Using Games Technology for Maritime Research: a Case Study

Allan Gillis
DRDC, Atlantic Research Centre
9 Grove Street, Dartmouth, Nova Scotia, B3A 3C5
CANADA

allan.gillis@drdc-rddc.gc.ca

ABSTRACT

The use of serious games has become widespread in many fields, both civilian and military. In the military realm this use has been dominated by first person shooter (FPS) style games that provide a useful virtual environment for a wide range of training and concept development applications. This paper describes the use of a non-FPS game, Dangerous Waters, for research in the maritime domain, and how that game was integrated with other systems. Specific advice is given for repurposing games and their related technology for use in research and training systems.

1.0 BACKGROUND

The use of first person shooter games in the defence community for training and concept development is well-established. While some other types of games are seeing use, it is still the first-person shooter game that dominates, particularly in the context of army training.

While first-person shooter games are very common in the commercial space, they are by no means the only genre of game available. In fact, they are not even the only type of virtual environment. This paper will discuss the use of a virtual non-first-person shooter game in a research context and also discuss some of the potential uses in training environments.

Before jumping into the use case, it is worth discussing some of the features of serious games that make them useful generally. The first, and most obvious, attribute of game technology that makes it so useful to us, is the low cost. Compared to traditional simulation systems, serious game technology is extremely economical (by orders of magnitude in many cases). Even in cases where a commercial game cannot be used off-the-shelf but requires modification, the cost is still much lower than that of traditional simulation systems. Another attribute of game technology is how accessible it is to end-users. Not only do the trainees (or in our case experiment participants) find it easy to pick up and use, so do scenario developers, instructors, and system administrators. This accessibility comes from the simple fact that games must be easy to use out-of-the-box, without instruction, or else they have no market. A third attraction of games is that we can often find a game that does most or all of what we require from a simulation system. It is entirely possible to find an off-the-shelf game costing less than $50 per seat that will meet all (or most) of your requirements for particular applications. This is also true for research systems; however it can be more difficult to find a product that does not require modification for research applications.

Of course, game technology does have some drawbacks. The fidelity of the simulation itself is often not to the standard of traditional simulators as the need to run on consumer hardware is of paramount importance, and gameplay is more important than fidelity. Game technology is often built on a closed architecture, and this can make it very difficult to take a commercial off-the-shelf (COTS) game and interface with existing simulation systems. For example, in the training or simulation context it is easy to imagine a need to interface with a Distributed Interactive Simulation (DIS) or High Level Architecture (HLA) simulation, and there are very few COTS games (if any) that can do this.

Luckily, many game companies have realized the market for military simulation and training can provide a lucrative secondary revenue stream. In order to address some of the shortcomings of COTS game technology, these companies have made non-commercial versions of their games to provide some visibility into the inner workings of the game, and allow customers to interface with other simulations, retrieve information from the game itself, or extend functionality into areas where they require it.

This paper will present a case study of the use of the non-first-person shooter game Dangerous Waters (DW) by Sonalysts[1] and other COTS components in a research environment. While DW is the serious game that was selected for the particular application discussed, the lessons learned are applicable to any serious game either within a research context or not.

2.0 VICTORIA CABABILITY EVALUATION LABORATORY (VCEL)

The Atlantic Research Centre of Defence Research & Development Canada (DRDC) has constructed a facility to conduct experimentation to support the command teams of the VICTORIA Class submarines of the Royal Canadian Navy (RCN). The facility consists of a reconfigurable space representing the control room of the VICTORIA Class boats, along with the IT infrastructure and recording devices required to provide simulated submarine systems and extract data from the runs. The facility uses off-the-shelf hardware, software, and consumer electronics extensively to meet the requirements of the experimental program.

The concept is to scale the simulation elements to meet the needs of the experimental program as they change. For example, while we could run the real combat system in the facility, our current experimental program does not require that level of fidelity. It is possible to imagine experiments where the full combat system is required, experiments where a game will be sufficient, or experiments that may require some real parts of real hardware and software but not the entire system.

