vWorld capability development support

Final report

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VWORLD CAPABILITY DEVELOPMENT SUPPORT
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EXECUTIVE SUMMARY

CAE Inc. was contracted (Solicitation No.W7707-135643/B) by Defence Research and Development Canada (DRDC) to provide support to a two year agility project to develop a capability to use Virtual Worlds (vWorlds) at DRDC Atlantic (Halifax, NS) and DRDC Toronto and to demonstrate the application of vWorld technologies to naval projects including the development and review of spatial systems such as naval compartment layouts and team processes. The support covered:

a. The provision of training on the OpenSimulator (OpenSim) vWorld technology;

b. Conduct of a compatibility study concerning the interoperability of OpenSim with other DND/CAF simulation tools and technology; and,

c. Conduct of a literature survey intended to inform DRDC as to how OpenSim or similar vWorld technology could be used to support activities such as concept development, collaborative design review, and experimentation for operations rooms in naval platforms.

To assist DRDC in future planning activities, the recommendations resulting from this work concentrate on are the most immediate pressing issues affecting the development and review of spatial systems for naval projects and are:

a. A tool chain and process should be established to take visual (3D) model source formats that will be used by DND and convert them to COLLADA format for import into OpenSim;

b. The manner and means by which terrain and visual model content will be shared amongst other simulation systems including serious games should be considered and documented; and,

c. A pilot project with a group of stakeholders should be established to use OpenSim for one of DRDC's intended application areas to gain experience and feedback on its use.

1 INTRODUCTION

This document is the final report developed for the project entitled *vWorld Capability Development Support*. This report was completed by CAE Inc. (CAE) for contract #W7707-135643/001/HAL to Defence Research and Development Canada (DRDC) – Atlantic administered by Public Works and Government Services Canada (PWGSC).

1.1 Background

Virtual worlds (vWorlds) are interactive, persistent simulated environments accessible by multiple distributed users simultaneously. Within a vWorld, human representation typically takes the form of avatars that may interact with the environment and each other. DRDC is interested in the use of a specific vWorld implementation technology – OpenSimulator (OpenSim) (1) – to enable the Department of National Defence/Canadian Armed Forces (DND/CAF) to develop and review spatial system designs such as compartment layouts and team processes on naval platforms.

OpenSim is an open source virtual world technology based on the protocols used by the pioneering online virtual world Second Life developed by Linden Labs. OpenSim is intended to be an open source version of Second Life and OpenSim viewers, both the scripting and visual content are largely compatible with Second Life and the differences are well documented.

1.2 Objective

The objective of contract #W7707-135643/001/HAL (2) was for CAE to provide support to a two year agility project to develop a capability to use vWorlds at DRDC Atlantic (Halifax, Nova Scotia) and DRDC Toronto and to demonstrate the application of vWorld technologies to naval projects. The major activities covered under the terms of the contract were:

a. Provision of training (3) on the use of the OpenSim vWorld technology;

b. Conduct of a compatibility study (4) concerning the interoperability of OpenSim with other DND/CAF simulation tools and technology; and,

c. Conduct of a literature survey (5) intended to inform DRDC as to how OpenSim or similar vWorld technology could be used to support activities such as concept development, collaborative design review, and experimentation for operations rooms in naval platforms.

1.3 This Document

This document is the final report of the vWorld Capability Development Support project. It contains a brief overview of the activities conducted within the project, and insights and opinions of the project team based on these same activities intended to assist DRDC in planning future activities.

The structure of this document is as follows:

a. **Section 1: Introduction.** Presents an overview of the contract, objectives, and scope of this report;

b. **Section 2: Method & Results.** Presents an overview of the activities conducted under the contract, and discusses developments that have occurred since those activities were completed;

c. **Section 3: Observations & Recommendations.** Presents observations, insights and opinions based on the activities conducted;

d. **Section 4: Conclusion.** Presents concluding remarks and recommended next steps;

e. **Section 5: References.** Presents a bibliography of the citations used in preparing this report; and,

f. **Section 6: Definitions and Acronyms.** Identifies the acronyms and abbreviations used throughout this document.

2 METHOD & RESULTS

This section presents an overview of the activities conducted and deliverables prepared under the contract, and discusses developments that have occurred since those activities were completed.

