
Discussion Paper:

Medical Capabilities in VBS2

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References

- A. VBS2 Whitepaper (<http://www.bisimulations.com/whitepaper>)

Classification

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Warning

This paper includes graphic images of dismembered US soldiers rendered in virtual simulation. Some readers may find these images disturbing; however they are included only to describe VBS2 capability and readers are urged not to take offence.

Revision History

Date	Reason For Changes	Version
14/08/10	Initial release.	1.0
27/08/10	Minor text updates	1.1

1. Executive Summary

Bohemia Interactive Simulations, Inc. (BISim) is pleased to provide this Discussion Paper on **medical capabilities in Virtual Battlespace 2 (VBS2)**.

BISim is dedicated to the development, delivery and support of serious game products to Government and Industry clients worldwide. We deliver affordable simulation platforms that provide vast, dynamic, high-fidelity virtual environments that are supported by easy-to-use development tools. Our most prolific and successful title, VBS2, is used primarily for tactical training and mission rehearsal, but has potential for employment in other domains, including medical.

This Discussion Paper provides an overview of current medical capabilities (as at VBS2 v1.40) and also describes the possibilities for the future, given the versatility of the VBS2 game engine and ongoing development work.



2. History of the Virtual Battlespace

2.1 Operation Flashpoint – the game engine behind the US Army’s DARWARS Ambush!

Until the release of Virtual Battlespace 1 (VBS1) in 2004, the primary focus of Bohemia Interactive was the development of computer games for entertainment. Czech-based Bohemia Interactive Studio (BIS) released Operation Flashpoint (OFP) in 2001, a landmark title that was the first to allow Players to explore massive, 3D, geo-typical virtual environments from the first person perspective. In OFP, Players were free to use any means at their disposal to defeat the virtual enemy, including attacking from any direction and using a wide range of vehicles and aircraft.

The game engine underlying OFP was titled Real Virtuality, and was built from the ground up by BIS software engineers. All aspects of the simulation including AI, physics, weather, day/night cycles, vehicles, aircraft, animation systems and networking were developed internally. It should also be noted that the majority of the programmers who started the development of the initial game engine in 1997 still work for Bohemia Interactive today.

Operation Flashpoint is the basis of the military training application DARWARS Ambush! developed by US-based BBN Technologies in 2004. DARWARS Ambush! aimed to provide a flexible training environment for soldiers to learn important lessons regarding both mounted and dismounted operations in conflict zones such as Iraq and Afghanistan. DARWARS Ambush! is widely considered a great success and this positive outcome was only possible due to the flexibility and extendibility of the OFP game engine.

2.2 Virtual Battlespace 1 (VBS1) – a successful game-based training tool for the USMC

The Australian branch of Bohemia Interactive, Bohemia Interactive Australia (BIA), was formed in 2001 with the mandate to develop “serious games” based on the Operation Flashpoint game engine. BIA released Virtual Battlefield Systems 1 (VBS1) in 2004, and delivered it to the United States Marine Corps (USMC) who used the product in a similar manner to the way the US Army was using DARWARS Ambush!. VBS1 was a successful game-based 3D



virtual environment tailored for “serious” usage, suited for military tactical training and mission rehearsal, despite serious limitations. VBS1 mission editing and after-action review (AAR) features were limited, it did not support real-world terrain import, and it wasn’t HLA or DIS compliant.

Both the US Army and USMC have used Bohemia Interactive’s game engines as the basis for their desktop tactical training simulations since 2004.



Despite the early success of VBS1 in the USMC, it was Australian Defence Force (ADF) funding that enabled VBS to succeed as a training tool. The ADF was first exposed to the potential of VBS “serious game” technology during the Headline Experiment in 2003, when an early version of VBS1 was used to analyse the effectiveness of various sized Infantry Section structures (the Virtual Infantry Section Experiment¹).

In 2005, the Australian Defence Simulation Office (ADSO) funded a range of improvements in VBS1 to make the product more suitable for mission rehearsal and training, as part of Mission Rehearsal Exercises (MRE) for deployments to Iraq. At this time, VBS1 was renamed to Virtual Battlespace 1, the AAR system was improved, the Instructor Interface was developed, and HLA/DIS compliance was implemented over a 12 month period of development. The majority of this development was sponsored by ADSO through a Deed of Standing Offer for the provision of Software and Software Support Services.