The Victoria Capability Evaluation Laboratory (VCEL) consists of a physical space (designed like a television or theatre set) that provides a reconfigurable area to run experiments. The structure is made of plywood, and it is easy to modify the space, move consoles, change the periscopes, and so on. This gives us a relatively low-cost representation of the space actually available inside the control room of the VICTORIA Class boats (Figure 1).

Figure 1: The VCEL experimental space.

Inside the structure are off-the-shelf consumer class computers, networking gear, and data capture equipment. Outside the structure is the “White Cell” area where we have more standard consumer grade computers, large LCD televisions, and a single rack for the switches and some simple servers.

2.1 Software System

Before talking about the use of game technology in the VCEL it is helpful to put it in context. In VCEL, we do not run only the game, but a number of pieces of software that work together to provide the synthetic environment. The game provides a number of critical functions, but would not be enough on its own.

A simple conceptual diagram is given in Figure 2.

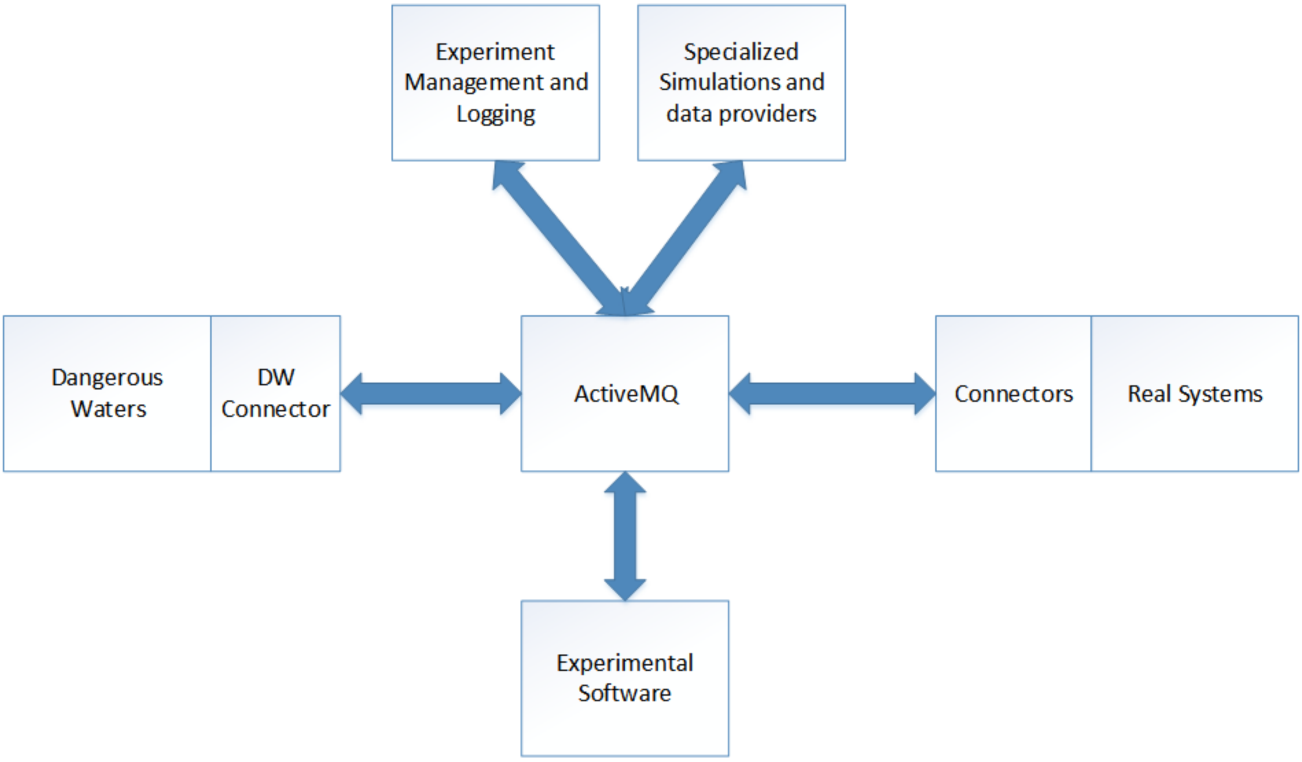

Figure 2: VCEL software system diagram.