2.1 Training Course

A training course on the OpenSim tool and supporting technologies was provided in March 2013. The objectives of the training course were to teach attendees how to:

a. Install, configure and maintain OpenSim to allow multiple OpenSim users to interact with a single, potentially distributed, virtual world from multiple distributed locations;

b. Create original content to populate the virtual world.

Table 2-1 lists the major tools used during the training course. For more details on the training course refer to the training course material (3).

Table 2-1: Major Tools used in the OpenSim Training Course

Tool	Version	Purpose
OpenSimulator	0.7.5	OpenSim server
MySQL	5.6.10.0	Database server used by the OpenSim server to store all elements of the virtual world
Hippo Viewer		OpenSim client user interface used by vWorld users
GIMP	2.8.4	An image manipulation program used for terrain creation
file_slraw.py		GIMP plug-in to save files in Second Life Raw format
Blender	2.49b	Graphics software used to create three dimensional (3D) visual models
Primstar	1.0	Blender plug-in to manage Second Life Sculpted Primitives

It was noted during the training course that the two main content creation tools, GIMP and Blender, were not the current version of those tools. However, the versions presented were the latest versions that were compatible with the OpenSim / Second Life plug-ins: file_slraw.py and Primstar 1.0.

In the year since the training course was delivered, there has been one main release of OpenSim, version 0.7.6, and one minor release, version 0.7.6.1. The changes introduced since version 0.7.5 are either internal or minor additional features or improvements and do not affect the validity or content of the training in any way.

The current version of MySQL (Community Server Edition) is 5.6.16. The changes over 5.6.10 also do not affect the validity or content of the training in any way.

2.2 Compatibility Study

A compatibility study was conducted concerning the interoperability of OpenSim with other DND/CAF simulation tools and technology. Interoperability was assessed with respect to simulation operation, terrain models, 3D models, and human factors tools within the context of four use cases: importing previously developed content, exporting content created in OpenSim, integrating OpenSim into a larger simulation, and enabling distributed simulation environments.

The results of the compatibility study can be summarised as follows:

a. With respect to the interoperability of simulation operation, there is no existing direct compatibility that is publically available. For example, OpenSim does not support the Distributed Interactive Simulation (DIS) or High Level Architecture (HLA) standards. However, as the source code for OpenSim is available it may be possible to develop this capability. Distributed simulation environments can be developed using multiple instances of OpenSim servers and clients, however, integrating within a larger simulation environment involving other technologies is likely to involve significant development effort;

b. For the most part, terrain source data formats used to create terrain databases for other simulation tools and technologies, such as JSAF and OneSAF, and terrain database formats themselves are likely to be able to be used to create terrain for OpenSim. Some formats are compatible either directly or by simple transformation. Incompatibilities are most likely to be due to the use of proprietary or undocumented formats in other tools rather than real technical limitations;

c. OpenSim is compatible with 3D models used by other tools and technologies via the COLLADA interchange file format for 3D applications. The name COLLADA is derived from the term Collaborative Design Activity. Free and commercial tools are available that are able to convert other formats to and from the COLLADA format. OpenSim does not currently have a native capability to export 3D models from its environment, although one could be developed;

d. OpenSim could be made compatible between human factors tools such as HumanCAD and IPME, although further investigation and experimentation is required to ascertain the technical feasibility and cost of this; and,

e. A compatibility checklist was developed to guide DRDC in the assessment of OpenSim compatibility with additional tools not reviewed in the report.

For more details on the compatibility study refer to the report (4).

As the compatibility study was being conducted, it became clear that the Hippo Viewer that was used during the training course is not the best OpenSim client to use if interoperability of 3D models is desired. This is because while the OpenSim server supports the use of the COLLADA 3D model file format, the Hippo Viewer client does not. As a result, we recommend the use of the Firestorm client, which can both import and view 3D models in COLLADA format,

instead of the Hippo Viewer. The only limitation of Firestorm compared to the Hippo Viewer is that it requires more powerful hardware (CPU and graphics card) to achieve the same level of performance as the more limited Hippo Viewer.

Importantly, the current version of the Firestorm viewer, version 4.6.1.40478, supports the 64 bit version of Windows (6).

