside of the computer lab.

4.3.8 AAR and Transition to Next Scenario

In accordance with official Canadian Army guidance on training (Department of National Defence, 1999, 2010), an AAR should be conducted at the end of each scenario. Section 4.4 on Assessment provides more details on the AAR process and the challenges we encountered with conducting it with the IED Awareness Simulator. Once the AAR is complete, another scenario can be initiated by the exercise controller, by issuing of task or convoy orders to the convoy commander. If the next scenario is to be started from the end point of the previous scenario, the vehicles may need to be repositioned to those locations after re-starting the system vice continuing to play the original scenario. A description of the procedures we used and technical considerations for the conduct of the AAR are given in Annex M.

4.4 Assessment

Assessment and feedback are key components of any training process (Army Lessons Learned Centre, 1999; Fu, Jensen & Hinkelman, 2008). CF instructors have well-established assessment and feedback practices (Army Lessons Learned Centre, 1999; Department of National Defence, 2010). Thus it is important for the IED Awareness Simulator to not only provide adequate feedback and assessment tools, but also to support the effective assessment of, and feedback to, the PTA.

To this end, the approach to assessment we took with the IED Awareness Simulator was one of continually monitoring and assessing the PTA during the training exercise through relatively unobtrusive means (i.e., observing without interrupting to give feedback, computerised logging), and providing training feedback (i.e., feedback on performance and training objectives) during an AAR session after the exercise. Research-oriented data (e.g., observational teamwork measures) which were less directly relevant to the PTA were analyzed afterwards.

For our purposes, unobtrusive observation during the exercise coupled with feedback after the exercise were the best way of ensuring the exercises were effective as a collective training event. This ensured that feedback to an individual in the PTA, for instance, did not disrupt the flow of the exercise for the rest of the team. This also ensured that the feedback remained at the collective level, rather than singling out a particular trainee, which helps to build a sense of team cohesion, one of the primary purposes of collective military exercises. Finally, keeping feedback until the end of the exercise helped to avoid disrupting the sense of immersion in the virtual world, or "presence" (Lee, 2004; Sheridan, 1992) for the trainees. This sense of immersion is thought to be an important factor in the effectiveness of synthetic training environments (Lee, 2004; Romano & Brna, 2001; Witmer & Singer, 1998). The specific assessment tools and methods we used during the exercises included:

- Observation by qualified instructors, with subjective notes/impressions
- Checklists (Annex M)
- Recordings of the PTA's actions in the simulation (using the VBS2 AAR functionality) and voice communications (using either CNRSim or SimSpeak)
- Observational rating instrument for assessing team dynamics (Thomson, Karthaus, Brown & Ste-Croix, 2009)

- Written knowledge tests administered before and after training sessions with the IED Awareness Simulator (Muller-Gass et al., 2009)
- Virtual IED lane to test evolution of cue integration during training event (Thomson et al., 2009)

Assessing the PTA's performance in the IED Awareness Simulator presented a number of challenges. VBS2 captures some basic data on events that occur within the simulation (player and vehicle position, basic states, weapons events etc.) but at a fairly low level of detail. More complex data such as whether certain conditions have been met (e.g., whether a vehicle passed a certain landmark) are more difficult to obtain. Furthermore, there are no automated facilities for extracting quantitative data of simulation events to log files or a database for subsequent statistical analysis, and thus data must be formatted by the user after extraction from VBS2. Finally, voice communications are not naturally integrated into VBS2, requiring some extra work to play them back with the visual AAR tool built into VBS2, and making it difficult to integrate them into a quantitative analysis of the other simulation events described above. Thus we were forced to rely solely on the observational and qualitative AAR facilities listed above.

As noted above, AARs are part of standard practice during training events in the CF, and in military training in general. The training cadre should take advantage of the VBS2 replay functionality as much as possible, as the training staff and the PTA's memories and notes of events can be inaccurate or incomplete. The PTA will get more benefit from seeing a mistake being played out rather than hearing about it (and perhaps not believing or agreeing with the assessor's version of events). CF Land Forces training publications (Department of National Defence, 1999, 2010) provide useful guidance on conducting AARs for collective training exercises. The AAR capability within VBS2 is thus a welcome and potentially powerful tool that the IED Awareness Simulator brings to CIED training. Unlike a typical live exercise, where Observer-Controller-Trainers (OCTs: specialized assessors trained to facilitate live Army exercises; see Department of National Defence, 2010) monitor the PTA during the exercise, and later prepare the AAR based on their notes and recollections, the AAR function in VBS2 is able to replay a visual animation of the whole simulation event, or any part thereof, from a variety of different viewpoints, including the point of view of specific "players" within the event. Thus it is in principle possible for everyone to review exactly what happened during the training event, unlike a live exercise. Many of the instructors and units who participated in our events appreciated this enhanced review capability. There are, however, a few technical issues which limited the full potential of the AAR in VBS2. As noted above, none of the voice communications tools we used were fully integrated with the VBS2 AAR system, resulting in incomplete voice recordings or poor synchronization between the voice stream and VBS2 as we learned to work with these tools. Furthermore, the AAR function sometimes fails to record the detail of certain entity movements in VBS2 (e.g., gestures by the PTA's avatars), resulting in an incomplete record of events. Finally, for large scenarios comprised of many entities, the resulting AAR file generated by VBS2 was often so large that playback was slow or would cause the application to crash. Nevertheless, the VBS2 AAR did prove useful despite these issues. Technical details of how to prepare AARs in VBS2 are provided in Annex N.

Implementing the observational assessment listed above during training events presented certain challenges as well. For instance, the traditional approach of employing OCTs to monitor the PTA during the simulation event was difficult to replicate in the synthetic environment because the assessors' view of the virtual environment was limited to what they could see on the

PTA's screens, which is a more restricted view on the training environment than OCTs typically enjoy during a field exercise. Thus, at some training events we ensured that assessors were provided with their own workstations at which they could unobtrusively view the synthetic environment from a variety of virtual locations and angles. Furthermore, the art and science of assessing team performance in virtual environments is still very much a work in progress (MacMillan, Entin, Morley, & Bennett, in press; Zachary et al., 2004). Thus the other observational methods listed above were exploratory measures developed in-house to study how best to assess training value in the IED Awareness Simulator. A detailed discussion of the conceptual and empirical work involved in the development of our observational methods is beyond the scope of this report, and interested readers are encouraged to consult Thomson et al. (2009) and Jarmasz et al. (2010) for more information.

Our experiences with the IED Awareness Simulator suggest a number of ways in which assessment of the PTA could be improved in synthetic environment. In addition to refining the methods described above, an obvious approach would be to automate certain performance metrics using improved data collection from VBS2. Given that the ultimate responsibility for evaluating the PTA rests with the training cadre (which in the CF typically includes the PTA's chain of command), such automated assessment tools are likely best implemented as tools that support the training cadre in their task, rather than as systems that replace human assessors. Such tools could be built into assessors' dedicated consoles during an exercise, for instance, using similar AI technology used in Intelligent Tutoring Systems. However, any such improvements first require the development of a data logging capability, which is one of the components of the IED Awareness Simulator that is still under development.

5 Conclusion: Thoughts on the Suitability of VBS2 as a Training Platform for Countering IEDs and other Types of Small Teams Training.

The IED Awareness Simulator was designed to provide a low-cost, low-footprint synthetic environment for training IED awareness for small-team Army units. The system was designed around the VBS2 “serious game” environment, which provides the bulk of the system’s functionality. However, VBS2 could not meet all the original requirements for the IED Awareness Simulator alone, and its use in research & training events exposed further limitations. This led to the development and integration of additional components (some still in progress), procedural work-arounds, and requests to the VBS2 developers (Bohemia Interactive) for additional models (specifically, CF vehicles and equipment) and bug fixes. Our experiences also allowed us to develop an approach for employing the Simulator for training events that worked well for us, and which is summarized here:

- Keep scenarios and terrains maps relatively simple;
- Focus scenarios on team dynamics, that is:
    - Design IED “situations” extended over time & space that require participation of many team members to piece it together, and communications back to higher command;
    - Avoid scenarios that emphasize lots of visual detail;
    - Avoid detailed psychomotor tasks that rely on very realistic kit (guns, detailed radio equipment procedures);
- Base IED events in scenarios on the “logic” of IED attacks (“affordances” for attacks provided by the terrain, social IED indicators) rather than on the details of the device; this information should be based on analysis of attack patterns in theatre;
- Set the right tone for the exercise with proper background materials, buy-in from the chain of command, good discipline during the event, and appropriate set-up of the physical environment in laboratory or training centre;
- Avoid use of built-in AI, and instead use role-players or external AI engines (e.g., CAMX) when possible;
- Ensure the PTA has time to learn how to control the system and get used to its “quirks” (so-called “sim-ism” or “game-ism), as a poor mastery of these can interfere with a training event;
- Ensure proper assessment of the PTA, including real-time observational measures, digital data collection and using VBS2’s AAR functionality.

Used in this way, the IED Awareness Simulator appears is a useful training environment for the team dynamics aspects of IED Awareness in small convoy teams. Our studies (Thomson et al., 2009; Jarmasz et al., 2010) show that measures of team communications and coordination effectiveness improve during CIED training events with the system, and that participants' knowledge and understanding of CIED drills in convoy missions improves training with VBS2 more than the traditional "sand box" method. Note, however, that we have not been able to assess whether the CIED training that occurs in VBS2 transfers to more realistic settings such as field exercises or operational missions due to a lack of troops and resources.

VBS2 is intended to be a multi-purpose synthetic environment (Bohemia Interactive, 2010) and accordingly its use in the CF extends beyond CIED training. There is also some evidence that it may be an effective training tool in other areas. For instance, the Armoured School at CTC Gagetown started using VBS2 as a supplement to classroom instruction in its Troop Warrant Officer course and saw the pass rate in the course improve dramatically (Roman & Brown, 2008). As VBS2 was acquired by the CF with little prior evidence pertaining to its training effectiveness, such findings are fortunate for the CF's investment into the VBS2 platform. However, the data on the effectiveness of VBS2 (and by extension systems built around it) for different skills are equivocal. For instance, Australia's Defence Science and Technology Organization (DSTO; Temby et al., 2009) found no benefits of VBS2 as compared to traditional instruction methods for training section attacks, a task which requires a high degree of psychomotor skills and careful physical coordination between team members in a dismounted setting. Thus more research is needed to determine VBS2's effectiveness as a training tool, and perhaps more importantly, the types of tasks and missions for which is it effective. This is of particular concern when applying VBS2 to training missions or tasks that don't focus on the platform's core strengths, namely small team command-and-control in kinetic missions. Non-kinetic missions involving social interactions with civilians, on the one hand, and basic soldier training involving a high degree of psychomotor skills, on the other, are two areas to which VBS2 might not be well suited, as shown by some of our experiences with CIED training, and DSTO's experiences with section attacks. Nevertheless, training organizations might feel tempted to apply VBS2 to precisely such types of training, given its versatility and widespread adoption.

In sum, VBS2 seems to "work" for certain types of small-team Army scenarios, at least, but at the cost of "bolt-on" additions and ad-hoc solutions, as we found when developing the IED Awareness Simulator. Our experiences have been echoed informally by researchers and VBS2 users across the CF and in other Allied militaries. Given that tactical, small-team simulations for land operations is a fairly new and under-developed area, especially relative to the more mature areas of aviation and marine simulation-based training, this state of affairs is perhaps not surprising. However, given the large investments made by various militaries into VBS2 (Bohemia doc), this is also perhaps problematic.

As simulation technology evolves at a rapid pace, it is likely that the CF will be looking to keep up with industry developments and upgrade its tactical Army simulation environment in the foreseeable future. It is advisable that the CF engage the human factors community much more tightly in preparing to develop or acquire new simulation platforms aimed at small teams training for the land forces. This could happen at many levels: training effectiveness evaluations of candidate platforms during the acquisition process; development of concepts of employment of synthetic training tools when defining new requirements and capabilities, or determining how best to use newly acquired tools; development of the simulation platform itself should the CF decide to invest effort into developing at least some aspects of new synthetic platforms in-house. While it is beyond the scope of this report to discuss the relative merits of acquiring a COTS system versus developing a tailored solution in-house, we note that there currently exist a number of advanced programmable game engines that would make the in-house development of a platform tailored to the CF's needs more feasible than in the past. Examples include commercial game engines such as the CryENGINE from Crytek Inc. (http://www.crytek.com/) and the Unity environment (Unity Technologies Inc., http://www.unity3d.com) and open-source such as Delta3D (http://www.delta3d.org/). In any case, more engagement with the human factors community could play a crucial role in ensuring the CF develops or acquires a more fit-for-purpose system for its next-generation tactical small-teams Land forces simulation platform.

This page intentionally left blank.

References

Army Lessons Learned Centre (1999). The After-Action Review Process: Learning More From our Training. *Dispatches,* vol. 6, no. 3 (November 1999).

Army Lessons Learned Centre (2010). Counter-Improvised Explosive Devices (C-IED). *Dispatches,* vol. 15, no. 1 (March 2010).

Bryun Martin, L., & Karthaus, C. (2009). "Cognitive Task Analysis of Improvised Explosive Device Detection and Assessment in CF Convoy Operations." DRDC Contract Report CR2009-176 (Draft). HumanSystems Incorporated.

Chief of Defence Staff (2008). CDS Supplemental Directive – Enhancement of CF C-IED Capabilities in Afghanistan. Department of National Defence, Ottawa.

Defence Research & Development Canada – Toronto (2003). DRDC Guidelines for Human Subject Participation in Research Projects. Department of National Defence, Toronto.

Department of National Defence (1999). *The After Action Review Process: Learning More from our Training. Dispatches, Vol. 6, No. 6.* Ottawa.

Department of National Defence (2006). *Canadian Forces counter improvised explosive device (IED) tactics, techniques and procedures handbook* (B-GJ-005-316/FP-004). Ottawa.

Department of National Defence (2010). *Training for Land Operations* (B-GL-300-008/FP-001). Ottawa.

Directorate of Land Command Systems Program Management (undated). SimSpeak. Product brochure. Ottawa.

Eles, P.T. (2009). "Characterizing the IED Threat: a Classification of IED Events in Kandahar Province (Initial Results)." Presentation to DRDC Toronto (Toronto, Canada, July 7).

Fu, D., Jensen, R., & Hinkelman, E. (2008). Evaluating Game Technologies for Training. 2008 IEEE Aerospace Conference Proceedings. Big Sky, Montana. March 1-8, 2008.

Hill, L. (2008), Use of Simulation in the Armour School, Special Event, Military Modelling and Simulation Symposium, SpringSim, Ottawa, Ontario

Jarmasz, J. Muller-Gass, A., Zotov, V., Lamb, M., Scourtoudis, E., Wojtarowicz, D., Thomson, M, & Bruyn-Martin, L. (2010). Blended solutions for Counter-IED training. In Proceedings of Military Modeling and Simulation 2010 Conference, 196-203.