ADSO also contracted Bohemia Interactive to develop a VBS1-based military history training product titled ‘Australians in Vietnam’, designed to teach soldiers, sailors and airmen about the Battles of Long Tan and Coral. The end product was highly successful: a stand-alone computer game tailored for education.

2.3 Aircrewman Virtual Reality Simulator– a revolutionary aircrewman training tool

In 2006, Bohemia Interactive was selected by the ADF to develop six Aircrewman Virtual Reality Simulators (AVRS), which combined VBS1 simulation technology with the latest in Virtual Reality tracking and display systems. Over a 12 month period of development, Bohemia Interactive developed and delivered a system

¹ See <http://www.itec.adfa.edu.au/research/vesl/Papers/viseSimTecT04.pdf> for more information

that is arguably the most successful simulation project in ADF Army Simulation Wing history: an affordable turnkey solution for aircrewman training – delivered on time and on budget.

This development is notable because it highlights the capability of Bohemia Interactive to provide turnkey simulator solutions in addition to commercial off-the-shelf (COTS) software development services.



2.4 Virtual Battlespace 2 (VBS2) – a worldwide benchmark in simulated training

BIA began developing Virtual Battlespace 2 (VBS2) after the ADF purchased an enterprise license of VBS1 in 2005. Building on three years of feedback regarding VBS1, VBS2 represents a powerful “serious game” platform that is now the worldwide benchmark for desktop-based simulation for tactical training and mission rehearsal.

Many requirements for VBS2 were derived from ADF experience with VBS1 during mission rehearsal exercises conducted in 2005. For example, the requirement for geo-specific terrain was paramount, but it took over six months to develop the city of As Samawah in VBS1. In contrast, it took only a few hours to generate the same terrain in the armor simulation ‘Steel Beasts’, because it supported VMAP (shape data) import. The need for run-time authoring became obvious due to time constraints during MREs: only a short amount of time was available for simulated training, and offline scenario editing would cost valuable minutes (bringing down the network session, modifying the scenario and restarting the network session). This need for rapid scenario modification resulted in the requirement for the VBS2 Real Time Editor. In addition, a robust AAR capability was important to allow the instructors to reinforce learning points.

VBS2 development commenced in December 2006 and was largely completed after 18 months. During development, Bohemia Interactive partnered with Calytrix Technologies to develop the VBS2 HLA/DIS gateway. In 2007, a second Czech-based development team was established to focus on improving the VBS2 Development Suite to support real-world terrain import.

In 2006, the USMC purchased an enterprise license of VBS1, with an upgrade to VBS2 upon release. Following initial delivery of VBS2 in 2007, they funded a range of enhancements that resulted in the development of the VBS2 Virtual Training Kit (VTK). Notably, the USMC did not provide any data for the

VBS2 VTK development: Bohemia Interactive relied instead on publically available reference information for all aspects. The USMC was then provided with full access to VBS2 configuration files and unencrypted models to allow them to incorporate classified or export controlled data as required.

This flexible development model has proven very successful: it allows Bohemia Interactive to conduct independent research and development from a relatively generic requirement, and allows the customer to configure settings to suit real-world and often classified data.

The VBS2 VTK was delivered to the USMC on time and budget in June 2008, and rolled out later that year to all USMC simulation centers and on all DVTE laptops. VBS2 quickly became the simulation of choice for USMC mission rehearsal and tactical training up to the combat team level. Bohemia Interactive was then awarded a sizable three year follow-on contract to continue enhancing the VBS2 product as an “Open Platform” that the USMC could tailor to their needs. Development commenced in June 2008 and the first VBS2 VTK2 release occurred in June 2009, again on time and budget.

While the ADF and USMC have been central to the success of VBS2, enterprise licenses have also been purchased by the United Kingdom Ministry of Defence (UK MoD), the US Army and the Canadian Forces. In all cases, Bohemia Interactive has modified the VBS2 product to suit the requirements of these organizations, while still maintaining a common international baseline. VBS2 is also in daily use by NATO, the Singapore Armed Forces and many countries across Europe.

VBS2 has become a defacto simulation standard, and a market is rapidly forming as industry begins to employ VBS2 for research and development. VBS2 includes development tools, an Application Programming Interface (API) and a scripting language in every release. The VBS2 International User Group meets bi-annually and VBS2 is a key component of upcoming joint simulation exercises.