2.3 Literature Survey

A literature survey was conducted to inform DRDC as to how OpenSim or similar vWorld technology could be used to support systems development, collaborative design review, and possibly experimentation for operations rooms in naval platforms.

The literature survey focussed on OpenSim with an aim to identify and to discuss:

a. Convergent and divergent trends;

b. Active user communities and applications;

c. The use of OpenSim in support of system development for: Navy operations, Navy training, other military operations and training, real-time defence and security (for example, emergency operations), or other real-time, operational, complex, high-risk environments;

d. How OpenSim can be linked to other analysis tools; and,

e. How OpenSim has been linked to other applications.

The conclusions of the literature survey were as follows:

a. Several vWorld platforms are available that could be and are or were being applied to military domains including: Second Life, OpenSim, Virtual Battle Space 2 (VBS2) / VBS3, Active Worlds, Croquet, On-Line Interactive Virtual Environment (OLIVE), Open Colbalt Alpha, OpenEnergySim, Open Wonderland, Pivote and Teleplace;

b. Converging trends reveal that OpenSim is being demonstrated as a capable and flexible platform. There is an active OpenSim user community in the application domains of interest to DRDC including organizations such as: US Naval Undersea Warfare Center (NUWC), the US Navy Postgraduate School, Florida Institute of Technology (Harris Institute for Assured Information), University of Edinburgh (Artificial Intelligence Applications Institute), and the US Army;

c. OpenSim can support diverse applications including systems development and training, and the number of institutions exploring vWorlds in general seems to be increasing as awareness of the technology increases. However, the scientific literature assessing the validity of vWorlds for training or analysis is immature and the effectiveness of these technologies remains to be determined;

d. Research and development or at the very least knowledgeable analysis is needed to match training requirements to evolving vWorld capabilities in order to establish the validity of a vWorld for the intended training application. Much of what is known about the effectiveness of simulation-based training should be applicable, but there are many misconceptions held by education practitioners; and,

e. Basic research is needed to develop open architecture (OA) frameworks for specifying vWorlds to promote exchange and reuse of models as well as reduce the incidence of models that cannot be exchanged between virtual environments.

The recommendations of the literature survey were as follows:

a. Employ a user centred design approach to develop tools fit for use in vWorlds for the purpose of systems development and training;

b. Conduct a number of use case experiments that compare vWorld development to conventional design methods to assess the relative costs and effectiveness of immersive environments for design. The use cases should be sufficiently challenging that they can discriminate between the design approaches, but limited in scope so that they could be conducted in an affordable manner. Further, the experimental design should explicitly include adequate training in both traditional and vWorld design methods to minimize biases due to learning the methods per se;

c. Employ a disciplined, instructional design approach before considering vWorlds as a potential solution for training delivery;

d. Conduct a directed investigation of training effectiveness. Effective training typically requires a disciplined application of instructional design, applying what is known about how people learn, how learning can be disrupted and how technologies support learning; and,

e. Validate the use of OpenSim for learning and training by employing transfer of training analysis methods.

For more details on the literature survey refer to the report (5).

3 OBSERVATIONS & RECOMMENDATIONS

This section presents observations, insights, opinions and recommendations based on the activities conducted under the project.

Throughout the duration of this project, a range of different tools and technologies have been encountered, considered, evaluated and/or used. They fall broadly in to four different categories:

a. Frameworks in which tools and technologies implementing virtual worlds, serious games and other applications may be developed, such as Unity3D;

b. Serious games, such as VBS2;

c. Virtual world products, such as OpenSim; and,

d. Tools and technologies to develop terrain, 3D models and other content for virtual worlds, such as GIMP and Blender.

Each has its own strengths and weaknesses and degree of relevance for application to DRDC's core interest: to develop and review spatial system designs such as compartment layouts and team processes on naval platforms.

3.1 Frameworks

Frameworks such as Unity3D do not provide a virtual world per se, they provide a development toolkit from which a virtual world (or virtual world user interface) may be developed. They are relevant inasmuch as they are often high quality, have large user bases, and are well supported products. However, the development of software using them is not aligned with DRDC's core interest in this project when there are adequate alternatives available.

As Unity3D is used for other purposes by DND/CAF, compatibility and interoperability of OpenSim with Unity3D is desirable, especially in the areas of content such as terrain and 3D models. Beyond that, we recommend not expending significant effort in pursuing the use of such frameworks without a clearly identified need.