Lee, K. M. (2004). Why Presence Occurs: Evolutionary Psychology, Media Equation, and Presence. *Presence, 13,* 494–505

Levesque, J.; F. Cazzolato; J. Martonosi. (2009). "CAMX: Civilian Activity Modelling for eXercises and eXperimentation." DRDC Technical Report TM2009-065.

MacMillan, J., Entin, E. B., Morley, R., & Bennett, W. (in press). Measuring team performance in complex dynamic environments: The SPOTLITE method. Military Psychology.

MacQuarrie, D., Taff, C., Asselstine, B., Hans, R., & Reid., S. (2008). Simulation-C2 Interoperability Through Data Mediation: the Virtual Command and Control Interface. Proceedings of the European Simulation Interoperability Workshop, 16-19 June 2008, Edinburg, UK.

Muller-Gass, A., Wojtarowicz, D., Jarmasz, J., Zotov, V., Scourtoudis, E., Kramkowski, E., Bromfield, S., Zanfir, A., Plumley, S., Swaby, M. (2009). Evaluation of Simulation-based IED Awareness Training. DRDC Protocol L-675 Amendment 1, DRDC Toronto.

Murphy, J.S. ed. (2010). Identifying Experts in the Detection of Improvised Explosive Devices (IED2). Technical Report, Arlington VA. TR 1269.

National Research Council of the National Academies (2008). *Behavioral modeling and simulation: from individuals to societies.* Washington, DC: National Academies Press.

Roman, P.A., & Brown., D. (2008). "Games – Just How Serious Are They?" In Proceedings of the Interservice/Industry Training, Simulation and Education Conference (I/ITSEC) 2008 (Orlando, FL, December 1-4). NDIA, Arlington, VA, 364-374.

Romano, D. M, & Brna, P. (2001). Presence and Reflection in Training: Support for Learning to Improve Quality Decision-Making Skills under Time Limitations. *Cyberpsychology & Behavior, 4,* 265-277.

Sheridan, T. B. (1992). Musings on telepresence and virtual presence. *Presence, 1,* 120-126.

Temby, P., Stephens, A., Whitney, S., Dabinet, P., Williams, J., Vozzo, A., & Galanis, G. (2009). Game-based Training for Infantry Teams. Presentation given at the Annual Meeting of The Technical Cooperation Program HUM Technical Panel 2, May 2009.

Thomson, M., Karthaus, C., Brown, A. L, & Ste-Croix, C. J. (2009). "Behaviourally-Anchored Rating Scale Development for Evaluating Team Performance in Canadian Forces Convoy Operations." DRDC Contract Report CR2009-108.

Witmer, B. G., & Singer, M. J. (1998). Measuring presence in virtual environments: a presence questionnaire. *Presence, 7,* 225–240.

Zachary, W., Scolaro, J., Stokes, J., Weiland, W., & Santarelli, T. (2004). Using synthetic naturalistic worlds to train teamwork and cooperation. In S. G. Schiflett, L. R. Elliott, E. Salas & M. D. Coovert (Eds.), *Scaled worlds: development, validation and applications* (pp. 316-352). Aldershot, UK: Ashgate.

Zorpette, G. (2008). "Countering IEDs," IEEE Spectrum (September): 27-35.

Annex A Hardware and Evironment Management

The DRDC Toronto Team Lab is configured to run VBS2 exercises for up to 40 participants in a closed network environment consisting of 20 dedicated desktop workstations, up to 20 additional laptops, and a central administration station / server. VBS2 log data and audio data (CNRSim or SimSpeak) are transferred via Windows networking to machines in separate rooms for AAR playback and debrief. The details of the typical layout we used are as follows:

1. **Room layout**: The physical arrangement of the training area can provide beneficial cues to the players, as well as prevent them from cheating or otherwise subverting the immersion of the training exercise.

    a. **Seating arrangement**: Player seating should be arranged such that section- or vehicle team-members are physically located next to each other, or if possible, in the same seating arrangement as the real vehicle. Players tend to communicate directly (vice over the radio nets) to other team members in such arrangements, but this is not necessarily unrealistic, and can take the place of a separate vehicle 'intercom' net if one is not available.

    b. **Desktop setup**: Each player station faces the room wall and is enclosed by two cubicle walls on either side. The cubicle walls prevent the players from looking at each others' screens, which tends to break their immersion and gives them visual information they would not otherwise have in a real situation.

    c. **Environmental controls**: Lighting and heating-ventilation-air conditioning (HVAC) settings should support the immersion of the simulation or mimic conditions in the real vehicle. Generally, lighting is dimmed and cooling is somewhat reduced (bearing in mind that operating a large number of computers in a poorly-cooled room can cause overheating or other equipment failures). The dimming and raising of the lights also serve as punctuation for the beginning and end of the exercise, helping to reinforce player immersion.

    d. **Admin station placement**: It is advantageous for the VBS2 admin station to be located in the same room as the player stations, as this allows for better awareness of what the players are doing and assists with the coordination of scenario events or on-the-fly adjustments. However, care must be taken to discourage players from looking at the admin screens to gain privileged information. This was accomplished in the DRDC lab by placing the admin station in the middle of the room with the screens facing the doorway, where no players are located.

2. **Computer equipment**: The recommended graphics and processor requirements for VBS2 are fairly high, but they are flexible enough that it can be configured down to suit hardware of varying specifications. The desktop player stations were configured as high-end gaming units at the time of purchase, while the laptops were multi-purpose units that were added as required for large exercise groups.

    a. **Specifications**:

    Server Machines: Dell Precision T7400

Quantity:	2
CPU:	Dual Quad-Core Intel Xeon E5430 (2.66 Ghz)
Memory:	8GB
Video Card:	NVIDIA GeForce GTX 280
Hard Disk:	2 x 1TB
OS:	Windows XP-64 SP2

    Desktop Machines: HP/Compaq dc7900

Quantity:	20
CPU:	Dual Core Intel E8400 - Core 2 Duo (3.00 Ghz)
Memory:	3GB
Video Card:	NVIDIA 9800 GT
Hard Disk:	74GB
OS:	Windows XP SP3

    Laptop Machines: HP/Compaq 8510p

Quantity:	20
CPU:	Dual Core Intel T7300 - Core 2 Duo (2.00 Ghz)
Memory:	3GB
Video Card:	ATI Mobility Radeon HD2600
Hard Disk:	120GB
OS:	Windows XP SP3

    b. **Control interface**: Each player station is equipped with a keyboard and mouse for basic interface with the simulation. This will be familiar to players experienced in PC gaming, but does require more key memorization for those that are less experienced. Keyboard ‘cheat sheets’ (diagrams of the key-to-VBS2 functions mapping) are provided at each station for both dismounted and in-vehicle control layouts.

If laptops are being used, it is highly recommended that they be provided with mice instead of relying on the touchpad, which is generally a poor choice for first-person game interfaces. Once mice are added, the touchpads should also be disabled because wrists and thumbs tend to accidentally brush against them trigger false input.

c. **Steering**: Several of the stations are also equipped with off-the-shelf steering wheels and pedals (the G25 model from Logitech Inc.), which allow the driver-players to operate their vehicles more realistically (though any player can still operate a vehicle with the keyboard controls).

It should be noted that VBS2 assigns input from the accelerator and brake pedals of PC steering hardware to ‘forward’ and ‘reverse’ (like the keyboard controls) rather than ‘accelerate’ and ‘brake’ (like a real vehicle). In this arrangement, forward acceleration is achieved by pressing the ‘forward’ pedal; however, pressing the ‘reverse’ pedal while the vehicle is moving forward will decelerate the vehicle, gradually bring it to a halt, then continue in reverse as long as the pedal is depressed (and vice-versa). This distinction is significant for players that are not used to typical game-vehicle controls, as there were a number of incidents where drivers started reversing unexpectedly when they firmly depressed the brake pedal in an attempt to halt the vehicle.

Some participants also noted that most in-game vehicles do not have rear-view and side mirrors. These would allow drivers to have better situational awareness and assist with coordinated driving operations.

d. **Audio**: Audio is provided through a combination (headphone and microphone) headset wired into each player station’s soundcard. The headphones completely covered the ears, which made it difficult for players to hear admins or other role-players that were speaking directly, instead of over the radio nets (this happened frequently due to inconvenience, lack of appropriate radio nets, or technical glitches). A headset with only one ear covered may help with this problem, but that would also reduce player immersion.

e. **Head tracking**: One station was temporarily equipped with a simple infrared head-tracking unit (NaturalPoint TrackIR) to evaluate its effectiveness. Unfortunately, it proved cumbersome and inaccurate, so it was not used for the remainder of the exercises.

f. **Network**: All player stations and both admin stations / servers are on the same 1000 Mbps (gigabit) network, isolated from the rest of the building network. All switches and NIC's are gigabit-capable and are wired together with CAT-6 Ethernet cables. As all the machines are Windows-based, they share a workgroup to facilitate file sharing and AAR transfers. Effort was made to eliminate any sources of latency or bandwidth-reduction, however VBS2 still routinely reported network dropouts and latency for reasons that could not be ascertained. It's possible this is a software issue specific to VBS2.

g. **Windows configuration**: By default, most Windows systems will have a 'sticky key' feature whereby hitting the Shift key repeatedly will bring up a dialog box asking if this accessibility feature should be enabled or not. This feature needs to be disabled as it would interfere with the VBS2 key mapping. To do so, hit the 'Settings' button to bring up the Accessibility Options menu, then hit the 'Settings' button next to each of StickyKeys, FilterKeys, and ToggleKeys, and clear all the checkboxes. It is not sufficient to clear the 'Use StickyKeys' box, as the prompt asking if you want it enabled will still trigger every time the key combination is pressed. If this is not done, players who repeatedly press the Shift key for some in-game purpose in VBS2 will be dropped back to the Windows desktop because of the prompt.

   Any background processes (such as antivirus scans) will significantly reduce the performance of VBS2 and should also be disabled before starting an exercise, assuming that this does not violate the security policies for the network that the VBS2 workstations are connected to.

3. **Voice communications**

a. **CNR-Sim**: While there is built-in radio functionality in VBS2, Bohemia Interactive has abandoned its development in favour of integration with a third-party radio application from Calytrix called the Comm Net Radio Simulator (CNR-Sim). It provides more advanced radio communication and logging capability, AAR integration, multiple nets, and remote control capability over a network, but it requires the CNR-Sim application to be loaded separately and left running in the background at each player station. AAR-integrated logging also requires an instance of its sister application CNR-Log to be running on the network.

The hotkeys that activate CNR-Sim's push-to-talk features must also be un-assigned from any actions in VBS2, otherwise inadvertent in-game actions will occur every time the radio is triggered by the player.

As of v1.45, disagreements between Bohemia Interactive and Calytrix have resulted in the removal of CNR-Sim and CNR-Log licenses from the standard VBS2 distribution package. Limited-functionality 'demo' copies of the software are still provided, but due to the uncertainty of the partnership between the two companies and the limitations of the demo version, it was recommended that another solution be found. Voice communications are now conducted using a product Simspeak, developed for the Canadian Forces.

b. **Simspeak**: Developed as a custom-written, Crown-owned alternative to CNR-Sim/Log, Simspeak provides the same functionality and AAR integration of the Calytrix products, and is available to other Government of Canada users free of charge (Directorate of Land Command Systems Program Management, undated brochure). Apart from some technical implementation differences, the following notes on radio usage still apply to Simspeak.

c. **Radio nets**: Initially, a variety of different CNR-Sim radio nets were established to provide different levels of communication within exercises. A global net was used by admins to disseminate information to all players; an admin net was used to coordinate scenario-specific actions between admins; each of the vehicles and sections were assigned their own nets to simulate their vehicle intercoms or Personal Role Radios (PRRs); an "OPFOR" (enemy force) net was used to coordinate the role-players; a "higher" command net was used for communication with the chain of command.

   This level of granularity and variety in radio nets proved too complex to be practical. As each net requires its own push-to-talk button or "hotkey," this used up a fair number of keys and caused frequent errors in net selection (even by admins). If a player had to switch seats due to a computer crash or roster change, they would also have to reconfigure which vehicle net they were assigned to by switching from the VBS2 application to CNR-Sim and adjusting the latter's parameters. In the end, only two radio nets were really used: a global channel that all players, admins, role-players, and "higher" could speak on, and vehicle-specific "intercom" nets (though the latter were sometimes ignored in favour of direct verbal communication).

d. **Radio reports**: Role-players for "higher" elements in the chain of command were usually located in a separate room, connected only by CNR-Sim radio to allow for 9- or 10-liner reports and more realistic radio interaction for the players. Technical glitches or a need for ”higher” to be present in the same room to observe the players occasionally meant that this arrangement was dropped and replaced by direct verbal communication.

4. **Licensing and Versions**: As of this writing, the Team Lab currently operates VBS2 VTK v1.5. Versions 1.22, 1.23 and 1.3 were used during the major CIED training events organized at DRDC Toronto. Licenses for VBS2 were managed as follows:

    a. **Pre-v1.3**: Licensing was originally handled through a Hardware Against Software Piracy (HASP) authentication USB dongle plugged into one of the servers. Floating licenses for all 40+ machines were located on this single dongle and were accessed over the network by individual clients.

    b. **Post-v1.3**: With the introduction of v1.3, all licensing is now handled through software-controlled keys. DRDC Toronto has been issued a pool of keys for VBS2, VBS Fires (an additional module for simulating calls-for-fire), and Fusion (the new application programming interface), which can be used as floating licenses over the Team Lab network, or detached for standalone use.

    c. **VTK, LVC, Admin versions**: The standard VBS2 installation includes shortcuts to several different versions or modes of the executable. The ‘VTK (Virtual Training Kit) User’ mode is the standard executable that players should use. It does not have access to the Real-Time Editor (RTE) feature that distinguishes the admin version, nor does it have access to the ‘Video’, ‘Audio’, or ‘Difficulty’ option menus. Admins should use the ‘VTK Administrator’ mode instead, to gain access to all the menus and features. The ‘LVC (Live Virtual Constructive) Game’ mode has additional network connectivity features that allow it to interface with DIS/HLA enabled applications, including the CNR-Sim/Log and Simspeak radio systems.

5. **Servers**: Two high-performance computers were designated ‘servers’ and acted as the scenario host and AAR host respectively. Due to lack of an alternative, the scenario host machine was also used as the admin station where mission progress was monitored, scripting and events were triggered, and other admin tasks were performed. Unfortunately, this places extra load on the machine and some (but not all) of the network latency and connectivity issues could be traced to admin activity on the server, particularly if that activity involved heavy graphical processing (flying around the map at high altitude, tracking a large number of players or entities, etc).

It is recommended that a dedicated server be setup instead of sharing its duties with an admin station, to minimize any performance bottlenecks.

Further details on VBS2 functions, installation and capabilities can be obtained from the developer, Bohemia Interactive, via their VBS2 website (www.bisimulations.com) or in their VBS2 capabilities whitepaper (Bohemia Interactive, 2010).

This page intentionally left blank.