2.5 Software development in non-military domains

VBS2 is not designed solely for military use. In addition to developing and supporting the VBS series for military training and mission rehearsal, Bohemia Interactive has experience in developing



applications outside the military training domain, using the baseline VBS2 product. Bohemia Interactive supplied VBS2 for Project Canary², a game-based training product that instructs on occupational health and safety for the Australian mining sector. In addition to VBS2 software, Bohemia Interactive provided support and on-site training for the software developer.

Bohemia Interactive also developed the VBS2-based Virtual Responder Trainer, a version tailored for first responders. This product simulated events such as fires and floods and including police, ambulance and fire-fighting vehicles.

2.6 Real Virtuality 3 – continued development for the entertainment market

While BISim has been focusing on the Virtual Battlespace series, the game developer BIS has continued to improve the Real Virtuality engine for the entertainment market. Real Virtuality 3 (RV3) is the result – a state-of-the-art game engine that is recognized worldwide as a leading next-generation software platform for first-person simulation. RV3 is the game engine behind the highly successful ArmA2, released in 2009, and also the recently released ArmA2: Operation Arrowhead. The most obvious improvement is graphical fidelity – years of effort have been applied to making the virtual environment as visually realistic as possible – but in addition to amazing graphics, the new engine has many other improvements including animation enhancements and multi-core support. Multi-core support enables the engine to be highly efficient, as simulation tasks are spread over multiple processor cores.



Screenshots from ArmA2: Operation Arrowhead, using Real Virtuality 3

² <http://www.projectcanary.com>

3. Current Medical Capability in VBS2

VBS2 is a “serious game” that is suited for tactical training and mission rehearsal in a networked, collective training environment. VBS2 allows groups of human participants to practice their tactics, techniques and procedures in the virtual domain, and employ weapon systems and platforms in a similar manner to how they are employed in the real world.

A good description of the general capabilities of VBS2 v1.40 (released in September 2010) can be found in the VBS2 Whitepaper, available from <http://www.bisimulations.com/whitepaper> (Reference A). If you are unfamiliar with the product then it is recommended that you first review this Whitepaper as it provides a good overview of the inherent capabilities of VBS2. A 30 minute video showing VBS2 capabilities can be downloaded [here](#), and a shorter 5 minute version is available online at the [VBS2 website](#).

VBS2 is a first-person virtual simulation, in which participants “play” as a character within the game and perform tasks such as fire and movement, operating a personal weapon or driving a vehicle. As a tactical trainer, VBS2 allows participants to engage in simulated combat and therefore a simulation of “damage” is key – as in the real world, participants in combat must wound or kill enemy forces in order to succeed, assuming the mission is to destroy the enemy. It is however also possible to perform non-kinetic training in VBS2, such as language and culture training.

As a collective training tool, VBS2 offers a unique opportunity to train human participants in the medical domain. A tactical maneuver in VBS2 plays out in a similar manner to one executed in the real world, providing a high fidelity, non-deterministic and realistic simulation of combat. Participant decisions directly affect the outcome of an engagement, and as a result, the same scenario executed repeatedly may have different results depending on participant actions. This means that responding to medical emergencies on the battlefield, such as severe wounding or amputation, demands real-time decision making. For example, in one run of a scenario it may be appropriate to request a CASEVAC by helicopter, but in another perhaps the OPFOR are still in the area and air assets are unable to safely land, so CASEVAC must be conducted by ground vehicle. VBS2 allows medical teams to practice operating in difficult situations, for example entering a building through a hostile crowd or responding to an IED strike. VBS2 also allows trainees to operate collectively – multiple medics can operate in the one networked, collective training environment.

Medical-related capabilities included in VBS2 v1.40 are as follows.

3.1 Fatigue simulation

A key aspect of VBS2 is fatigue simulation, which has been developed to be as realistic as possible, modeling both aerobic and anaerobic energy in the simulated human body.

The VBS2 fatigue model constantly monitors soldier activity and determines two key aspects – how tired they are, and what their breathing rate is. The system uses an “energy expenditure” model; every action performed in-game spends energy. This includes moving, changing posture, holding breath when aiming etc. Two types of energy expenditure are monitored. Anaerobic is short-term expenditure, i.e. over the last ten seconds. Aerobic expenditure is longer-term activity, i.e. actions conducted over the last minute.