3.2 Serious Games vs. Virtual Worlds

Serious games and vWorlds share many features, including: simulated worlds in which multiple, sometimes distributed, users can interact with each other and the environment; physics engines of varying degrees of fidelity; and the use of terrain and 3D visual models.

At a fundamental level, the most significant difference between a virtual world and a serious game is that a virtual world is persistent, in theory indefinitely, while a serious game is designed around the execution of a scenario in a finite amount of time. A result of this is that participants

in a serious game will typically exercise together from the start of the scenario until the end, while users in a virtual world will come and go as time and the inclination permits – there is no clear "end". The virtual world provides an environment for collaboration in which not all the participants need to be involved all the time, or even at the same time.

Another major difference between vWorlds like OpenSim and serious games is that the vWorld provides a mechanism for building the virtual world (for example, deforming terrain and adding new objects) from "nothing" while serious games only allow a participant to affect the world in "realistic" ways.

As a result of these differences (and others), serious games and virtual worlds have different primary uses and different audiences. This results in different trade-offs for a specific implementation of each technology and they are optimised differently.

Within the scope of DRDC's interest in OpenSim, reuse of content between serious games and virtual worlds is desirable from a cost and effort perspective, but at this point in time there is little value in attempting to consider connecting the systems at runtime.

3.3 Content & Content Generation Tools

For OpenSim to be used in DRDC's primary intended application domain, developing and reviewing spatial system designs such as compartment layouts and team processes on naval platforms, the most important question to be addressed is developing a process to import content into OpenSim.

In the context of OpenSim, virtual world content is of two main types: terrain and 3D models. Note that for DRDC's primary intended application domain importing terrain is not essential, although for other applications it may be.

3.3.1 Terrain

The OpenSim (Second Life) RAW[1] terrain format is well defined and, in a software development sense, not particularly difficult to develop translators for. Open source software such as GIMP (with a plug-in) can be used to create the terrain.

It is notable that the MOSES project (7) has developed a translator to convert DTED terrain data into the RAW format used in OpenSim (8). This extension has not been contributed back to the OpenSim community; however it may be available to DRDC upon request.

Should DRDC need to convert terrain data in other (well defined) formats into the RAW format, developing software to do this should not take significant effort if such software does not already exist.

[1] RAW is not an acronym, it means that the file format contains only basic terrain data according to a fixed format and does not contain meta-data to enable the file format to be flexibly interpreted.

In comparing OpenSim with any other simulation or serious game system, it is worth noting that the resolution (fidelity) of terrain may differ between simulations, even if the same source data is used. As a result, the "same" terrain may be represented in different ways in different systems. Should true interoperability between different systems be desired, the potential for this should be taken into account.

3.3.2 Visual (3D) Models

OpenSim supports two different types of visual (3D) models: an internal format for simple geometric shapes to which textures may be applied, and the open COLLADA file format.

Support for the COLLADA format is not consistent across all OpenSim clients: some clients do not support it; some display COLLADA models but do not provide a mechanism to import them to the virtual world; while some support both display and import. Furthermore, in at least some cases the version of the COLLADA format is different. We found that a model generated by Blender in COLLADA version 1.3 format did not work in OpenSim, but a model generated by Blender in COLLADA version 1.4 format did work.

There are many different file formats used by 3D applications, and not all 3D applications support COLLADA. DRDC has indicated that Intergraph's SmartMarine 3D for ship design and SmartPlant 3D for plant design are two CAD applications used or intended to be used by DND, and these applications do not natively support COLLADA.

It is critical for DRDC to establish a tool chain and process to take source formats such as those used by SmartMarine 3D and convert them to COLLADA format for import into OpenSim. The Compatibility Report (4) contains some options as a starting point, but none of them have been tested.

Establishing such a tool chain will also help identify whether there are any undocumented limitations in the OpenSim client support for COLLADA, such as a maximum polygon count for an individual model or a performance penalty for very complex models. Such limitations are common in image generation and other visual software. Should such limitations exist, mitigations might include upgrading the OpenSim client software or reducing the complexity of the visual models.