Annex B Sample Scenario Sequence

We did not have access to adequate terrain maps of locations in Afghanistan for our CIED training events. Therefore, we used the terrains provided out-of-the-box in VBS2 that most closely resembled Afghanistan, primarily the As Samawah map (a roughly georeferenced map of the city of the same name in Iraq), although we also occasionally used some maps of fictional locations that represented terrain that was geotypical of either arid or temperate, woodland environments (see Figure 2). Given the mission-specific focus of our training events, specific areas of the maps were designated as known locations within the CF's Area of Operations in Afghanistan (e.g., Kandahar Air Field [KAF], Kandahar Provincial Reconstruction Team headquarters [PRT], Forward Operating Base [FOB] Wilson, Spin Buldak). Certain roads in the terrain were designated as the principal routes and were assigned colour codes (green, blue, red) to facilitate identification. As discussed in the main text of the report, the scenarios constituted a set of CIED situations of progressive complexity and difficulty, and were based on the scenarios originally designed for the Actions On training videos, designed in collaboration with the CIED Task Force and the CIED cell of the Tactics School at CTC Gagetown.

The scenario progression we designed and used as a template for most of our training events is as follows:

Scenario 1: KAF to FOB Spin Buldak (green route: 4 lane paved highway with median)
  Key Activity: Convoy drills, no incidents

Scenario 2: FOB Wilson to FOB Spin Buldak (blue route: 1 lane dirt road)
  Key Activity: IED Strike (no damage to vehicles, no casualties)
  Key Response: Speed Through, IED Contact Report

Scenario 3: FOB Spin Buldak to PRT (green route: 4 lane paved highway with median)
  Key Activity: Vehicle breakdown, maintenance (RRR) required
  Key Response: Cordon and request RRR

Scenario 4: PRT to FOB Spin Buldak (green route: 4 lane paved highway with median)
  Key Activity: IED Find
  Key Response: IED Contact Report, Speed Through/Cordon and 10 Liner

Scenario 5: FOB Spin Buldak to FOB Wilson (red route: 2 lane paved road)
  Key Activity: Vehicle breakdown, able to fix on site
  Key Response: Long Halt, fix vehicle and carry on with mission

Scenario 6: FOB Wilson to PRT (red route: 2 lane paved road)
  Key Activity: IED Strike, Mobility Kill (no serious casualties, only minor scrapes/burns that Tactical Combat Casualty Care can take care of on site)
  Key Response: IED Contact Report, Cordon, 10 Liner, Request QRF or RRR (9 Liner not necessary)

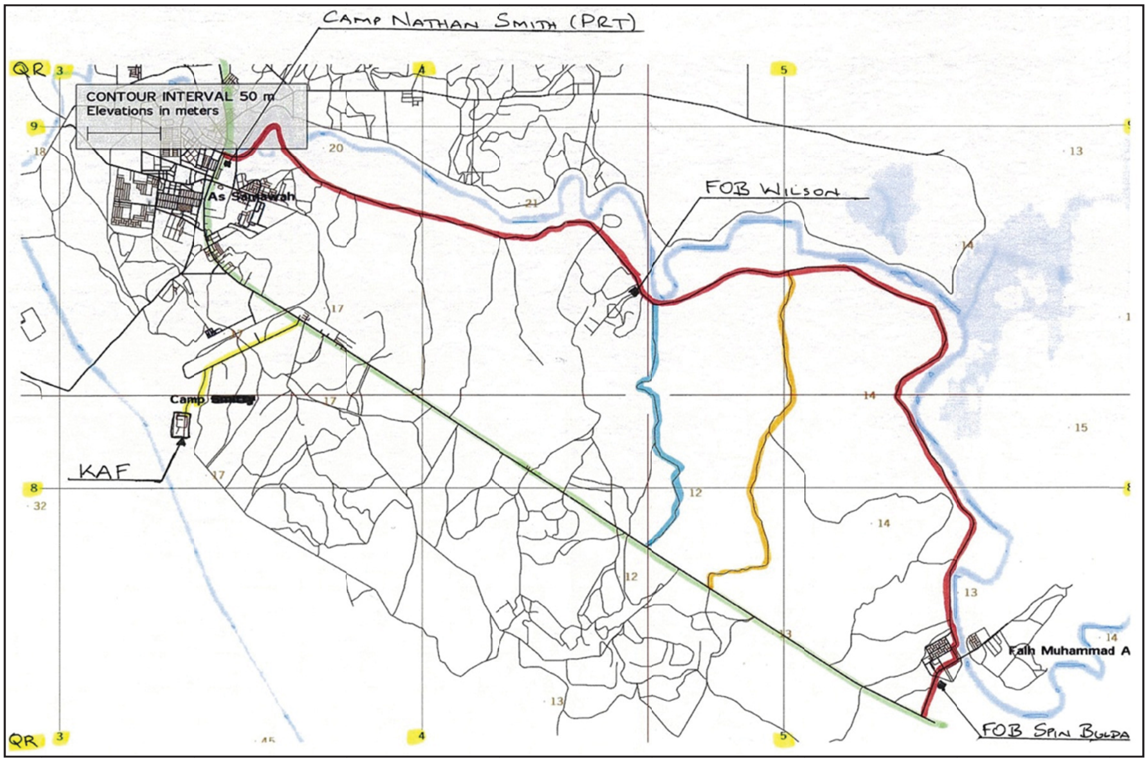

Figure 2: The VBS2 "As Samawah" terrain used in the CIED training scenarios.

Annex C Content Management

This Annex provides some technical aspects of content management for VBS2.

C.1 User profiles

VBS2 supports multiple user profiles on a single workstation. The active user is determined via a login prompt on the VBS2 main menu. Each user profile which retains all of that user's custom scenarios, maps, and settings. The different modes of the VBS2 application (described in Annex A) provide different degreesof access to user profiles. The VTK Admin mode has a dropdown menu listing all profiles on that machine, including any User-mode profiles. The VTK User mode has a text entry field but no dropdown, to avoid tampering with the Admin profiles.

The VTK User mode supports, in addition to profile names that can be defined in the VTK Admin mode, nicknames for each profile. The nickname is the player name that will be visible to others in the game and in any RTE menus. This can be changed from session to session without having to create a new profile every time. It is recommended that short, logical nicknames (usually incorporating a unit callsign and workstation number) be assigned to each player and that players not be allowed to modify them. It can be argued that allowing players to use their own names may assist in situational awareness and ease communication since the nickname is the only visual means of identifying other characters in-game, but from an administrator's point of view, having to identify specific players in the RTE (e.g. to revive players that have accidentally died or to move them around) during a fast-paced scenario can be challenging if there is no logical naming convention. A compromise might be to write up the real names of each player onto large labels that can be taped to their workstation to help admins identify them, and use these names as the nicknames.

The limited width of text fields in the RTE entity-list interface (which varies according to screen resolution, and was approximately 26 characters on our systems) also makes long names impractical, especially if the only uniquely identifying part of the name is at the end, beyond the edge of the window (there are currently no scrollbars for these menus, but recent versions have added a floating tooltip that displays the entire name). Thus we recommend using short user names, or including any uniquely identifying parts of the name at the beginning.

C.2 Third-party add-ons

Extra content that should be accessible to all users and admins is placed in its own folder, separate from the profile-specific content. It should be noted that third-party content carries no guarantee of quality or stability; for example, the third-party CADPAT uniformed soldier model that was obtained from a user forum contained a software bug that would occasionally make character faces appear to melt or stretch when the model was added to a scenario. As VBS2 is based on the same code as Bohemia Interactive's commercial videogame Armed Assault (ArmA), most add-ons and user-created content from the commercial product can be imported for use in VBS2. Add-ons from the sequel, Armed Assault II, are not compatible however, and cannot be imported into VBS2. Some sources of useful content include:

a. The official Bohemia Simulations web forum (VBS)
http://forums.bisimulations.com

b. The official Bohemia Studios web forum (ArmA)
http://forums.bistudios.com

c. VBS/ArmA enthusiast forums
http://www.armaholic.com/forums.php

Annex D Stock VBS2 Maps and Terrains

1. As Samawah
SIZE: 40km x 50km
TERRAIN: Desert; In-land with two large rivers
ELEVATION: Flat (15-30m above sea level)
FEATURES: 4 city areas, 1 FOB (Camp Smitty)
NOTES: This is the primary map used for Afghan-like training and demonstrations, due to its desert setting and geotypical structures (based on satellite imagery from As Samawah in southern Iraq). It also offers a good mix of dense urban and sparse rural areas, and has a forward operating base (FOB) to the south. Despite its large size, this map runs reasonably well on most machines (unlike the Basra map described below).

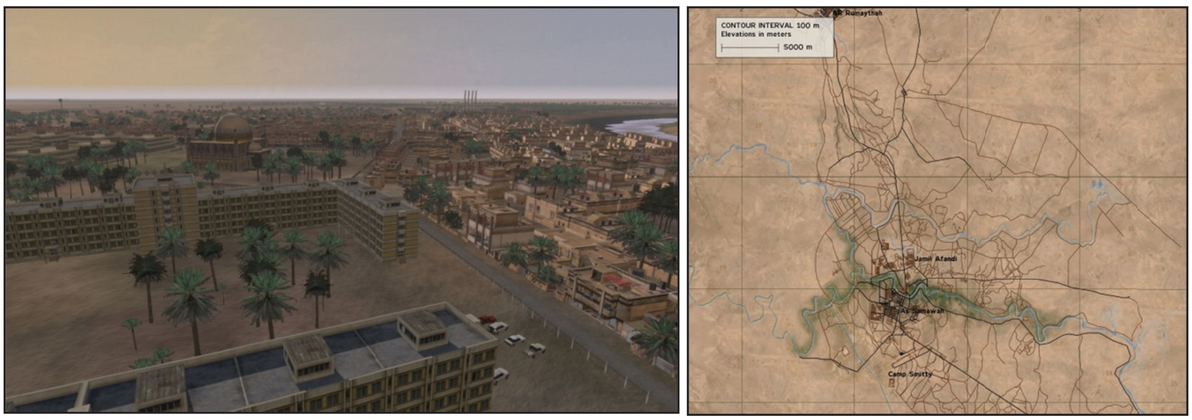

Figure 3: Screenshots of the As Samawah terrain

2. Sahrani
SIZE: 20km x 20km
TERRAIN: Temperate/Sub-tropical; Island
ELEVATION: Mountainous (0-500m above sea level)
FEATURES: 3 city areas, at least 30 smaller settlements, 1 paved airfield
NOTES: This medium-sized map offers a wide range of settlements to stage training scenarios in and has a temperate European / North American environment, with forests, beaches, grassy fields, and farmland. It is also the only map to offer large mountainous regions. The airfield on the southern island is a good location for site security and air vehicle scenarios. The forested in-land areas on the northern island can be used as a stand-in for a Canadian environment.

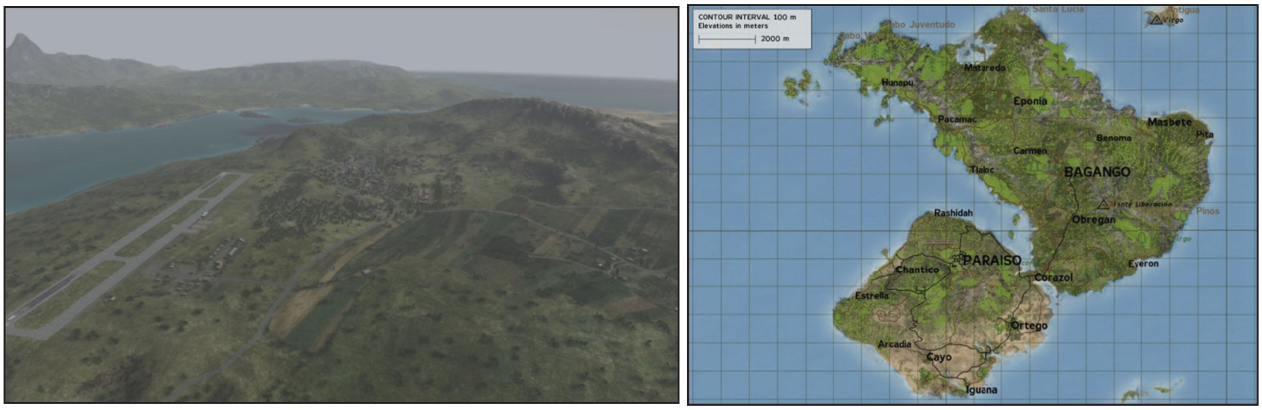

Figure 4: Screenshots of the Sahrani terrain

3. Porto

SIZE: 2km x 1km
TERRAIN: Temperate; Island
ELEVATION: Hilly (0-25m above sea level)
FEATURES: 1 central settlement
NOTES: This small island map has a fairly dense medium-sized settlement on it that is suitable for novice player training and familiarization. The ocean naturally contains the area, preventing players from straying too far. There is enough room for simple vehicle familiarization, but not enough for actual exercises or convoy scenarios.

Figure 5: Screenshots of the Porto terrain

4. Rahmadi

SIZE: 2km x 2km

TERRAIN: Tropical; Island

ELEVATION: Hilly (0-45m above sea level)

FEATURES: 1 small settlement, 1 dirt airstrip

NOTES: This island map is slightly larger than Porto, but lacks any real towns, roads, or vegetation (there is one small settlement available, but it consists of only a dozen shacks and small structures). A dirt airstrip lines the west side of the settlement. The sparseness of this map offers scenario builders the opportunity to add their own structures as they see fit and the small size of the island nearly guarantees that it will run well on any machine.

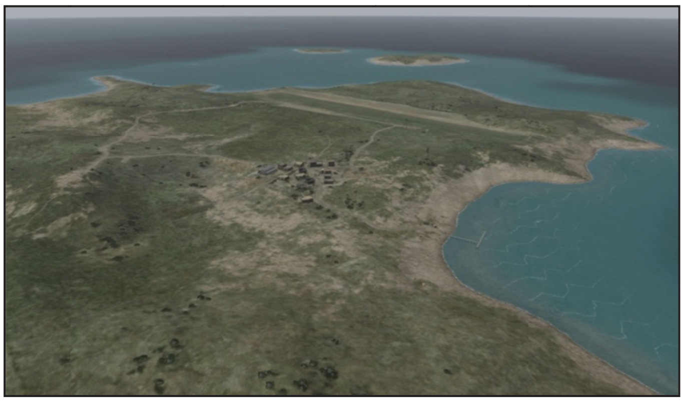

Figure 6: Screenshots of the Rahmadi terrain

5. Basra

SIZE: 20km x 25km

TERRAIN: Desert; In-land with several rivers

ELEVATION: Flat (0-10m above sea level)

FEATURES: Densely populated urban environment, large military airfield

NOTES: The large airfield on this map has potential as a KAF stand-in, but because of the enormous entity- and texture-footprint of this map, it runs poorly on even our most powerful PC's. The map is almost entirely urban and has a high density of roads and structures (based on Al Basrah in southeastern Iraq). Despite its quality, this map is not recommended for exercises where consistent performance is required.