At the centre of the system is ActiveMQ[2]. This is a free and open source server for implementing messaging between software components. We use it as the backbone through which all the disparate pieces of the system communicate.

At the top of the diagram are the system management, monitoring, and logging applications. In VCEL, these were all written in-house to meet our specific needs. There is also a box for specialized simulations and data providers; two examples in VCEL are a data provider that reads sound-speed profiles and responds to queries, and a very basic Automatic Information System (AIS) network simulation that creates AIS reports for other software to consume.

To the right are real systems that are integrated with VCEL. Currently we only support the ECPINS-W[3] commercial off-the-shelf (COTS) electronic charting and navigation system. In principle, anything could be connected, though an adaptor would be required to interface with ActiveMQ. Figure 3 shows the ECPINS station in VCEL.

Figure 3: The ECPINS system.

At the bottom of Figure 2 is a box representing experimental software. In the VCEL context, this means prototype interfaces or entire systems meant for operators to use directly. We have been very successful using Adobe Flash as a rapid application development (RAD) tool for creating new operator interfaces and systems, and for emulating real systems where it is impractical to use them directly.

Finally, on the left of Figure 2 is a modified version of Sonalysts' "Dangerous Waters[1]" modern naval combat game. This software provides all operator interfaces, periscope, sonar, radar, electronic countermeasures (ECM), weapons & effects, ship motion simulation, as well as an extensive scenario editor. While it does not directly simulate a VICTORIA class submarine, it does allow us to provide representative stations where real naval operators can do their jobs.

2.2 Dangerous Waters

Dangerous Waters (DW) is a commercial game that was first released in 2006 and is still currently available at a cost of approximately $15 per seat[4]. There are many features of DW that make it particularly attractive in the maritime context. First, it includes simulations of many platforms: maritime patrol aircraft, maritime helicopters, surface ships, and submarines. While it is fair to call DW a virtual simulation, it is not the same kind of environment provided in a first-person shooter game. In DW each crew station is modelled by a separate interface and most of these interfaces are not windows into the 3-D environment. For example, the sonar operator has several different sonar screens that emulate real systems but does not have a view "out the window". Additionally, DW provides a unique multiplayer mode where each crew station (Figure 4) on the controllable platforms can be run by a separate player. This was critical to our experimentation because we needed to have a complete command crew doing their jobs within the control centre of the submarine.

Figure 4: The target motion analysis and fire control stations inside VCEL.

Unfortunately the commercial version of DW did not meet all of our requirements. While it is possible for several players to participate in a single game over a network, there is no provision for interoperability with other simulations and software. As a result we used a "non-commercial" version of DW called Dangerous Waters MSEAS (DW-MSEAS). This version of DW was originally created to support an entirely different research program for DRDC, and while it had several significant enhancements compared to the commercial version (including HLA compatibility), we also contracted Sonalysts to create an API that allows access to the internal simulation state. For the remainder of this paper, DW-MSEAS is only used when the capability referred to is not available within the COTS DW product.

2.2.1 What did we get for "free"?

When choosing a serious games product it is important to consider just how much capability comes "for free". How much of the core functionality require is already within the product, and how much will have to be developed to fulfil the requirements? It is also important to consider what content already exists that can be reused, and what content may need to be created for your specific purpose.

With DW we were able to get essentially all of the core functionality required to simulate the operation of a submarine. DW includes an overall tactical picture, electronic warfare, radar, radios, ship control, periscope, narrow and broadband passive sonar, active sonar, as well as target motion analysis and fire control. When the submarine is operating on the surface, there is also a sail-bridge position available. Under-the-hood DW includes an underwater acoustics model, environmental modelling of currents, time-of-day, sea state, wind, rain and cloud levels, and everything else needed for a simulation of the physical environment.