This simulation of energy sources – aerobic and anaerobic – is a reasonable model of how the human body works.

Each of the aerobic and anaerobic expenditures are compared to a maximum (i.e., full activity and hence fully tired) energy expenditure possible. So, for example, if a soldier’s aerobic energy expenditure is 30 units and the maximum aerobic expenditure is 100 units, then that soldier is at 30% (0.3) tiredness aerobically.

The overall fatigue or tiredness level of a soldier is the average of their aerobic and anaerobic tiredness.

Maximum expenditure levels for both aerobic and anaerobic are set to match a soldier running non-stop for the period in question. In other words, to max-out anaerobic fatigue, a soldier simply has to run for 10 seconds. This means that a character will fully recover after resting a maximum of 1 minute, noting that the more energy expenditure they have, the longer (up to a minute) they will need to rest to fully recover. Resting for 10 seconds will recover anaerobic energy, so the soldier will recover at least halfway (simulating quickly catching breath).

The activities that cost energy are:

- Movement
 - Proportional to distance covered
 - Scaled by type of movement (crawling is far more expensive)
- Changing Posture

- Each possible major posture change (between the states of lying, kneeling, standing) has an associated energy cost
- Carrying a load
 - Each 1kg of load carried by the soldier increases the cost (of movement and posture changes) by 1.5% - this figure is based on military studies of fatigue and load carrying
- Holding Breath
 - Holding breath (for firing) has energy cost. The cost is proportional to the total time the breath could have been held for

The fatigue model also incorporates a breathing rate. Breathing rate is measured in breaths per minute and is derived from fatigue. It also directly feeds into the weapon aiming system as the frequency of sway of the weapon. Breath rate varies from 8 breaths per minute – at rest – up to 50 breaths per minute – at full load. These values are based on published work and also empirical data.

Breath rate also has a lag or recovery model – the instantaneous breath rate is calculated based on current level, but a higher breath rate may be used if the soldier is still recovering from strenuous activity in the past. This is achieved by analyzing a one minute window of past breathing levels.

The fatigue system is designed to be extendable, so new types of actions (for example cutting wire) can be factored in. There is also a suppression model considered – if a soldier is under fire, or close to explosion, then this can have a corresponding effect on fatigue, if the system is configured as such. Finally, the rate at which a soldier fatigues depends on their endurance, a parameter which is set when the VBS2 scenario is created (to simulate fitter soldiers).

3.2 Injury modeling

As described, VBS2 provides a simulation of combat and therefore a damage system is included to allow character entities to be wounded or killed. Each VBS2 character has an overall health value as well as appendages that can be separately wounded. When the health of a character reaches zero then the character will die and is no longer operable in VBS2. Health is typically reduced by wounding, which can be caused by the following:

- “Direct hit” of bullets or shells fired from a weapon platform – note that injuries can be local (e.g. hands, arms, legs, head or torso).



- “Indirect hit” from nearby shell or grenade impacts, with the intensity of the damage taken dependant on distance and available cover.



- Impact from a collision results in damage being taken, for example when a character entity is hit by a moving vehicle. Injury will also result from falling from height (e.g. falling off the roof of a building).



As described above, injuries can be localized – for example only arms may be wounded. Each 3D character model has “blood textures” defined to give a visual indication of localized damage. The image below shows a US Army character that has been wounded in the right forearm. This wounded soldier will experience increased fatigue and difficulty in aiming his weapon.

Likewise, injuries to legs will result in characters being unable to walk, forcing them to crawl. The image on the next page shows an Arab entity who has been shot in the lower right leg.

Each hit on a limb reduces overall health, so character entities will die if they are repeatedly hit on their appendages. They will die more quickly if shot in the head or torso, however.





3.2.1 Amputations

VBS2 v1.40 provides a prototype body dismemberment simulation, allowing various previously defined body parts to be removed from a 3D character model in real time. The system in v1.40 provides a script command (`setAmputation`) to remove the following body parts from a US Army soldier model:

- Head
- Left and right hand
- Left and right forearm
- Left and right foot
- Left and right leg

As shown in the image on the right, dismembered bodies can be dragged and carried and otherwise interacted with (placed into body bags etc).

Future plans for amputations and dismemberment are covered in Section 4 below.