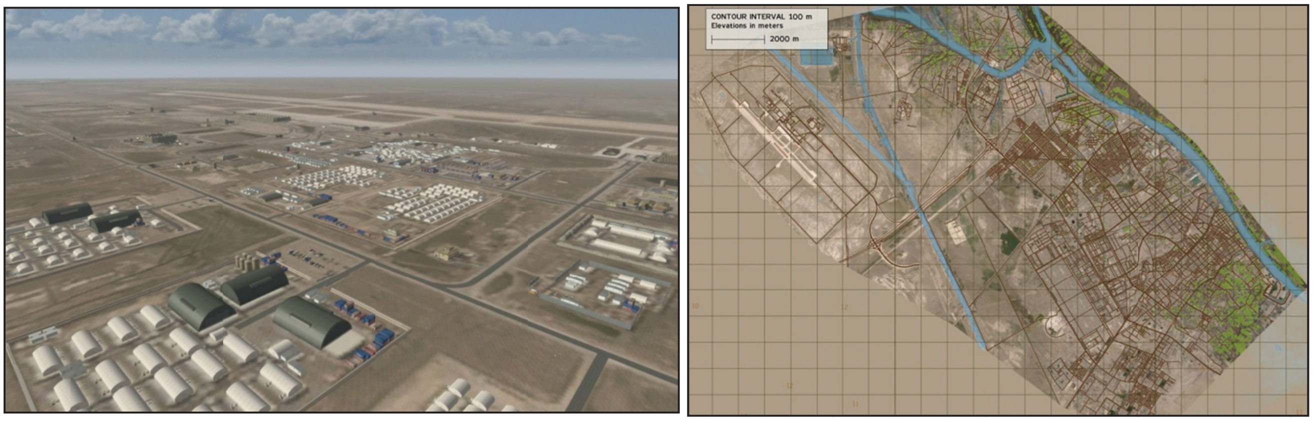

Figure 7: Screenshots of the Basra terrain

6. Baghdad Green Zone

SIZE: 10km x 20km

TERRAIN: Desert; In-land with a river

ELEVATION: Flat (45-60m above sea level)

FEATURES: Many Baghdad-specific landmarks, commercial airport

NOTES: Aimed primarily at American and British users, this map features a number of Baghdad landmarks including the Swords of Qadisiyyah, the Republican Palace, and the Monument to the Unknown Soldier. Baghdad International Airport is also modeled, but appears to be missing proper texturing for its runways and paved areas. Apart from the landmarks, there is relatively little ground clutter or realistic urban neighborhoods, making this a poor map for anything other than familiarization with Baghdad itself.

Figure 8: Screenshots of the Baghdad Green Zone terrain

7. Prison

SIZE: 1km x 1km
TERRAIN: Temperate; In-land
ELEVATION: Flat (65-80m above sea level)
FEATURES: Low-security prison complex
NOTES: While the temperate forested environment could be useful as a North American analogue, the abrupt end of all vegetation at the edges of this very small map make it impractical for all but the smallest-scale dismounted exercises.

Figure 9: Screenshots of the Prison terrain

8. Warminster

SIZE: 5km x 5km
TERRAIN: Temperate; In-land
ELEVATION: Flat (200m above sea level)
FEATURES: Training complex with vehicle course, shooting ranges, obstacle course
NOTES: This map can be useful for training and familiarization scenarios to help new players learn how to operate their weapons, drive vehicles, and move their characters around obstacles. The surrounding area features low-density residential roads and light forests.

Figure 10: Screenshots of the Warminster terrain

9. Geotypical Afghanistan

SIZE: 25km x 25km
TERRAIN: Desert; In-land
ELEVATION: Mountainous (300-1400m above sea level)
FEATURES: Very low density rural, several small FOBs, towns, caves
NOTES: This newly introduced map provides a useful alternative to the largely Iraq-based Middle Eastern maps previously available. There are a number of typical ISAF forward operating bases scattered across the map. Settled civilian areas are very limited.

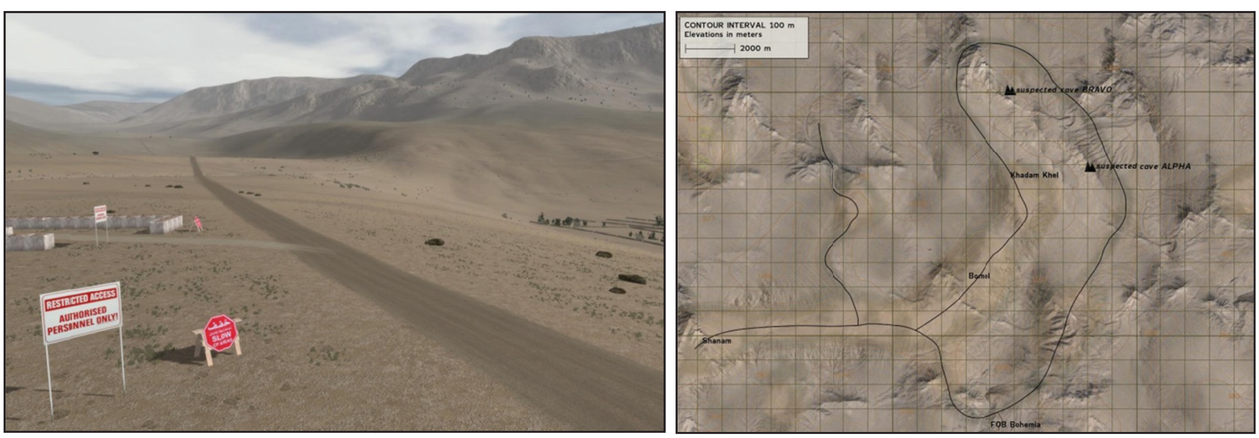

Figure 11: Screenshots of the Geotypical Afghanistan terrain

10. Geotypical Eastern Europe
SIZE: 25km x 25km
TERRAIN: Temperate; Island
ELEVATION: Hilly (0-200m above sea level)
FEATURES: Medium to high density urban, 1 paved airfield
NOTES: The coastline of this map is identical to Sahrani, but the topography has been flattened out somewhat and a very large number of high-rise structures have been added to all the urban areas. Unique structures, including harbours, estates, bridges, and lighthouses have also been introduced.

Figure 12: Screenshots of the Geotypical Eastern Europe terrain

11. Geotypical Tropical
SIZE: 25km x 25km
TERRAIN: Tropical; In-land with large rivers
ELEVATION: Hilly (60-260m above sea level)
FEATURES: Scattered huts, two small villages
NOTES: Possible North African stand-in. No roads have been laid on this map and despite the name, there is a significant amount of temperate forest along the river banks.

Figure 13: Screenshots of the Geotypical Tropical terrain

Annex E IED Placement in scenarios

The scenarios developed for the IED Awareness Trainer had the aim of simulating IED events that conformed to the "logic" of IED attacks discussed above in a controlled and reproducible manner. From a technical point of view, this involved the following considerations:

1. **Configuring IEDs**: IEDs are found in the Editor Object list and are placed by selecting 'IED' and double-clicking anywhere on the RTE map or in the 3D view. A menu will appear allowing the admin to specify a variety of properties for the device. The majority of scenarios used at DRDC require that players be alive and focus on reacting to the IED event, rather than treating the wounded or attempting Casualty Evacuation (CASEVAC). To ensure that nobody is killed or injured by the IED blast, the 'Explosion type' is set to 'Fake'. Even the 'Wound only' setting will knock players unconscious, toss them out of their vehicles, or disable their ability to walk, which tended to interfere with the scenario's training objectives. The explosion size should also be set to a fairly large value, otherwise it may not be obvious to players that it has actually detonated (particularly if they are in a vehicle convoy moving at high speed). IEDs used in these training scenarios were command-detonated only (regardless of the triggering mechanism that was portrayed in the scenario), to allow admins full control over the explosion. For instance, even when the IED was intended to simulate a pressure-plate device or a proximity device, the in-game IED was set and triggered manually

2. **Planting IEDs**: IEDs were planted on the ground, secured to objects, or placed in vehicles. In order for vehicle-borne IEDs (VBIEDs) to move with the vehicle, it must be attached by holding down the Shift key, left-clicking on the IED, then left-clicking on the target vehicle (IEDs can be attached to people using the same procedure). This can also be accomplished by right-clicking on the IED and selecting 'Attach to vehicle' or 'Attach to unit' from the context menu, and left-clicking on the target. If the IED is intended to be found by players, it is left visible, but for VBIED or detonation scenarios, the device is made invisible by selecting 'Hide / Unhide IED' from its context menu. Note that IEDs will be visible to players the moment they are added to the map, so if this is being done during a live scenario, it should be done away from the view of players or added via an overlay.

3. **Triggering IEDs**: Automatically detonated IEDs were found to be too unreliable (e.g. a pressure plate may not trigger even when a vehicle drives over it) so all detonations were controlled by admins, as mentioned above. This can be done by right-clicking the IED in the RTE and selecting 'Explode IED', but this may be tricky to do with a fast-moving VBIED. An easier way is to use a radio trigger. This is done by adding a trigger, then right-clicking the IED and select 'Attach to trigger' from the context menu and left-clicking on the trigger. The admin can then pull up their in-game radio and detonate the

IED by selecting the appropriate tag from the menu (hit the '0' key to bring up the radio, select 'Reply', then 'Radio Alpha' or whichever other trigger is required; the quick hotkey sequence for this is 0, 0, 1; this in-game radio menu has nothing to do with actual voice communications). This is a particularly effective way of controlling multiple IEDs that have to go off at different times, using several different radio triggers.

The problem with this approach, however, is that any player (not just the admin) can trigger the IED if they have access to a radio. This is being rectified in a future version of VBS2 by allowing triggers to be assigned to specific players only. Until this is implemented, instruct players not to touch this radio command, or not to use the in-game radio menu at all since they should be relying on CNR-Sim or Simspeak for voice communications.

A role-player driving a VBIED can also manually detonate from their action menu, by selecting 'Explode IED'. The action menu is opened and navigated by rolling the mouse wheel or hitting either square bracket key.

4. **Finding IEDs:** To be consistent with training objectives, IEDs emplacements must conform to the "logic" of IED emplacements documented by Eles (2009) and Bruyn Martin and Karthaus (2009), discussed above. In IED find scenarios, where the intention is for players to locate the device before it can be triggered, there is the added problem of making the device visible and identifiable as an IED, but not to the extent that the exercise becomes trivial. Due to the sparseness of the virtual environment, objects of any kind tend to stick out if they are placed in isolation (e.g. on the side of the road or out in the open); on the other hand, clutter and other in-game objects tend to lack sufficient detail to differentiate harmless piles of garbage from an IED, a command-wire from a video rendering glitch, or a freshly dug dirt patch from a texture error or shadow.

    a. For IED find scenarios, the only effective solution in our experience was to place obvious-looking devices outside of direct line-of-sight, but not cluttered by other objects that would interfere with identification (e.g. attached to the back of street signs, placed in the back of an empty flatbed truck, behind trees, next to culverts). We typically accompanied other indicators in addition to the IED, in order to train the PTA to attend to environmental cues of IED threats, such as trigger men looking at the players from a distance through binoculars, empty streets and disrupted pattern-of-life, aiming markers and geographical features, etc. In this way, locating the device is non-trivial and requires the PTA to learn to attend to environmental cues rather than focus narrowly on devices, but once found, there is no ambiguity as to what the device is.

    b. Without the ability to clearly identify devices (due to the insufficient visual fidelity of VBS2), any in-game object becomes suspicious to players and scenarios quickly become tedious and time-consuming as they stop to search every object they come across. The focus of the exercise should be to identify and integrate IED indicators in the environment, with the device itself merely being confirmation that they've correctly identified a threat.

5. **Detonation scenarios**: Devices or cues that are difficult to realistically reproduce in-game (e.g. a buried pressure-plate IED by the side of the road) should be saved for scenarios where detonation is meant to be unavoidable and a response, rather than identification, is the primary focus. In these scenarios, the in-game IED will simply be kept invisible.

    a. It can be difficult to precisely time a manual detonation if the target vehicle is moving at high speed, or if the driver decides to take a different route away from the IED location. One way to overcome this problem is to attach the invisible IED to the target vehicle itself rather than the ground, ensuring that the vehicle will be hit no matter where it is. An unfortunate side-effect of this approach is that the target vehicle is now considered a VBIED, and therefore gives the driver the option of detonating it from their action menu. For now, all the admin can do is instruct the players not touch that menu item.

    b. It is also recommended that the invisible IED be attached in front of the vehicle rather than behind or to the side, as players may not see the detonation in these positions, especially as we exclusively used "fake" IEDs as discussed above, so players only have visual and auditory cues to rely on to tell them that they have been hit. This is also the reason we tend to use 'Huge' or 'Extra Huge' explosion sizes for these IEDs.

This page intentionally left blank.

Annex F Available VBS2 Entities for CF missions

1. **LAV-III**
   ENTITY NAME: LAV III - ISV
   FORCE: CA Army (Armored Woodland)
   ARMAMENT: 25mm chaingun (turret), 7.62mm MG (coaxial), 7.62mm GPMG (pintle)
   CREWABLE POSITIONS: Driver, Commander, Gunner, 8x Passengers
   NOTES: The LAV-III is one of only two Canadian vehicles included in VBS2 at the time of writing. The vehicle model is fairly accurate, except for the turret interface, lack of ECM, and substitution of a 7.62mm GPMG for the C9 5.56mm LMG at the Commander position.

Figure 14: LAV-III model

2. **Griffon**
   ENTITY NAME: CH-146 - M134
   FORCE: CA Army (Air)
   ARMAMENT: 2x M134 doorgun
   CREWABLE POSITONS: Pilot, Co-Pilot, 2x Gunners, 4x Passengers
   NOTES: The CH-146 is one of only two true Canadian vehicles implemented in VBS2. The Griffon is used in scenarios in an overwatch role, or in a medical evacuation role in certain highly-scripted situations.

Figure 15: CH-146/M134 Griffon model

3. **RG-31**
   ENTITY NAME: RG-31 - M240
   FORCE: US Army (Armored Desert)
   ARMAMENT: 7.62mm GPMG (turret)
   CREWABLE POSITIONS: Driver, Gunner, 7x Passengers
   NOTES: Not an exact model of the CF RG-31. Accurate, except for the turret (should be RWS) and hatch positions.

Figure 16: RG-31-M240 model

4. **TLAV**
ENTITY NAME: M113A4
FORCE: AU Army (Armored Desert)
ARMAMENT: .50 cal Browning MG (turret)
CREWABLE POSITIONS: Driver, Gunner, 8x Passengers
NOTES: CF TLAVs are a shorter, 5-wheeled A3 variant, unlike this A4. The only other option (the US Army Armored Desert M113A3) lacks a turret, however, which is even less like the CF TLAV. This M113 has a non-CF camouflage pattern and lacks usable hatches for the passenger positions.

Figure 17: TLAV/M113A4 model

5. **Coyote**
ENTITY NAME: LAV25A2
FORCE: USMC (Armored Desert)
ARMAMENT: 25mm chaingun (turret), 7.62mm MG (coax), 7.62mm GPMG (pintle)
CREWABLE POSITIONS: Driver, Commander, Gunner, 4x Passengers
NOTES: The USMC LAV25 does not possess the telescoping surveillance package of the CF Coyote, and as a result, has a somewhat different seating arrangement in the rear cabin.