A key element of DW (mentioned earlier), is its multi-player capabilities. Every station can be crewed by an individual person, allowing all of the positions in the command room of the submarine to be filled by human participants. In addition, a single scenario can also support multiple platforms all with full command crews. There are some limitations to this, for example the sonar suite is occupied by a single operator, not the multiple operators any real submarine would utilize.

From a content perspective, DW also provided us with enough to get started. While the VICTORIA class submarine is not a controllable platform within DW, there are several controllable submarine platforms that can stand in for the VICTORIA class. In our current experiment, we are making use of the LOS ANGELES class controllable submarine within DW to simulate the VICTORIA class. DW also comes with a complete terrain database for the world between 85° north and 75° south latitude (this latitude range is larger than is typical of many COTS games). It is worth noting that both “Simulation Engine II (SEII)” by Sonalysts[5], and “Command Modern Air / Naval Operations” by WarfareSims[6] offer a full 3D globe.

Apart from the core simulation functions and usable content, DW also provides an excellent scenario generation tool. Not only does this tool allow for the creation of comprehensive scenarios, it is very easy to use.

2.2.2 What was missing from DW for DRDC experimentation?

Although DW contained most of what we needed to run our current experimental program, modifications were required to adapt it to our specific environment. First and foremost, the experimental software that forms the focus of our current program requires input that is only found within DW. Although the DW-MSEAS version is HLA compatible, the information that it was able to exchange via HLA and the Real-time Platform Reference (RPR) federation object model (FOM) did not include most of the things we are interested in, such as tracks and raw values from the sonar simulations.

2.3 Phased implementation of VCEL

The initial concept for VCEL envisioned a software suite that was created specifically for the space, not the use of off-the-shelf components. This thinking was based on our first examination of the types of experiments that we expected to be conducting in support of the RCN.

As we neared completion of the physical space, we realized we would require an interim simulation capability in order to do some concept development and to test our assumptions about the usefulness of the space. At this stage we decided that DW, although unable to communicate effectively with the rest of the planned experimental systems, would be an excellent vehicle to provide that interim capability.

As we began to integrate DW-MSEAS into the experimental facility, we began to fully appreciate the range of its capabilities. Although there were clearly critical limitations in the software, we realized it would be possible to make use of DW for almost all of the simulation required for our initial experimentation program, as long as these deficiencies could be addressed. The most important of these was the restricted view of the internal data and state of DW-MSEAS. To address this, we contracted Sonalysts, the makers of DW, to provide an applications programming interface (API) that would allow much more visibility into the inner workings of the product.

With the API we were able to integrate the internal data from DW-MSEAS into our overall simulation backbone. Once on the backbone, we were able to connect to real systems, specialised simulations, and all of our simulation monitoring and logging applications. The API made it possible for DW-MSEAS to become the very core of the simulation system while allowing us to fill in gaps (or provide replacements) for any data that DW-MSEAS was providing.

As we continue to develop VCEL, and move on to new experimental programs, we will continue to augment the basic simulation capability of DW-MSEAS. One of our long term goals is to replace the entire underwater acoustics model of DW with our own, much higher fidelity, sonar simulation. Not only will we replace the simulation of the underwater acoustics, we will also replace the DW operator consoles with our own Flash-based emulations of the real system aboard the VICTORIA class.

2.4 Consumer hardware used in VCEL

DW was not the only COTS product used in VCEL, and it is worth mentioning some of the consumer grade hardware components that are used within the facility. We were able to save significant amounts of money by using this kind of equipment, and provide capability that was not fully available off-the-shelf.

Because we are looking at crew performance as part of our experimentation, it is important to capture all of the interactions between the members of the crew, and one key aspect of that is recording their voice conversations. The original VCEL concept was to use wireless lapel microphones and a multichannel commercial sound system, designed for concerts and other stage productions. Unfortunately we were unable to use wireless technology due to security considerations, which meant our microphones would have to be wired into the recording hardware.