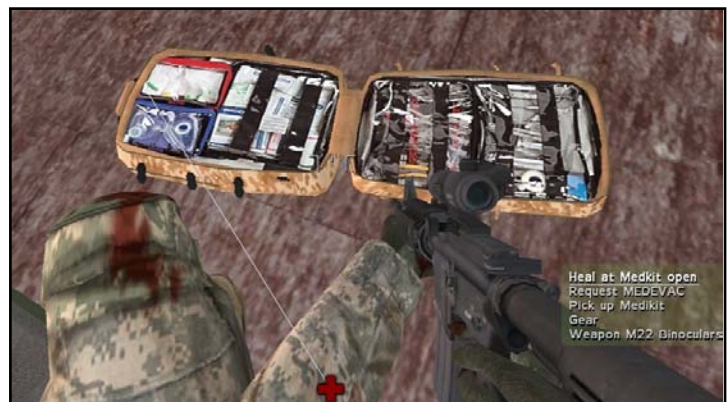
3.3 Treatments

In VBS2 v1.40 the treatment of wounds is generic (all wounds are treated in the same manner). First aid can be applied in the following ways.

- Visiting a first aid tent – when a wounded character entity is close to a first aid tent, he or she can use the VBS2 action menu (bottom right of the following image) to “Heal at Field Hospital”. Full health will be restored after a period of time.



- Self-treatment using a medical backpack – VBS2 includes a medical backpack object that can be carried by any character entity and used when required. As above, full health will be restored after a period of time.



- Treatment by a medic – there is a special “medic” character in VBS2 that can heal any unit. As for the first aid tent and medical backpack above, healing at a medic restores full health after a period of time. A special animation is played during “healing” (it is not possible to perform other actions while being healed).



Note that an administrator can also heal any character in real-time through the VBS2 Real Time Editor.

3.4 Extractions

Casualty evacuation is possible by numerous means within VBS2. Note, all aircraft and vehicles within VBS2 are operable, so very complex CASEVAC scenarios can be created easily using the VBS2 scenario editor.

- Dragging – it is possible to drag wounded or killed entities in VBS2. While dragging it is not possible to engage enemies and movement and fatigue is impacted accordingly.



- Litter carry – both 2 and 4 man litter carry is supported in VBS2. Either wounded or dead characters can be carried on litters.



- Loading onto a vehicle – both wounded and dead characters can be loaded onto various vehicles, from ambulances through to aircraft.



- CASEVAC requests by helicopter – VBS2 supports the US standard 9 line CASEVAC request, as shown in the following image. If the Player characters have not prepared the LZ correctly (using markers or smoke, etc) then the CASEVAC helicopter will be unable to land, and report to the Player character accordingly. This CASEVAC interface is designed to practice US soldiers in performing CASEVAC requests.

MEDEVAC REQUEST FORM	
LINE 1:	02808156
LINE 2:	VTK2
LINE 3:	A2, E3
LINE 4:	A
LINE 5:	L5 Special Equipment (A=None/B=Hoist/C=Extraction/D=Ventilator)
LINE 6:	N
LINE 7:	D
LINE 8:	A
LINE 9:	
<input type="button" value="SEND"/>	

- Body bags – dead units can be placed in a human remains pouch (body bag), and then handled in a similar manner to wounded or dead entities, i.e. dragged or loaded on to vehicles.



3.5 Customization

As described in Reference A, VBS2 is highly customizable due to the VBS2 Development Suite that is included with every copy of the product, and the comprehensive VBS2 script language that incorporates over 1,400 unique script commands. The medical capabilities described previously in this section are those inherent in the product, and are accessible through the VBS2 scenario editor. However, using the script language it is possible to simulate other medical conditions, such as white-out from a flash-bang, and the Development Suite allows appropriately trained personnel to create new “blood textures” to give a more realistic representation of wounds.

An example of a scripted enhancement is shown in the image on the right – the blood particles visible on the ground have been created by a 3rd party author using the script language and the Development Suite. [More information.](#)



4. Future Plans and Opportunities

The previous section described medical capabilities available in VBS2 v1.40, scheduled for release in September 2010. However, work on medical capability is ongoing and BISim plans to continue improving fidelity as demanded by the military requirement.

4.1 Contracted development

BISim is presently contracted to improve VBS2 by several military organizations. Improvements that are both contracted and likely to be contracted are summarized below.