Figure 18: LAV25A2/Coyote Model

6. **Bison**
ENTITY NAME: ASLAV PC - M2
FORCE: AU Army (Armored Desert)
ARMAMENT: .50 cal Browning MG (pintle)
CREWABLE POSITIONS: Driver, Gunner, 11x Passengers
NOTES: The CF Bison fulfills MRT/Recovery, and Ambulance roles, for which it is armed with a C6 LMG or unarmed, respectively, rather than the .50 BMG of the ASLAV. The ASLAV has none of the associated repair or CASEVAC features, and uses an Australian camouflage pattern.

Figure 19: ASLAV PC-M2/Bison Model

7. **Infantry (Pre-v1.4)**
ENTITY NAMES: Automatic Rifleman; Corpsman; Leader
FORCE: USMC (Desert)
ARMAMENT: M249; M16A2; M16A4/M203
NOTES: The closest visual approximation to CF CADPAT AR infantry models are found in the USMC Desert force. The M16A2 is analogous to the C7 and the M249 is analogous to the C9. Kit and vest load-outs vary.

Figure 20: USMC Infantry models used in lieu of CF Infantry models, before VBS2 v1.4

8. **Infantry (Post-v1.4)**

ENTITY NAMES: CAN Soldier AR / CAN Soldier CADPAT

FORCE: Canadian Army - Soldier

ARMAMENT: C7A2, C6, C9, M136 LAW

NOTES: Proper first-party CF soldiers have been added to the Canadian distribution of VBS2 and feature Arid (AR) or Temperate (CADPAT) uniforms. Gear variants are provided as different unit types: the basic soldier wears a load vest and carries a C7A2; AT variants additionally carry a LAW; GPMG variants carry a C6; LMG variants carry a C9; Leader variants additionally carry binoculars; all variants are also available with flak vests.

Figure 21: CF Infantry soldiers with CADPAT uniforms and CF-issue weapons, in version v1.4 and above

This page intentionally left blank.

Annex G Scripting and RTE

G.1 The Real-Time Editor

One of the most powerful and versatile elements of VBS2 is the Real-Time Editor (RTE). It allows admins to add, move, edit, remove, heal, damage, revive, or kill entities, trigger scripts, adjust scenario settings (time of day, weather, etc), rearrange buildings, and perform a wide variety of other tasks on-the-fly during a scenario. Almost any feature found in the Offline Mission Editor (OME) can be used in the RTE. To access it, hit the ‘M’ key to load up the 2D map view and provide access to the RTE functions. Non-admin players will be able to see a simplified 2D map by hitting ‘M’ as well, but they will not have access to the various menus and controls in the RTE interface. Some tips for getting the most out of the RTE:

1. **Entity selection**: Entities are selected by clicking on them with the mouse’s left button. Once selected, entities remain so until other entities are selected. Scrolling around the map, using menus, and many other interface interactions will NOT “deselect” the entity. This has its uses, but more often than not, it results in the inadvertent movement or deletion of entities, as it is very easy for admins to lose track of which entities had previously been selected. At best, this is a minor annoyance that can be undone; at worst, this can cause a building to disappear during an exercise, or cause players to be dragged halfway across the map. Any changes made through the RTE are committed instantly and are visible to all players. Admins must take great care when selecting and editing entities during live exercises. A good habit to develop is to “deselect” all entities before performing a new action; this can be done by “selecting” (i.e., left-clicking on) empty ground.

2. **3D View**: An admin can right-click anywhere on the 2D RTE map and select the “Default camera” option to drop into a 3-dimensional view at that location. The admin still has access to all the same menus and controls they had in the 2D view, but can now fly around the game world with the W-A-S-D keys (and Q/Z for up/down). Holding down the shift-key increases the speed of this movement. The 3D view provides greater situational awareness than the map view and is a useful way for instructors and exercise staff playing the role of higher command to monitor the progress of the players, or for admins to precisely place and orient new entities.

   Admins in 3D view are not considered entities and are therefore invisible to players. Nevertheless, while using the RTE, the game still considers the admin to be ‘inhabiting’ whichever character they were last in control of; hitting the ‘Esc’ key from the RTE will return the admin to this character’s first-person view.

3. **'Player' versus 'Playable'**: These are two similar but distinct properties when adding new character entities in the OME which use a rather confusing naming convention. The Player property can be set to 'Player' or 'AI', and indicates whether the character is controlled by a human operator or by a scripted artificial intelligence. The Playable property, however, is relevant to AI entities only, and indicates whether an AI character can also be overridden and controlled by a human operator (changing the value of Playable for a Player character does nothing). Thus, there are three meaningful combinations of these properties:

    i. Player (available for human players only; remains idle if no human player takes control)
    ii. AI-Playable (available for human players; acts autonomously if no human player takes control)
    iii. AI-Non-Playable (not available for human players; acts autonomously at all times)

    A VBS2 scenario must contain at least as many Player or AI-Playable characters as there are human players who wish to join the mission (the networking administration screen, knows as the "networking lobby," for the scenario will have an open slot available for each Player or Playable character). However the number of Player or AI-Playable characters can exceed the number of human players, in which case the excess characters will be idle or act autonomously, respectively.

    Note that this property can only be set when using the OME (the number of slots available for human players has to be known before a scenario is loaded, so it must be established offline beforehand). Characters added to the scenario on-the-fly with the RTE will not have property fields for Player/Playable and will behave by default as AI-Non-Playable. This also means that the number of slots available for users cannot be increased once the mission starts – it's better to design a scenario with too many Player/Playable characters than too few.

    Another important note is to ensure that the button next to each unit in the network lobby shows the AI icon. If this icon is not shown, this unit will not be controlled in-game by artificial intelligence. More importantly, if a player unit is killed with this option disabled, they will respawn as a seagull entity with no way of again becoming "human" in this role.

Figure 22 AI Icon

4. **Controlling entities**: Admins can take direct control of any character in the game world by selecting it, opening the right-click menu, and selecting 'Switch to vehicle' (characters

currently under the control of another player cannot be taken over in this manner, but any other type of character, including AI-Non-Playables, can). The admin will then be switched to the standard first-person player interface for that entity. Be warned that even under the control of an admin, characters can still be incapacitated or killed.

5. **Multiple admins**: It is possible for more than one admin to join a mission and, therefore, for more than one admin to be using the RTE at any given time. This adds another layer of complexity to running live exercises, as there is no indication of what the other admins are doing (other than the effects of their actions; e.g. entities appearing out of nowhere or objects being picked up and moved around). As mentioned above, other admins' 'inhabited' characters may appear to be idle, but they could very well be roaming around in 3D view or performing other actions in the RTE. Some form of coordination between admins needs to be established to avoid confusion and conflicts.

6. **Overlays**: The overlay mechanism allows admins to overcome the problem of having all their actions immediately visible to players. This is particularly useful for setting up scenario events or other complex groups of objects that cannot be scripted ahead of time. By adding a new overlay from the 'Overlays' menu tab at the top of the RTE screen, objects, markers, and triggers can be placed in the scenario and kept hidden until the overlay is committed. Committing an overlay immediately updates the game world with its contents, making the changes visible to players all at once. Overlays can also be saved and re-used later any number of times, which can be useful for commonly used sets of objects (e.g. a vehicle-borne IED setup, or a roadblock). Note that characters (even AI-Non-Playable characters) cannot be added via overlays.

7. **Reviving players**: Dead characters under the control of a human player can be revived by right-clicking on their icon in the 2D RTE view, their body in the 3D RTE view, or their name in the entity list, and selecting 'Revive unit'. Characters not currently under the control of a human player can only be revived through scripts or the developer console. Adjusting their 'Health' property back up to 100%, or attempting to 'Switch to vehicle' into these dead characters will not work. To revive them, open the 'Tools' menu in the RTE, select 'Developer Console', enter *respawn [name]* (no brackets) in the code box, and hit the 'Execute' button. If the dead character does not already have a name assigned to it, edit its properties and give it a name first.

8. **Re-assigning players**: Human players can only be assigned roles when they connect to a scenario. Once actively engaged in the scenario, they cannot be re-assigned to another character. The only way around this restriction is for an admin to call up the main menu (by hitting the 'Esc' key repeatedly), then select the 'Participants' item, and 'Kick' the player out of the game. The player can then re-join as a different Player or Playable character.

9. **Weather and time**: Admins can adjust the weather and time-of-day using the 'Scenario Settings' item in the 'Tools' menu of the RTE interface. There are sliders for Overcast, Fog, Rain, Snow, and Wind (the 'Wanted Overcast' and 'Wanted Fog' sliders will transition the current Overcast and Fog values to the 'Wanted' values over a period of 30 minutes). The time can be entered through the 'Hour' and 'Minute' fields or by clicking on the 'Set Time' button to bring up an interactive time-of-day slider. Be warned that moving these sliders will immediately affect all connected players in the scenario; avoid changing them during a live scenario unless specifically required.

G.2 Scripting

Scripting is theoretically a powerful way to automate scenario events and perform more sophisticated tasks than is possible through either the OME or RTE interface. However, due to bugs, instability, and the unpredictability of some scripted events, this has not been a reliable tool in our experience, except in very specific circumstances). We recommend that admins and role-players perform important scenario tasks manually wherever possible. The following provide an overview of specific script-related issues we encountered.

1. **AI-controlled vehicles**: Entities added from the 'Vehicle' menu will automatically have a full crew complement of AI characters, so if the intention is to provide a vehicle for players to take control of, the 'Empty Vehicle' menu should be used instead. By default, vehicles with civilian AI drivers will react to gunfire and other threats by frantically trying to escape. This can be very disruptive to an exercise if an admin has unwittingly dropped AI-controlled vehicles into the scenario. AI drivers also have poor directional control and will have a tough time following scripted routes (even simple routes or straight lines). It is recommended that human role-players be used for driving tasks rather than leaving vehicles under AI control.

2. **Auto-revive scripts**: An automated script can be entered in the Developer Console to revive players immediately by constantly checking all players for status and calling the *respawn* command when it finds a dead one (e.g. *{_x addEventHandler ["Killed", {respawn player }]}foreach allunits*). This script will have an increasingly negative effect on performance as the number of units in the scenario increases.

3. **Triggers**: Triggers are special, invisible objects that execute specified scripts when certain conditions are met. Triggers are found in the Editor Object list in the bottom right-hand corner of the RTE screen (if this window is set to preview mode, click on the tab icons until the Editor Object list appears) and are placed by selecting 'Trigger' and double-clicking anywhere on the RTE map or in the 3D view. A menu will appear allowing the admin to specify a variety of properties for the trigger. The two most useful types are radio triggers and proximity triggers.

i. **Radio triggers**: Set the 'Activation' field to 'Radio Alpha' (or any of the other radio tags). Admins and any players equipped with an in-game radio will now have an option in their radio interface to activate the trigger.

ii. **Proximity triggers**: Set the 'Activation' field to 'OPFOR', 'BLUFOR', 'Civilian', or 'Independent' (depending on what type of unit you want the trigger to detect) and 'Activation type' to 'Present'. The trigger will execute if any unit of the type specified enters its activation area. To adjust this area, change the 'Size' field to the desired value in meters; alternatively, go to the RTE 2D or 3D view, hold left-Alt and right-click/drag the mouse forwards or backwards to increase or decrease its radius.

For triggers that need to be activated more than once, set the 'Repeatedly' field to 'True'. More complex triggers can be constructed by entering script code into the 'Condition' field, but this will override the other menu fields. If this is not the intention, leave the 'Condition' field set to '*this*' (if it's left blank the trigger will not activate at all). Once the radio call, proximity event, or other scripted condition is met, the script code in the 'On Activation' field will execute. In addition, any special effects selected from the 'Advanced' menu of the trigger will execute, and any attached IEDs will detonate.

4. **Invulnerability**: There is a script command that will disable player damage but this does not, unfortunately, prevent certain 'instant kill' effects, notably those of IEDs set to 'Fatal'. To issue the command, open the 'Tools' menu in the RTE, select 'Developer Console', and enter *[name] allowDammage false* (no brackets, two m's required in 'Dammage'), where *name* is the character to make invulnerable. Note that this is not a player name, but rather the name of the character entity they are in control of. Alternatively, the command can be issued in each player character's 'Init' line (in their property menu) as *this allowDammage false*. Consult the following tables to determine which effects are still valid under these conditions:

Table 1: Allowable damage states for 'normal' characters

	Admin menu 'Wound' command	Admin menu 'Kill' command	Weapons fire	Grenades (varies by range)	'Fake' IED	'Wound only' IED (varies by range)	'Fatal' IED (varies by range)
Health Damage	X	-	X	X	-	X	X
Temporary Unconsciousness	-	-	-	X	-	X	X
Death	-	X	X	X	-	-	X

Table 2: Allowable damage states for 'invulnerable' characters

	Admin menu 'Wound' command	Admin menu 'Kill' command	Weapons fire	Grenades (varies by range)	'Fake' IED	'Wound only' IED (varies by range)	'Fatal' IED (varies by range)
Health Damage	X	-	-	-	-	-	-
Temporary Unconsciousness	-	-	-	-	-	X	X
Death	-	X	-	-	-	-	X

Because of all these limitations and caveats, it was still necessary to set all IEDs to 'Fake' to avoid killing players or knocking them unconscious. The only real benefit of setting *allowDammage* to false is to eliminate friendly-fire deaths and reduce the amount of reviving admins have to do during live scenarios.

Annex H Technical aspects of other scenarios

H.1 Convoy scenarios

Convoys were a common VBS2 training scenario. These scenarios could be done in conjunction with IED threat environments to practice IED drills, or in safe environments to focus on communications and teamwork. Convoys present their own challenges for players and admins, as described below.

1. **Vehicle identification**: One of the first problems that players will encounter in a vehicle or convoy scenario is that of coordinating who should go in which vehicle; related to this is the problem of distinguishing one vehicle from another. A simple way to ease this process is to label each vehicle with a unit callsign. Vehicles will have a field in their property menu called 'URN Marking: Veh' which will accept an alpha-numeric string and display it directly on the side of the vehicle.

2. **Vehicle spacing**: Maintaining speed and spacing in aconvoy in the synthetic environment can be difficult for players because of differences in perception of speed and vehicle control between the real world and the VBS2 world. It is especially important that in-game ranging and hands-on vehicle training be conducted before convoy scenarios. It is also vital that all the drivers be briefed about the accelerate/reverse buttonology issue (i.e., the "brake" button inVBS2 actually applies a reverse force to the vehicle, eventually leading it to move in reverse, rather than come to a full stop).