As you can imagine, wired microphones made the idea unworkable inside the confined spaces of the mock-up submarine control room. We decided to replace this system with very small MP3 players available from any electronics store (in particular we used the Sansa clip with 8 GB of storage space). Not only are these MP3 players very lightweight but they have very good microphones and by supplying one to every participant and the exercise controllers, we are able to capture exactly the same data as the wireless recording system. The MP3 players are tiny fraction of the cost of the original solution ($30 each) and they can be upgraded independently, or replaced if they break from local sources, 7 days a week. Figure 5 shows one of these MP3 players clipped to the lapel of an experimental subject.

Figure 5: Commercial MP3 player used for voice recording.

Another extremely important aspect of crew interaction is understanding and recording where the individuals are at any given time. We have two methods to record this information; an off-the-shelf commercial security camera system that records up to three days of data at a time, and a custom software solution we created in-house that uses the Microsoft Kinect controller to automatically capture the spatial position of the crew. Figure 6 is a screen capture of the connect data as it is being collected in real-time.

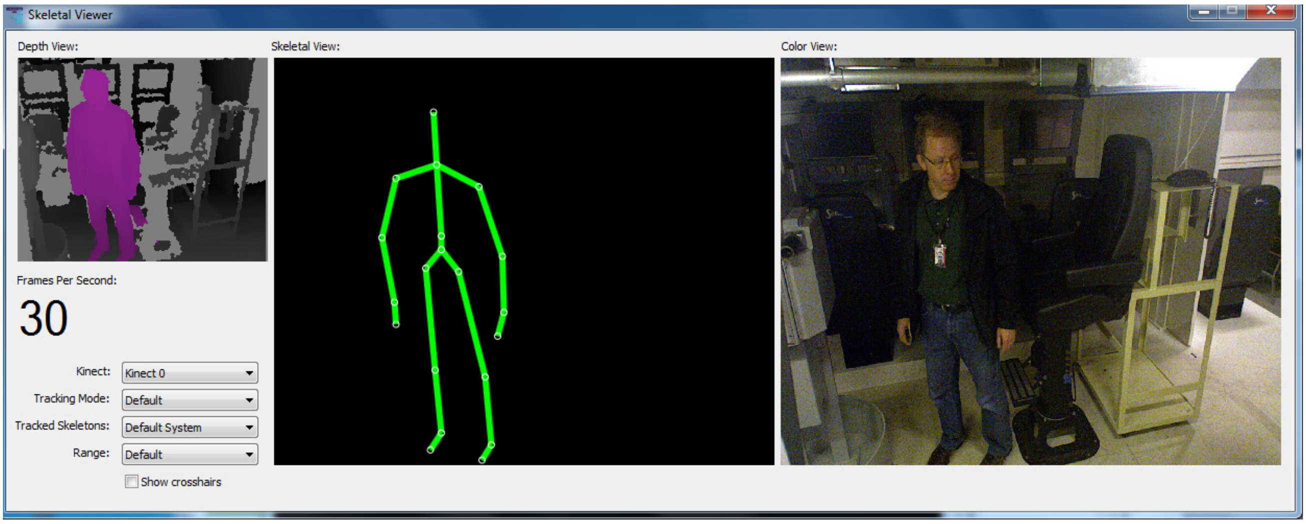

Figure 6: Screen-shot of the Kinect based data acquisition system in action.

All of the computer equipment used in VCEL is COTS, and most of that is consumer class hardware that can be purchased at any computer retailer. Exceptions to this are the network switches, which are enterprise-grade, and the rack-mount equipment which, while still COTS, is lower-end enterprise grade. In the past we have found that the types of network switches sold for household use often cannot handle the kind of throughput required by simulation systems.