4.1.1 Amputations

VBS2 v1.40 includes a prototype dismemberment capability as described in Paragraph 3.2.1 above. BISim is contracted to improve this capability so that dismemberment will occur automatically depending on the amount of damage taken (for indirect hits) and the caliber of a round hitting the body (for direct hits). Additionally, body parts will be visible in the virtual environment and can also be interacted with (picked up) and placed by an Administrator in the VBS2 scenario editor. This will enable manual placement of incidents such as vehicle accidents or carnage resulting from an IED explosion.

4.1.2 Sound effects

BISim is contracted to increase “battlefield realism” by improving sound effects. Wounded units may scream or groan depending on the type of injury they’ve sustained.

4.1.3 Bleeding

BISim will likely be contracted in the near future to simulate bleeding. Presently, wounded VBS2 characters don’t “bleed-out”, but this enhancement will force characters to die after a period of time (depending on the seriousness of their wounds) if first-aid is not applied to stem bleeding.

4.1.4 Medical aid interface

BISim is likely to be contracted to improve in-game medical aid functionality. This would tie into the existing wounding and casualty evacuation simulation. If a character is wounded, then Player characters are to be able to access a new “Medical Aid” action item, which will initially provide a list of symptoms. The Player may then administer different types of aid based upon the medical kit carried and the medical skills of the Player (as defined by the Administrator when creating the scenario). Once selected, appropriate

character animations will play while aid is being administered. Symptoms and available aid are to be customizable in the VBS2 scenario editor. Additionally, the system is to allow the Player character to make mistakes that may worsen the condition of the wounded entity.

4.2 Further improving medical capability

As described previously, VBS2 presents a unique opportunity for medical simulation because it is a collective training tool that immerses participants in realistic combat situations. The kinetic battlespace is represented at a high level of fidelity and many weapon systems and platforms are included. Extending VBS2 into the medical domain is already contemplated by numerous customers as shown by the contracted development described above, but these are really just first steps.

Most medical simulations are stand-alone, designed for a single participant to practice some medical skill (for example triage, or treating bullet wounds). **VBS2 is fundamentally different because it is a networked tactical training and mission rehearsal tool**, providing a base layer of functionality not present in stand-alone simulations.

VBS2 offers the ability to practice medical skills within a collective training environment, involving human participants ranging from infantry medics through to CASEVAC vehicle drivers through to Commanders who must adjust their plans based upon the injuries their forces are sustaining.

In the same manner that VBS2 provides networked, collective language and culture training through [Virtual Role Players](#), VBS2 can provide multi-participant medical training in realistic theatre-specific scenarios. For example, Bohemia Interactive could extend VBS2 to simulate sucking chest wounds, allowing in-game participants to make decisions regarding administration of first aid and extraction of the casualty

Bohemia Interactive is prepared to either improve the medical capability inherent in the simulation, or extend VBS2 so that other Defense contractors can build the required user interfaces using the VBS2 Development Suite. **New VBS2 medical capabilities can be implemented quickly and affordably**, as shown by previous related development. Additionally, BISim generally offers discounts on mutually-beneficial VBS2 development because such improvements roll back into the VBS2 baseline and are provided to all enterprise customers (e.g. the UK MOD, CF, ADF and NZDF).

4.3 Real Virtuality 3

As described in Paragraph 2.6, Bohemia Interactive has continued development on the core Real Virtuality game engine that underpins VBS2. The latest version, Real Virtuality 3 (RV3), provides extremely high-fidelity graphics and very life-like character models. If required, such capability can be ported back to VBS2 at minimal cost. For example, if VBS2 medical simulation demands more realistic-looking characters, then RV3 character models (including highly detailed facial animations) can be converted to VBS2. Examples of high-resolution RV3 Afghan character models are shown in the images below.



4.4 Conclusion

VBS2 is presently the “game for training” of choice for the US Army, USMC, USAJFKSWCS, CF, UK MOD, ADF and NZDF, and its user base grows weekly. VBS2 is an “Open Platform” and includes a Development Suite and a powerful scripting language. As most customers share a common VBS2 baseline, capability funded by one organization is generally provided to other organizations as a matter of course. Clearly, there is a great opportunity for medical training to be provided in this virtual game-based simulation and, for the first time, **allowing medical skills to be practiced in a real-time, networked, collective training environment.**

Bohemia Interactive is proud to serve our military customers, and stands ready to support the medical training requirement through funded enhancements to the VBS2 simulation engine.

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