3. **Turrets**: Some CF convoys will include turreted vehicles such as the LAV-III. The turret is usually operated by whoever is in the gunner seat. Turning-out from the default gunner position will give the gunner a better view of the vehicle's surroundings and the positioning of the turret itself relative to the body of the vehicle. The turret may lose some range of motion if the driver, commander, or passengers turn-out and open their hatches. This is not a malfunction; the full range of motion will return once all hatches are closed. If time permits, gunners should also receive some hands-on training beforehand to familiarize themselves with the turret's firing modes and get a feel for the ballistics and target ranging from the gunner's position. Rules of Engagement will also be an important training topic, as the gunner is usually the first crew member to identify and respond to threats in the environment.

H.2 UAV use

Several Unmanned Aerial Vehicles (UAVs) are available for use in VBS2, and though they were not heavily used during convoy and counter-IED scenarios, they are useful in-game assets that can provide a unique view of the battlefield for higher command during exercises or for guests during demonstrations. The MQ-1 Predator and MQ-9 Reaper UAVs in particular possess a variety of realistic-looking thermal sensor views, which are useful when the objective is to provide a compelling UAV display (rather than an accurate one). Below are various aspects of using UAVs in VBS2 we encountered during our simulation events.

1. **Control Links**: Three entities are required for a UAV to be functional in a scenario: the UAV itself, a Ground Control Station (GCS), and a Control Link. UAVs and GCSs can be found in the Quick Add entity list on the left-hand side of the RTE screen (under 'Vehicle' > 'Unmanned Vehicles'); however, the Control Link is a special object that must be added from the Editor Object list on the lower right-hand side of the screen. The Control Link is invisible to players and can be placed anywhere on the map, though for convenience, it is recommended that the Link be placed near the GCS. The Control Link must then be attached to a GCS by right-clicking on it, selecting 'Link to unit', then left-clicking on the GCS. Any player may now walk up to the GCS and take control of the UAV.

   It is possible to attach a Control Link directly to a specific player or vehicle, forgoing a GCS altogether, but we've generally found the GCS to be a more flexible and stable option (e.g. different people may need to use the UAV, or the linked player/vehicle may crash or get killed).

2. **Placing the UAV**: The UAV itself should be added to the scenario with the 'Special' flag set to 'Flying', unless there is a specific need for the UAV to take off from the ground. UAVs can be assigned a waypoint route before the scenario is started, but as of v1.3, UAVs seem to have great difficulty in following these routes. More often than not, they will overshoot the first waypoint and spend the rest of the scenario flying in irregular circles around that waypoint instead of continuing on to the next one. This is less likely to happen if the required turn to stay on course is gentle, and the UAV is set to the lowest possible airpseed.

   If the desired waypoint route is an orbit over a particular area, one solution is to assign a single waypoint far off in the distance (e.g. near the edge of the map) such that the UAV will fly past the area of interest, start the scenario, then quickly assume control of the UAV at the GCS and lock onto a target with the 'L' key. Camera lock-on should force the UAV to orbit the target; if this isn't working, ensure that the ‘Allow camera locking’ and ‘Enable automatic orbiting’ options are enabled in the Control Link’s property menu.

As of v1.4, a new 'LOITER' waypoint type has been added that performs the same function. A direction of orbit and radius in meters must be provided (it is recommended that the radius be at least 1000m). Note that if a Loiter waypoint is used, camera locking will no longer automatically update the center of the orbit.

3. **Controlling the UAV**: If using a GCS, admins must move their character into close proximity of the GCS and hit the ‘U’ key to interact with it. From the action menu, select ‘UAV Controller’ to automatically switch to the UAV camera view (or if there are multiple UAVs in the scenario, select from the presented list of UAVs and hit enter). Controls while in this view include:

    U: enable / disable autopilot (assume manual flight control)
    W: increase autopilot set speed
    S: decrease autopilot set speed
    Q: increase autopilot set altitude
    Z: decrease autopilot set altitude
    L: engage / disengage lock onto target nearest cursor
    Keypad +: zoom camera in
    Keypad -: zoom camera out
    V: switch to third-person view
    Ctrl-M: show GPS mini-map
        G: fade mini-map background to transparent
        H: fade mini-map background to opaque
        Shift-Left Mouse Button: add waypoint on mini-map
        Shift-Right Mouse Button: delete waypoint on mini-map

    N: activate thermal imaging (repeat to cycle through different views)
        Alt-~: enable / disable thermal imaging auto-brightness and auto-contrast
        Alt-1: decrease brightness (auto must be off)
        Alt-2: increase brightness (auto must be off)
        Alt-3: decrease contrast (auto must be off)
        Alt-4: increase contrast (auto must be off)

4. **Orbiting targets**: It is recommended that UAVs be flown at minimum airspeed and medium altitude (1500-2500ft) to ensure a clear, stable camera view. If altitude is set too low, buildings and other obstructions will cause the UAV to lose camera lock and stop tracking the target. If altitude is set too high, the

object/terrain draw distance may be exceeded and make viewing the target difficult.

Orbiting of a locked target is not foolproof and requires some trial and error to establish. If targets are changed repeatedly in rapid succession, the UAV may not correctly update the orbit route or get confused and disengage orbit altogether. The UAV also requires some time to line up an approach vector to the desired route (this should be visible as a spiraling waypoint path in the RTE map view or the UAV mini-map). Flying at high speed may also make it impossible for the UAV to turn tightly enough to hit its approach vector; the piloting AI does not appear to be intelligent enough to resolve this problem and will continue to circle around and re-try the approach forever if this happens.

Annex I Performance considerations

VBS2 can run reasonably well on a wide variety of computer hardware but this, as with any 3D application, will depend on several factors, as described below.

1. **Scenario complexity**: The choice of map and the number of entities placed on it will greatly affect peak and average framerates on any machine. Smaller maps with fewer entities will allow improved performance. Entities which are ‘baked’ into the map (i.e. are part of the map’s original design and have been optimized into the file; this typically only includes roads and buildings) appear to have less of an impact than entities which are added later via the RTE or offline editor. For this reason, it is advantageous to find existing sections of maps that are suitable for use rather than attempting to create new areas by adding a large number of objects to the map. The disadvantage with this approach is that ‘baked’ objects cannot be moved or edited in the RTE, so they must be accepted as-is. If no suitable areas can be found, Bohemia’s map editing tool ‘Visitor’ can be used to create a new map with all the desired buildings, roads, and objects baked into it. This is a complex and time-consuming process, however, that goes beyond the scope of this document.

   Entity AI and complex scripting also consumes a significant amount of CPU resources. Having large numbers of AI civilians or scripted OPFOR entities can bog down the entire scenario and also has negative consequences for AAR performance.

2. **Video settings**: The Video options menu in VBS2 has a number of settings that can have a severe impact on performance. In rough order of significance, they are:

   a. **Resolution**: Currently, with the computer equipment identified in Annex A, 1680x1050 is the highest resolution that could be run without running into significant performance problems. The native resolution of the monitors used by the desktop client machines was also 1680x1050, so there was no practical reason to exceed it. The laptops were run at 1280x1024 or less, due to their reduced graphical processing power. Running at high resolutions reduces the need for antialiasing (described below), as there are more pixels available to draw polygon edges. Conversely, high antialiasing compensates for the subjective effects of using a lower-resolution display. Therefore, some subjective trade-offs can be made between these two features.

   b. **Terrain / Object Draw Distance**: These settings determine how far away from the player (in meters) terrain and objects will be drawn. Terrain beyond the terrain limit will gradually be fogged until it is no longer visible. Objects beyond the object limit will simply not be drawn at all, and may pop-in abruptly if this distance is set too near or is significantly different from the terrain draw distance. For ground units, distances beyond 2-3km are generally not required due to occlusion by buildings and other nearby objects, but aircraft / UAV controllers and FACs will want this set as high as possible. Be aware that as the player's altitude increases, the amount of terrain and entities that will have to be drawn will increase geometrically, creating an enormous computational burden that may not be immediately obvious when standing on the ground.

c. **Shadow detail**: The drawing of shadows requires significant computing power, compounded by the number of entities that are in the scene (each one requiring extra calculations). The intermediate values for this setting attempt to reduce this burden by simplifying the shadows' shape and reducing its resolution, but this tends to look highly unrealistic. For this reason, it is recommended that the shadows either be set to 'High' or turned off altogether.

d. **Antialiasing**: Antialiasing smoothes the edges of polygons on screen and reduces the incidence of jagged or 'crawling' lines that typically occur at lower screen resolutions. This is a hardware feature of any modern videocard, but it still carries a noticeable performance hit if set too high. It is recommended that this feature be used for resolutions of 1280x1024 or less.

e. **Terrain / Objects detail**: These settings affect the number of polygons used to draw objects or the terrain surface. Lowering these settings will improve the performance (speed) of the simulation, but will significantly reduce the realism of the game, as the low-detail vehicle and character models are quite poor. One exception is for maps that have little or no elevation changes (such as As Samawah or other desert maps); in this case, dropping the terrain detail setting can save some horsepower with minimal impact on fidelity.

f. **Shading detail / Postprocess effects**: Modern videocards that support shader model 2.0 / 3.0 should have little problem rendering these graphical effects (depth-of-field, light bloom, etc). Unless there is some compatibility issue with the hardware available, it is recommended that these settings be kept 'High'.

g. **Anisotropic filtering**: This setting improves the clarity and detail of textures, particularly when viewed at shallow angles (e.g. looking down a long road, terrain in the distance when flying, etc). This carries a minimal performance hit and is recommended to be kept at 'High'.

h. **Texture detail**: This setting should be kept as high as possible; lower resolution textures will make signs difficult to read and make objects look significantly less realistic. This carries almost no performance hit until the amount of texture memory used exceeds the amount available on the videocard, in which case a sharp decrease in performance may occur. Modern videocards with 512mb of video memory or more should be able to run at the 'Very High' setting.

3. **Network performance**: Since VBS2 is a team training environment, maintaining good network performance is crucial to keeping the clients synchronized with each other and avoiding disruptive 'lag'. If such problems do arise, a broken chain-link icon will appear in the bottom right corner of the screen (yellow to indicate poor connection quality, red to indicate critically poor quality or lost connection). In this state, other player-controlled entities may appear to move in a very disjointed manner or jump from place to place every few seconds. For convoy scenarios or any other scenario where players are moving at high speed, even a small amount of lag will be very disruptive and make it almost impossible to maintain vehicle spacing.

   All the client and server machines and any network switches or hubs used to connect them should support gigabit Ethernet. Wireless connections are not recommended as they are significantly slower and prone to interference. Internet or LAN traffic should be kept to a minimum to avoid using up bandwidth (while VBS2 doesn't actually use much bandwidth itself, any heavy network congestion may interfere with VBS2's ability to maintain timely communication). It is recommended that the client and server machines be kept on their own closed network, or that external connections be disconnected while running training exercises.

The server must also be free to manage all the client connections and overhead associated with running a networked scenario. Any heavy burden on the server's CPUs or memory will negatively impact network performance. For this reason, it is recommended that a dedicated server be run on a separate machine from any admin or player stations.

This page intentionally left blank.

Annex J Sample Schedule

Sample Schedule for Day 1

0700-0820	CIED Theory and TTP review including CIED "Actions-On" Training Video 3 – IED Strike, Convoy Speed Through
0820-0830	Break
0830-0930	VBS2 Controls and Familiarization Training & VBS2 ROEs
0930-1000	Overview of Mission Brief & ROEs
1000-1230	Scenario 1 - Convoy drills, no incidents Convoy Orders issues to Convoy Commander (5min) Convoy Commander's plan & issue of his orders to the Convoy (15min) Re-org/rehearsals (30min) VBS2 mission play (45min) Assessors prep AAR/PTA on break (10min) AAR (45min)
1230-1315	Lunch
1315-1330	CIED "Actions-On" Training Video 4 - Vulnerable Point Search, IED Strike, Vehicle Mobility Kill (10:00min)
1330-1600	Scenario 2 - IED Strike (no damage to vehicles, no casualties)

Sample Convoy Orders (Issued by Exercise Staff to Convoy Commander)

You will be conducting a combat patrol from __________ and __________ to link up with ________________ for future operations.

1. SITUATION
   a. Enemy. Insurgent cells are actively carrying out IED attacks along major routes within our area of operations. Major strikes within the last 6 months have been recorded as per the ISTAR overlay.
   b. Friendly. No friendly traffic is anticipated during this move.
2. MISSION

   You will conduct a combat move from ______________ to _______________ and arrive NLT _________ hrs (**1hr and 15 min from current time**) for orders.
3. EXECUTION
   a. Concept of Operations
   b. Route: ____ route as per trace
   c. ECM Equipment: Each vehicle has ECM and one PCM.

This page intentionally left blank.

Annex K VBS2 Familiarization Training

Though the majority of exercise participants were not specifically familiar with VBS2, many had played similar PC games and were comfortable with the conventions and control schemes it uses. For the benefit of those participants that are not as comfortable with these conventions, it is important to conduct some form of training and familiarization with the software. Some key points to consider include:

1. **Buttonology**: The last two pages of the VBS2 user manual are keyboard maps for both infantry and vehicle controls. It is recommended that these be printed and placed at each player station as a reference. There are also built-in training and familiarization scenarios accessible from the main VBS2 menu under 'Training Scenarios'. These are short, single-player tutorials that teach players how to move their characters and interact with the game world. There is also some merit in conducting your own custom multiplayer training to get players familiar with identifying other players on-screen, using the comms, maintaining situational awareness, and any scenario-specific tasks that must be performed in-game (e.g. 5's and 20's, seeing what IEDs look like in VBS2, ranging, etc). This can be conducted in small maps like Porto or Warminster, or in a section of the map that will actually be used for the exercise to follow. A sample training curriculum is outlined below:

    a. **Basic Movement**
        - Movement (W/A/S/D)
        - Mouse-look
        - Lean left/right (Q/E)
        - Run (Shift-W)
        - Sprint (double-tap W)
        - Move point-to-point as a group
        - Form up line-abreast

    b. **Posture**
        - Stand (C)
        - Crouch (X)
        - Prone (Z)
        - Posture drill

    c. **Free-look**
        - Momentary free-look (hold Alt, mouse-look)
        - Toggle free-look (double-tap Alt)
        - Free-look in vehicles

    d. **Weapons**
        - Raise/Lower weapon (double-tap Ctrl)

- Switch weapons (Spacebar)
- Fire weapon (Left mouse button)
- Use optics (V)
- Reload (R)
- Focus / Hold breath (Right mouse button)
- Aiming reticules and accuracy
- Basic target shooting

e. **Equipment**

- Map (M)
- GPS mini-map (Ctrl-M)
- Grid coordinates and navigation
- NVGs (N)
- Binoculars (B)
- Compass (G)
- Watch (T)
- Inventory menu (I)
- Action menu (mouse wheel)
- Directional SA

f. **Vehicles**

- Vehicle interaction menu (U)
- Exit vehicle (double-tap H)
- Driving (W/A/S/D)
- Brake behavior
- Left/Right turn signals (Insert / PageUp)
- Turn-out / Turn-in (Z)
- Turret operation

g. **Radios**

- Press-to-talk (hotkey depends on CNR-Sim configuration)
- Selecting different radio nets

h. **Ranging**

- Demonstrate what people, vehicles, and objects look like at set distances (50m, 100m, 250m, etc)

i. **IEDs**

- What IEDs look like
- What IED strikes look like and what their effects are
- IED indicators (culverts, command wires, disturbed earth, aiming markers, trigger men, pattern of life, etc)

j. **Drills**

- 5’s & 20’s
- Vulnerable Point Search
- Cordon
- Rules of engagement

2. **Game-isms**: Certain idiosyncrasies and unrealistic phenomena that occur within the game have been loosely termed ‘game-isms’ and may need to be pointed out to new players.