3.0 SOME KEY LESSONS

While it is unlikely that any other experimental facility will require exactly the same hardware and software as VCEL, we hope that our experience creating this kind of facility can provide some key lessons for anyone considering the use of serious game technology.

The most important factor to consider when choosing a serious games product, is how much of that product's capability is actually going to be useful in your context. The best cost savings are achieved when the game product closely matches the problem domain for your simulation. This is the key reason that Virtual Battlespace (VBS) has proven so useful for infantry, armoured, and tactical aviation training, and why DW can be so useful in the maritime domain.

The second most important factor is that no off-the-shelf game product is likely to provide everything you need. Therefore, it is important to consider what will need to be added to the game in order to make it meet your requirements, and how difficult those additions are likely to be. If it is a simple matter of content, such as terrain, 3-D models, or scenarios, then it is likely that the cost and complexity of the task will be low. If significant software development, or reengineering of the game's code base is required, adapting the game to your needs will certainly be much more expensive and time-consuming to accomplish.

When designing your system, it is worthwhile considering the consumer grade hardware available that may meet your requirements. Clearly commercial desktop machines are now at least as capable as more expensive professional workstations, and for game technology might even perform better. Similarly, you may consider off-the-shelf MP3 player/recorders instead of an expensive multi-track recording system, as we did for VCEL.

Another area where significant cost savings can be realized is in the control systems used with the games, or even with more complex simulations. For previous research project we used a Logitech PS3 steering wheel for a small boat simulator based on VBS2. Not only are the commercial steering wheels tough (after all they are meant to survive hundreds of hours of abuse by children), they are a fraction of the cost of even the cheapest specialized controllers. It is worth noting however, that not all consumer components are equally robust; for that same project we used a commercial active infra-red head tracking device that participants were able to break in about 10 minutes of use. Always consider the merits of these devices on an individual basis.

Try to consider how other off-the-shelf systems might be useful in your application. On the surface it would seem unlikely that the Microsoft Kinect controller would be useful in a submarine research facility, but with a minimum of programming we were able to use it as an excellent automated data collection and processing tool. It seems likely that there are many applications for the kind of technologies found in cellular telephones and tablets for laboratories and training facilities. The possibilities are limited only by your imagination and, of course, the resources you have to develop them.

Talk to your colleagues about the problems you have in your systems as they may already have the solution that you need and be willing to give it to you free. If not they may have something very similar that you could extend to everyone's benefit. Our use of DW is such an example. Our modifications to DW have turned out to be of interest to at least one other research group, and various elements of the Canadian Armed Forces.

4.0 CONCLUSION

A modified version of the DW commercial game proved very valuable to us as the core simulation engine for VCEL. It provided most of the functionality and content we required out-of-the-box, and the API that was added made it easy to integrate the game with other systems (both real and simulated). Other consumer technology also proved useful to VCEL, specifically the Microsoft Kinect and small MP3 players.

Many of the technologies developed for games are useful for more "serious" applications in research and training. When choosing game technology, it is important to find products that provide most (or all) of the functionality and content you require, and that can be extended as necessary. There is not a serious game product to solve every problem, but the array of tools available is already large and is constantly expanding. The right use of game technology can reduce the cost and risk of your project.

5.0 REFERENCES

[1] Sonalysts Combat Simulations, "Dangerous Waters", web site, http://www.sonalystscombatsims.com/dangerous_waters/index.html (Access date: September 2013)

[2] "Apache ActiveMQ" web site, http://activemq.apache.org/ (Access date: Septembre 2013)

[3] OSI Maritime Systems, "Electronic Chart Precise Integrated Navigation System – Warship", web site, http://osimaritime.com/solutions/ecpins/ (Access date: September 2013)

[4] Strategy First web site, http://www.strategyfirst.com/games/1483-dangerous-waters.html (Access date: September 2013)

[5] Sonalysts Inc, unpublished presentation, August 2013.

[6] WarfareSims web site, “Command Modern Air / Naval Operations”, http://www.warfaresims.com/?page_id=1101 (Access date: September 2013)