3.3.3 OpenSim as a Source of Content

OpenSim was not designed to be an application from which terrain and visual models could be easily exported. As such, as it currently stands, DRDC should regard OpenSim as a consumer of such content and not a producer. To share terrain and visual models with other applications, formal processes should be put in place to document the source or common repository of such data and how they are used (delivered to) each application which uses it.

3.4 Popularity

With respect to the interest of the mainstream media, Second Life (as the major example of a virtual world product) seems to have peaked between 2006 or 2007 (9). This is not unusual for a new technology. It is notable that the MOSES project changed to use OpenSim when Second Life Enterprise was closed down (8).

Furthermore, when performing research for the Compatibility Study (4) we found that some virtual world products that had been announced around 2009 and 2010 currently have no visible web presence. We inferred that no business case had been found for their existence and they were discontinued.

As such, the use of open source software such as OpenSim where the source code is freely available, and the possibility of collaborating with other defence organisations using OpenSim is a good choice for DRDC.

3.5 OpenSim & Other Simulation Runtime Interoperability

OpenSim was not designed to be interoperable with any simulations at runtime other than other instances of itself. As discussed above, the content is compatible with Second Life.

As the source code for OpenSim is available, it is technically possible to make it interoperate at runtime with other simulation systems that have either a well-defined API or their source code is available. The use of DIS or HLA to connect to military simulations or simulators, and connection with IPME, are two examples of this discussed in the Compatibility Report (4).

Should such interoperation be considered in the future, a strong use case for the connection should be available which demonstrates clearly the benefits of the development effort using OpenSim rather than an existing technology that is already able to interoperate in this manner. For example, should a virtual naval operations room be required to interoperate with a military simulation using HLA for the purpose of an exercise, it may be better to take content developed in a format such as COLLADA which has been used in OpenSim and reuse it within a simulation (serious game) such as VBS3 which already has an HLA interface than develop an HLA interface for OpenSim.

Nevertheless, given the current interests of DRDC, it is unlikely that this activity will be necessary in the short to medium term.

3.6 Usability & Other Issues

The literature survey (5) that was conducted raised a number of interesting issues with regards to issues such as usability and the effectiveness of using vWorlds. To identify whether these will be significant issues for DRDC's primary audience we recommend that, once the visual model tool chain issues discussed above have been resolved, a pilot project with a group of

stakeholders be established to gain experience and feedback on its use. The results of this pilot project should be published.

4 CONCLUSION

This report summarised the major activities conducted for the project entitled *vWorld Capability Development Support* under the terms of contract #W7707-135643/001/HAL. The activities were:

a. Provision of training on the use of the OpenSim vWorld technology;

b. Conduct of a compatibility study concerning the interoperability of OpenSim with other DND/CAF simulation tools and technology; and,

c. Conduct of a literature survey intended to inform DRDC as to how OpenSim or similar vWorld technology could be used to support activities such as concept development, collaborative design review, and experimentation for operations rooms in naval platforms.

This report also included observations, insights, opinions and recommendations of the project team derived from these activities intended to assist DRDC in planning future activities. In order of priority, we believe that:

a. A tool chain and process should be established to take visual (3D) model source formats that will be used by DND and convert them to COLLADA format for import into OpenSim;

b. The manner and means by which terrain and visual model content will be shared amongst other simulation systems including serious games should be considered and documented; and,

c. A pilot project with a group of stakeholders should be established to use OpenSim for one of DRDC's intended application areas to gain experience and feedback on its use.

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6 DEFINITIONS AND ACRONYMS

The following list identifies the acronyms and abbreviations used throughout this document:

3D	3-Dimensional
API	Application Programming Interface
CAE	CAE Inc.
CAF	Canadian Armed Forces
COLLADA	Collaboration Design Activity
DIS	Distributed Interactive Simulation
DND	Department of National Defence
DRDC	Defence Research & Development Canada
HLA	High Level Architecture
IPME	Integrated Performance Modelling Environment
MOSES	Military OpenSimulator Enterprise Strategy
NUWC	Naval Undersea Warfare Center
OLIVE	On-Line Interactive Virtual Environment
OpenSim	OpenSimulator
PWGSC	Public Works and Government Services Canada
VBS2	Virtual Battlespace 2
VBS3	Virtual Battlespace 3
vWorld	Virtual World