    a. **Death and injury**: Players’ screens will fade to black with an on-screen message indicating death or unconsciousness if they are hit by ‘Fatal’ or ‘Wound Only’ IEDs (or falls, explosions, weapons fire, etc). In the latter case, they will regain consciousness within 10 seconds followed by a period of shakiness. In the case of player death, they should be instructed to alert an admin and get them to revive their character.

    b. **‘Fake’ IED blasts**: If ‘Fake’ IEDs (i.e., IED objects that create a visible and audible detonation without producing any other effects on players) are to be used in the scenario, it may be useful to inform players of this and allow them to experience what a Fake IED hit is like in-game during the tutorial phase, so it’s clear what is happening if and when they get hit during the actual exercise (without this precaution, players might not even be aware that a “fake” IED has exploded). This may have the side-effect of reducing immersion and the sense of danger for players, however, so it’s up to admins to decide if this is worth revealing.

    c. **IED triggers**: Players should be instructed not to touch radio or action menu items that deal with detonating or disarming IEDs, as these are special scenario events to be controlled by admins.

    d. **Simulated events**: Certain scenario events, like vehicle breakdowns, cannot be reproduced very well by VBS2 (in the case of breakdowns, lowering the health of the vehicle would eventually lead to it catching on fire and becoming permanently disabled; emptying it of fuel is visible on the driver’s vehicle interface and may be confusing), requiring admins to use placeholder messages on-screen to inform players that the event is occurring (e.g. “Your vehicle is experiencing a mechanical failure”). To issue messages to all players, open the Dev Console, enter *hint “text”* (including quotation marks, where *text* is the message to be displayed) in the script field, and hit the ‘Execute global’ button. Sending a message to an individual player or multiple specific players will require additional scripting (e.g. an if-then statement checking the players’ names, then sending the hint command). Players may have to perform certain tasks verbally (e.g. checking ECM status before starting a convoy) in order to practice the drills that are currently not simulated in VBS2 (note that VBS2 models some ECM activity in select vehicles, and does so in a rudimentary manner that may not be adequate for all scenarios). This is important to do in order to prevent negative transfer of training, that is, to instil the discipline of the drills that cannot be physically practiced in the simulator, but without which incorrect SOPs would be practiced and perhaps remembered.

e. **Graphical glitches**: As with any 3D videogame environment, VBS2 has numerous glitches and subtle flaws in the rendering of the terrain or objects in the game world. In IED-find scenarios, players will often mistake these glitches (e.g. the visible discontinuity between texture sections, or a flickering artefact on-screen) for command wires or other suspicious items. It may be helpful to demonstrate what some of these glitches look like beforehand, or failing that, have 'higher' issue directives on-the-fly when too much time is being spent inspecting non-IED objects (e.g. "The convoy is required to be at the FOB ASAP; mount up and continue as scheduled").

f. **Civilian AI behavior**: As mentioned previously, AI behavior can be somewhat unpredictable and players should not necessarily expect AI entities to behave like real people. Civilian AI entities will automatically flee from weapons fire, whether they are on foot or in a vehicle; civilians set to wander will walk right onto roadways and will not notice or yield to vehicles; civilians travelling as a group will tend to 'orbit' the center of the group and may occasionally break into a sprint to catch up with the group (this caused some problems during scenarios, as players often perceived this as suspicious or threatening behavior); characters in general do not have good idle animations and will appear to be standing motionless or staring at a fixed point (again, often perceived as suspicious).

Annex L Conducting Simulation Activity

The actual running of a simulation event can be challenging for the white team, as players often seem to find ways to do the unexpected. They may spend the bulk of an IED scenario inspecting harmless junk and miss the IED; they may decide the village where the IED strike is planned is too suspicious and change the convoy route to a completely different section of the map; they may decide to engage innocent civilian role-players with turret fire; they may start playing around with the inventory, map, or radio interfaces and inadvertently break the scenario. Almost all of these situations are valuable learning experiences for everyone involved, but making sure that the original training objective is met requires flexibility on the part of the white team. The following are a fewkey insights we learned about the actual conduct of the simulation activity itself.

1. **Multiple contingencies**: There should always be more than one training event built into any scenario. Due to unpredictable player behavior, technical glitches, or other unanticipated problems, the primary event may not work. In this case, there should be a plan in place to move seamlessly to a secondary or tertiary event. In the case of IED scenarios, this could involve setting multiple devices in multiple locations, backed up by an invisible IED attached to one of the vehicles themselves. For convoy small-arms ambushes, have multiple teams of OPFOR characters ready to go, and make sure role-players and admins know how to switch to another team if the convoy changes its route.

2. **Scenario length**: Long scenarios (over an hour in length) can be problematic for a variety of technical reasons. Taxing the computer hardware for long periods of time can lead to overheating, crashes, memory leaks, and other glitches. Long scenarios tend to increase loading delays and decrease performance during the subsequent AAR. The map also tends to accumulate 'junk' as a scenario progresses (e.g. craters from explosions, knocked down trees and buildings, damage to vehicles, dead OPFOR or civilian characters, etc) which reduces performance and may interfere with the next scenario. Post-mission analysis and recordkeeping becomes more difficult if too many things are happening in long, continuous sessions. For these reasons, it is recommended that training objectives be limited in number and scenarios be broken down into smaller chunks such that each focus on one particular objective. Aim for scenarios that take no longer than 30 minutes.

   Between each session, VBS2 should be shut down on all the clients and servers and started fresh for the next session. If the scenario requires the players to continue from where they left off, take note of their rough locations and reposition their vehicles and characters in the new session to match.

3. **Role-players**: Ideally, all civilian or OPFOR role-players supporting a scenario should be experienced admins who are familiar with the RTE interface and are comfortable with adjusting to the players' actions as the scenario progresses. All role-players should be briefed on ROE and the training objectives for the scenario, so they have some context for their actions. Rehearsals are also recommended beforehand to reduce confusion and unnecessary communications traffic during the live scenario.

.

Annex M Sample Assessment Checklist

The following checklist was designed to be used as an assessment tool for the AAR process when conducting training with the IED Awareness Simulator for operations in an IED threat environment to confirm and assess employment of CF C-IED TTPs.

Convoy Brief

Was a convoy/patrol brief done prior to the start of the scenario?

- If so, did it include/cover the following:
  - Past IED incidents on planned route(s) with the following detail:
    - locations (by grid or map feature)
    - type of IED (VBIED, RCIED etc)
    - location of previous cordons and ICPs/RVs if known?
  - Was the route of previous convoys/patrols mentioned to ensure a pattern wasn't being set wrt time of departure, route, loc of halts, loc of VPS conducted, etc?
  - Routes and convoy details such as:
    - route plan
    - OOM
    - speed (fast but varying the speeds)
    - spacing (varying on the move and at halts)
    - location/tasks for pers
    - location/status of ECM equipment
  - Identify likely VPS locations?
  - Actions on:
    - Contact
    - Vehicle breakdown
    - VPS
    - Halts (5&20s)
    - IED Find
    - IED Detonation
    - Civilian traffic (foot and vehicle)
  - ROE refresher
  - Individual crew responsibilities/tactical measures for:
    - convoy commander

vehicle commander (2i/c)

drivers

gunners

guys in back (GIB) (passenger/air sentry & dismount duties)

Overall rating on brief given 1 2 3 4 5
Comments____

Overall rating on attention/participation of convoy members to the brief 1 2 3 4 5
Comments____

Convoy Discipline

Were the following C-IED TTP convoy/patrol drills followed?

Was vehicle ECM confirmed to be turned on?

Did they drive in the center of the road?

Always (except when standoff required)

Often

Sometimes

Never

N/A (road width too small)

Did they drive fast but varying their speeds?

Did they communicate about varying speeds?

Comments ____

Did they vary spacing between vehicles on the move?

Did they communicate about varying spacing?

Comments ____

Were troops vigilant (searching for IED indicators) on the move? Did they:

Communicate indicators they saw within their vehicle crew?

Communicate indicators they saw with the rest of the convoy/patrol?

Were they prompted to communicate what they see by:

Convoy commander

Vehicle commander

Other crew member

Rating on vigilance 1 2 3 4 5

Comments ____

Overall Comments____

Actions on Halts

Purpose of halt? VPS Vehicle problem Unnecessary Other __________________

Did they conduct 5&20s Drill? Both vehs One veh only No

Did they assess the area before stopping?

Did they do mounted 5s before dismounting?

Did they check under the vehicle?

Did they cover all ground and elevation levels?

Comments: ____

If VPS, rate how well it was conducted? 1 2 3 4 5

Was ECM coverage sufficient?

Comments: ____

Was security established and maintained throughout? 1 2 3 4 5

Length of time at halt _____min Too short Sufficient Too long

Actions on IED Find

Was the IED suspected/found?

What indicators lead them to the find? _____________________________________

____

If they missed the IED, list comments on what was missed and why.

____

Was SAID followed?

Did they STOP if they detected IED before entering Kill Zone (KZ)?

If so, was it in a safe area/safe distance from the possible IED?

Did they conduct 5&20 Drills? Both vehs One veh only No

Did they assess the area before stopping?

Did they do mounted 5s before dismounting?

Did they check under the vehicle?

Did they cover all ground and elevation levels?

Comments: ____

____

Did they SPEED through after noting the Find to move out of the KZ?

Did they designate an RV/halt loc?

Did they STRIKE BACK if applicable?

Did they get off the KZ first?

Were ROEs followed?

Did they ASSESS the situation?

Did they communicate indicators seen?

Did they focus out and look for secondary IEDs or follow on attack?

Did they determine a COA?

Were all call signs & individuals in the convoy immediately INFORMED?

Was a contact report initiated to higher?

Was an IED contact report sent? (Was it correct?)

Were the 5C's employed?

Was the IED CONFIRMED from a safe distance?

Was higher CONTACTED (EOD 10 Liner information sent)?

Was area immediately CLEARED of all personnel & vehicles?

Was CORDON established? Distance from IED ____________m

If this is not the first cordon observed, is there a pattern being set?

Were 5&20s done in new loc if moved? Both vehs One veh only No

Did they assess the area before stopping?

Did they do mounted 5s before dismounting?

Did they check under the vehicle?

Did they cover all ground and elevation levels?

Comments: ____
____

Was the scene CONTROLLED?

Was a visual maintained on the IED (with binos/scopes)?

Was security maintained?

Overall rating on drills 1 2 3 4 5

Comments____

Overall rating on teamwork 1 2 3 4 5

Comments____

Actions on IED Detonation (no casualties)

Was the IED suspected/found prior to detonation?
What indicators were communicated?

____

____

If they missed the indicators or ignored them, comment on what and why.

____

____

Was SAID followed?

Did they STOP if they detected IED before entering Kill Zone (KZ)?

If so, was it in a safe area/safe distance from the possible IED?

Did they conduct 5&20 Drills? Both vehs One veh only No

Did they assess the area before stopping?

Did they do mounted 5s before dismounting?

Did they check under the vehicle?

Did they cover all ground and elevation levels?

Comments: ____

____

Did vehicles STOP after the detonation in the KZ? (or if hit while at halt did they all remain stationary?)

Comments: ____

____

Did the mobile vehicles SPEED through after the IED detonation to move out of the KZ or STOP prior to moving into the KZ?

Did they designate an RV/halt loc?

Did they STRIKE BACK if applicable?

Did they get off the KZ first?

Were ROEs followed?

Did they ASSESS the situation?

Check for casualties?

Check for vehicle damage/mobility?

Did they communicate indicators seen?

Did they focus out and look for secondary IEDs or a follow on attack?

Did they determine a COA?

Were all call signs & individuals in the convoy immediately INFORMED

about the strike?

about the COA? (Frag O)

Was a contact report initiated to higher?

Was an IED contact report sent? (Was it correct?)

Were the 5C's employed?

Was the detonation CONFIRMED to be an IED?

Was the IED CONFIRMED from a safe distance?

Was higher CONTACTED (EOD 10 Liner information sent)?

Was the KZ immediately CLEARED of all all unnecessary pers & vehs?

Was CORDON established? Distance from IED ____________m

If this is not the first cordon observed, is there a pattern being set?

Were 5&20s done in new loc if moved? Both vehs One veh only No

Did they assess the area before stopping?

Did they do mounted 5s before dismounting?

Did they check under the vehicle?

Did they cover all ground and elevation levels?

Comments: ____

____

Was the scene CONTROLLED?

Was a visual maintained on the IED (with binos/scopes)?

Was security maintained?

Overall rating on drills 1 2 3 4 5

Comments____

____

Overall rating on teamwork 1 2 3 4 5

Comments____

____

Actions on QRF Handover

Was a handover done?

Was the layout of the cordon clearly and correctly passed on?

This page intentionally left blank.

Annex N After-Action Review

One of the key features that distinguish VBS2 from other gaming environments is the After-Action Review functionality. It allows instructors to debrief players on what went right and what went wrong during the exercise. This also allows for exercises conducted in the IED Awareness Simulator to conform to CF doctrine on conducting exercises, which require the conduct of some kind of AAR after training events (Department of National Defence, 2010)

At DRDC, AARs were conducted by operating the VBS2 AAR functionality in room separate from the main “playing” area (see Annex A) with two playback stations, each driving a 50” plasma display.

The VBS2 AAR “recordings” capture everything that happens to the entities within the scenario in a VBS2 *.aar* file, while the CNR-Sim / CNR-Log software captures the comms audio and synchronizes comms playback during the AAR (the SimSpeak software performs a similar function but requires manual synchronization of the audio playback with the AAR).

N.1 Steps of the VBS2 AAR process

The following describes the steps involved in setting up an AAR in VBS2; it assumes that CNR-Sim is being used as the comms software for the event, however the procedure for using SimSpeak instead is practically the same.

1. **Recording**:

    a. **LVC**: If comms audio from CNR-Sim/CNR-Log is required, one of the admins must start VBS2 using the ‘VBS2 LVC Admin Host CNRLog’ shortcut. This will allow VBS2 to interface with the CNR-Log audio server (via DIS) and to record and synchronize the comms audio. Loading VBS2 with the regular ‘VTK Admin’ shortcut will not properly engage CNR-Log.

    b. **CNR**: All players should already have the CNR-Sim application running in the background (otherwise they will not be able to communicate). The admin using ‘VBS2 LVC Admin Host CNRLog’ should also have CNR-Log running in the background on their machine to manage and capture all the comms coming from the CNR-Sim clients. Be sure to test the entire comm net beforehand, as some of the CNR configuration items can be tricky. See the CNR manual for instructions. Stop CNR recording and save the log folder after the VBS2 scenario ends.

c. **Start recording**: The admin using 'VBS2 LVC Admin Host CNRLog' can begin recording at any time by opening up the RTE interface and pressing the grey circle button at the top-right side of the screen, next to the recording timer. Once AAR recording is activated, the button will change to a red square and the timer will start running. Hit the red square to stop the recording.

d. **Tagging events**: Notable events during the scenario can be bookmarked for easy reference later during AAR playback by using the bookmark menu on the left-hand side of the RTE interface (click the bookmark tab icon if it's showing the Layer or Quick Add menus instead). Give events clear and concise names to reduce confusion during the AAR.

2. **Playback**:

   a. **Required files**: AARs require two sets of saved data in order to function correctly: the *.aar* file produced by VBS2 and the log folder produced by CNR-Log (recorded comms audio; this folder includes an *.ser* file, an index file, and a data file with no extension). The *.aar* file must be in the VBS2 AAR folder on the machine that will be used to playback the AAR. The log folder can be on any machine on the same network, as long as the CNR-Log server application is running on that machine and the IP for that server is entered in the VBS2 AAR machine's *vbsClient.config* file.

   b. **Server arrangement**: Because most training exercises involved multiple scenarios being run back-to-back, it was necessary to run AAR playbacks on a different machine (in a separate AAR room) from the VBS2 server that recorded the file, while the next scenario was being setup in the main exercise room. This required that the *.aar* file be copied quickly over the network to the AAR room once the scenario ended. As long as the CNR-Log server is running on the same network, it is not necessary for the log folder to be moved anywhere. However, the comms audio will play off the audio hardware on the CNR-Log server, so for practical reasons, this machine should be in the AAR room or wired such that its audio is piped to speakers in the AAR room.

   c. **Starting the AAR**: Launch VBS2 with the 'VBS2 LVC Admin Host CNRLog' shortcut under 'CNR'. This will allow VBS2 to interface with the CNR-Log audio server to playback and synchronize the comms audio with the rest of the AAR. Make sure that CNR-Log has the appropriate log folder loaded for the AAR that is being presented (if the AAR is being conducted immediately after the exercise, CNR-Log should still have the last log open). Click the 'After Action Review' button in the VBS2 main menu and select the desired *.aar* file.

Comms audio should automatically synchronize and play at the appropriate times during the AAR.

d. **Multiple AAR playbacks**: In order to minimize the impact of the delays involved in loading and cueing up AAR playbacks, DRDC used a second machine to run AARs simultaneously. This allowed the training coordinator to discuss an event of interest on one machine, while an admin cued up the next event on the other, switching back and forth between the two as the AAR progressed. An undocumented feature of the CNR-Log system is that multiple AAR clients can access the same CNR-Log server at the same time without any special configuration or adjustment. The only caveat is that only one AAR should be playing (e.g. in the 'Play' mode via the VCR-style controls) at any given moment, otherwise the comms from one will interrupt the other. Cueing by clicking or dragging the mouse through the timeline while paused will NOT trigger comms audio, and is safe to use while another AAR is playing.

e. **CNR-Log sessions**: CNR-Log refers to each log as a 'session' and has its own internal time-stamping mechanism to keep track of when comms events from VBS2 are happening. Another undocumented feature of CNR-Log is that these sessions can automatically distinguish between different AARs, thereby allowing multiple *.aar* files to use one continuous CNR-Log session for audio. This was discovered by accident when a CNR-Log session was left recording for multiple VBS2 scenarios; all of the various AARs for those scenarios were able to find and cue up the correct comms audio from this single CNR-Log session without any kind of intervention or reconfiguration. For archiving and recordkeeping purposes, it's still recommended that CNR-Log sessions be stopped at the end of each VBS2 scenario so there is one log folder for each *.aar*, but this is potentially a very useful feature.

N.2 AAR Performance and Usage Considerations

The AAR system records all the entities, their properties, movement, gaze, firing events, etc. There are some game variables, however, that are not recorded properly in the AAR and can lead to confusing events during playback. One example of these is turret position on particular vehicles which results in constantly jittering turret position. Also, player animation and movements are not recorded precisely and can result in awkward movement transitions in the AAR.

Events can also be tagged during the recording of an AAR; these will appear in the bookmark list on left-hand side of the AAR interface (click the bookmark tab icon to bring up the list). Doubleclick on any bookmark to skip directly to the tagged event. Communications events are shown as colored markers on the timeline.

The VBS2 AAR functionality generates an enormous amount of data and playing it back requires a great deal of CPU, memory, and hard disk performance. This burden increases with the number of entities that must be kept track of. Careful scenario design and re-using a minimal number of civilian and role-player characters for different parts of the scenario can help increase performance both in the scenario and later during the AAR. Some issues that should be considered when using the AAR function include:

1. **Loading delays**: The initial loading of the AAR playback file may take 5-15 minutes (even while the interface appears to have loaded up, cursor response and interactivity may not become available for several minutes; this is normal). Cueing through the AAR playback may also be slow, depending on the number of entities in the scenario. As mentioned above, two AAR stations were used to mitigate these delays.

2. **AAR length**: Running and recording long scenarios (over an hour in length) will impact AAR performance, as the system must load up data for everything that occurred during the scenario. The longer the scenario, the more data it must read, and consequently, the longer it will take to load the AAR.

3. **Cueing delays**: A related problem is the length of time it takes the AAR system to jump to an arbitrary point in the playback timeline. It appears that the system must sequentially process all the data and events in the intervening time period from where the playback currently is and where the playback is cued to. This means that skipping over large sections of the timeline will take longer than skipping shorter sections.

4. **Inconsistencies**: Not everything that individual players see and experience will be in the AAR and vice versa. It is important to understand that the AAR is not a video recording, but rather a data recording of entity positions, states and events. When the AAR is played back, VBS2 is actually running a simplified gameplay session using the captured data to drive its entities. This means that if the graphical settings (e.g. draw distance, model detail, etc) on the AAR machine are significantly different from the machines the scenario was run on, what is visible in the AAR may not accurate reflect what players saw at the time. Conversely, some admin-like features (e.g. the ability to see ‘invisible’ IEDs, markers, and other special objects) are available in the AAR that will not have been available to players during the scenario.

List of symbols/abbreviations/acronyms/initialisms

AAR	After-Action Review
AI	Artificial Intelligence
BLUEFOR	Blue Force
CASEVAC	Casualty Evacuation
CF	Canadian Forces
CIED	Counter-Improvised Explosive Device
CTA	Cognitive Task Analysis
CTC	Combat Training Centre
DND	Department of National Defence
DRDC	Defence Research & Development Canada
DRDKIM	Director Research and Development Knowledge and Information Management
ECM	Electronic Counter-Measures
EOD	Explosive Ordnance Disposal
ETHAR	Explosive Threat Hazard Awareness and Recognition
IED	Improvised Explosive Device
OCT	Observer-Controller Trainer
OPFOR	Opposing Force
PTA	Primary Training Audience
QRF	Quick Reaction Force
R&D	Research & Development
RCIED	Remote-Controlled Improvised Explosive Device
ROE	Rules of Engagement
RTE	Real-Time Editor
SME	Subject-Matter Expert
UAV	Uninhabited Aerial Vehicle
VBIED	Vehicle-Borne Improvised Explosive Device
VBS2	Virtual Battle Space 2
VPS	Vulnerable Point Search

This page intentionally left blank.

Distribution list

Document No.: DRDC Toronto TM 2013-027

LIST PART 1: Internal Distribution by Centre

2 Director Science & Technology Land
DRDC Corporate
Attn: Michel Symczak (Michel.Symczak@drdc-rddc.gc.ca)
Mark Espenant (Marc.Espenant@drdc-rddc.gc.ca)
305 Rideau St.
Ottawa, Ontario
K1A 0K2 (electronic copy)

2 DRDC CORA Land & Operational Commands
Attn: Jérôme Levesque (Jerome.Levesque@forces.gc.ca)
Philip Eles (Philip.Eles@forces.gc.ca)
National Defence Headquarters
101 Colonel By Drive
Ottawa, Ontario
Canada K1A 0K2 (electronic copy)

4 TOTAL LIST PART 1

LIST PART 2: External Distribution by DRDKIM

1 Library and Archives Canada

1 Directorate of Land Concepts and Designs
Attn: Bruce Chapman (BRUCE.CHAPMAN@forces.gc.ca)
Empire Building, Hwy 15
CFB Kingston
K7K 7B4 (electronic copy)

1 Canadian Forces Air Warfare Centre
Attn: François Cazzolato
National Defence Headquarters
101 Colonel By Drive
Ottawa, Ontario
Canada K1A 0K2 (electronic copy)

1 Counter-IED Task Force
Attn: Maj Gail Luc Hamel (LUC.HAMEL@forces.gc.ca)
National Defence Headquarters
101 Colonel By Drive
Ottawa, Ontario
Canada K1A 0K2 (electronic copy)

1 Directorate of Land Synthetic Environments
Attn: Chris Taff (CHRIS.TAFF@forces.gc.ca)
Building A-31
Canadian Forces Base Kingston
PO Box 17000
Kingston, Ontario
Canada K7K 7B4 (electronic copy)

1 Directorate of Army Training
Capability Development
Attn: LCol Dave Beyer (Dave.Beyer@forces.gc.ca)
Canadian Forces Base Kingston
PO Box 17000
Kingston, Ontario
Canada K7K 7B4 (electronic copy)

3 Combat Training Centre Gagetown
Tactics School
Attn: Maj Dan Schurman (DAN.SCHURMAN@forces.gc.ca)
Maj Thomas Batty (Thomas.Batty@forces.gc.ca)
Mr Dan Daigle (DAN.DAIGLE@forces.gc.ca)
Building J7
CFB Gagetown
Oromocto, New Brunswick
E2V 4J5 (electronic copy)

1 Directorate of Land Requirements
Simulation & Training (6-5)
Attn: Maj Mike Lakatos (MICHAEL.LAKATOS@forces.gc.ca)
National Defence Headquarters
101 Colonel By Drive
Ottawa, ON, K1A 0K2 (electronic copy)

3 Canadian Defence Academy
Attn: Maj Chris Horeczy (CHRISTOPHER.HORECZY@forces.gc.ca)
LCdr Remi Tremblay (REMI.TREMBLAY@forces.gc.ca)
Mr. Bill Railer (BILL.RAILER@forces.gc.ca)
Canadian Defence Academy Headquarters
CFB Kingston
PO Box 17000
Kingston, ON, K7K 7B4(electronic copy)

16 TOTAL LIST PART 2

This page intentionally left blank.

DOCUMENT CONTROL DATA

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (The name and address of the organization preparing the document. Organizations for whom the document was prepared, e.g. Centre sponsoring a contractor's report, or tasking agency, are entered in section 8.) Defence R&D Canada – Toronto 1133 Sheppard Avenue West P.O. Box 2000 Toronto, Ontario M3M 3B9	2. SECURITY CLASSIFICATION (Overall security classification of the document including special warning terms if applicable.) UNCLASSIFIED (NON-CONTROLLED GOODS) DMC A REVIEW: GCEC APRIL 2011

3. TITLE (The complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S, C or U) in parentheses after the title.)

Simulation-Based Training for IED Awareness: Best Practices and Experiences

4. AUTHORS (last name, followed by initials – ranks, titles, etc. not to be used)

Jerzy Jarmasz; Dorothy Wojtarowicz; Jason Dielschneider; Ken Ueno

5. DATE OF PUBLICATION (Month and year of publication of document.) March 2013	6a. NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.) 112	6b. NO. OF REFS (Total cited in document.) 25

7. DESCRIPTIVE NOTES (The category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

Technical Memorandum

8. SPONSORING ACTIVITY (The name of the department project office or laboratory sponsoring the research and development – include address.)

Defence R&D Canada – Toronto
1133 Sheppard Avenue West
P.O. Box 2000
Toronto, Ontario M3K 2C9

9a. PROJECT OR GRANT NO. (If appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant.) 12RR03	9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.)
10a. ORIGINATOR'S DOCUMENT NUMBER (The official document number by which the document is identified by the originating activity. This number must be unique to this document.) DRDC Toronto TM 2013-027	10b. OTHER DOCUMENT NO(s). (Any other numbers which may be assigned this document either by the originator or by the sponsor.)

11. DOCUMENT AVAILABILITY (Any limitations on further dissemination of the document, other than those imposed by security classification.)

Unlimited

12. DOCUMENT ANNOUNCEMENT (Any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availability (11). However, where further distribution (beyond the audience specified in (11) is possible, a wider announcement audience may be selected.))

Unlimited

13. ABSTRACT (A brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), (R), or (U). It is not necessary to include here abstracts in both official languages unless the text is bilingual.)

Improvised Explosive Devices (IEDs) have been major threats to CF soldiers in recent conflicts (e.g., in Afghanistan) and will likely continue to be a threat in the foreseeable future. Accordingly, Defence Research & Development Canada - Toronto (DRDC Toronto) has been investigating training methods and technologies to better prepare soldiers to detect and assess IED threats in theatre. One of these tools, the IED Awareness Simulator, was designed by DRDC Toronto around the "serious games" Virtual Battle Space 2 (VBS2) platform, for the purpose of training the team aspects of IED detection in convoys. This report describes the design requirements for the IED Awareness Simulation, the procedures we developed for using it during counter-IED training events, and our "lessons learned" about what works well and what doesn't in the simulator, in particular regarding its core application, VBS2. We conclude with recommendations for the development of future synthetic training environments for teamwork and command-and-control in tactical asymmetric conflicts.

Les dispositifs explosifs de circonstance (IED) ont constitué un grand danger pour les soldats des FC au cours des conflits récents (p. ex. en Afghanistan) et continueront probablement de poser un danger dans un avenir rapproché. Recherche et développement pour la défense Canada (RDDC) Toronto étudie donc des méthodes et des technologies d'instruction pour mieux préparer les soldats à détecter et à évaluer les dangers que présentent les IED dans le théâtre. Un de ces outils, le simulateur sur la lutte contre les IED, a été conçu par RDDC Toronto en se servant du jeu sérieux Virtual Battle Space 2 (VBS2) comme plateforme afin d'enseigner à une équipe les particularités de la détection des IED dans un convoi. Le présent rapport décrit les exigences de conception de la simulation sur la lutte contre les IED, les procédures que nous avons élaborées pour les instructions sur la neutralisation des IED, et les « leçons retenues » sur ce qui fonctionne et ce qui ne fonctionne pas dans le simulateur, notamment en ce qui a trait à son application principale, soit VBS2. Pour conclure, nous formulons des recommandations sur la mise au point future d'environnement d'instruction sur simulateur pour le travail en équipe et le commandement et contrôle dans les conflits aux tactiques asymétriques.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

Improvised Explosive Devices; IEDs; training; simulation-based training; serious games; Virtual Battle Space 2; VBS2

Defence R&D Canada

Canada's Leader in Defence
and National Security
Science and Technology

R & D pour la défense Canada

Chef de file au Canada en matière
de science et de technologie pour
la défense et la sécurité nationale

DEFENCE R&D DÉFENSE

www.drdc-rddc.gc.ca