Effective Acquisition of Virtual Worlds; Ensuring Return on Investment

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ABSTRACT

The acquisition of training technology is complicated by a lack of objective measures with which to perform a cost-benefit analysis. Virtual worlds are among one of the most recent tools to consider, yet they don't fit the usual metrics such as screen numbers, seat time or number of decision points. To further complicate matters, the term "virtual world" is often used generically to encompass a wide variety of environments from social networking applications and gaming engines to Massive, Multi-player Online Games (MMOG) and Massive, Multi-player Online Environments (MMOE). The challenge for the training professional is to differentiate between an instructionally valid use of a virtual world and a flashy application that does not contribute to the objectives. This paper will address the problem by presenting the following:

- Compare the features of various virtual worlds within several scenarios
- Evaluate virtual world features in the context of a media selection model allowing an objective approach for matching the most cost-effective solution to the requirement.
- Techniques to estimate costs to apply virtual worlds
- Guidelines to keep virtual world development costs down
- Hidden benefits of distance learning in a virtual world that are not evident in other forms of distance learning.
- Mitigating risks that threaten the successful execution of a virtual world project
- Examples of misapplications of virtual worlds
- How to avoid potential traps training professionals may find themselves in when driven by popular opinion to apply virtual worlds
- How to maximize transferability of data between virtual worlds
- How to objectively determine the cost-benefit trade off between various virtual worlds.

This paper will prepare readers with objective ways to acquire and execute virtual worlds while ensuring they are getting the expected return for the training dollars invested.

ABOUT THE AUTHOR

Jay Graser is a retired USAF officer with 24 years of training industry experience. His work has ranged from certifying platform instructors to pioneering Category D flight simulators. He is currently a Program Manager with SRA International working with technology-based training, including virtual worlds. At Sikorsky Aircraft, he led a team responsible for training customers to operate and maintain over 3400 aircraft worldwide. At the USAF Expeditionary Center, he set the standards for 135 instructors, established a measurement system and integrated new training technologies. In addition to being a guest speaker for Southern Illinois University's Workforce Education Curriculum, Mr. Graser has presented the following: "Investigation Enhancement through Information Technology," to International Society of Air Safety Investigators, 2003 Annual International Seminar; "Applying Instructional Systems Design in a Multimedia World," to Lakewood Publications Training Conference 99; "How Training Fits Into Your Company's Strategic Plan," to 98 ASTD Tech Skills Conference; "Managing Training as a Business Decision," to 97 ASTD Tech Skills Conference; "Capturing Synergy… More Than Just Chartered Teams," to the American Society for Quality; and "Covey's 7 Habits," to 1995 Quality Air Force Symposium.

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INTRODUCTION

With every new technology that has had potential to contribute to learning and training, instructional system developers, project managers and acquisition professionals have been challenged with how to evaluate, compare and acquire these technologies in a manner that reduces the risk of failure and maximizes return on investment (ROI). Virtual worlds are just one of the latest tools in a long line of technology options over the years. This paper is not meant to advocate any one virtual world or tool, but attempt to apply some objective methods to the process of evaluating and acquiring virtual worlds for the purposes of learning and training.

WHAT IS BEING ACQUIRED?

Before you begin your acquisition process, make sure you clearly define what you are buying. Consider that when you go to buy a car, you probably do not know how to build a car, or even the mechanics of how it all works, but you need a basic understanding of the car's features in order to make a comparison and an informed buying decision. Virtual worlds of one kind or another have been around for decades. When we began training flight crews together in one simulator and later linking simulators together via the High Level Architecture, we were creating a virtual world. However a full motion simulator can easily cost $25M, making them cost prohibitive for creating virtual worlds on a large scale. In recent years, creating a similar learning environment has become far less expensive than it was even 10 years ago. Programs that once required a Silicon Graphics computer, can now be run on a gaming laptop for a fraction of the cost. Although the cost has come down significantly, virtual worlds can still amount to a sizable investment, for which it is reasonable to expect some kind of return, such as improved mission performance. The subject of ROI with regard to training is, in itself, controversial. Jack Phillips, author of Return on Investment in Training and Performance Improvement Programs, states "While some professionals argue that it is not possible to calculate the ROI, others quietly and deliberately proceed to develop measures and ROI calculations." (Phillips, 2003) In order to make an informed decision regarding the acquisition, you need to become educated on at least some of the basics of virtual worlds. This paper is intended to provide enough technical depth for you to make an informed decision without needing to be a technical expert.

Virtual Worlds Defined

Let's start by defining a "virtual world." Merriam-Webster defines virtual as "being on or simulated on a computer or computer network (i.e., virtual books, virtual keyboard); occurring or existing primarily online (i.e., virtual library; virtual shopping); or existing within a virtual reality (i.e., virtual world, virtual tour)." ZDNet defines a virtual world as "A 3D computer environment in which users are represented on screen as themselves or as made-up characters and interact in real time with other users. Massively multiuser online games (MMOGs) and worlds such as Second Life® are examples. See MMOG, MMORPG, Second Life® and metaverse."

In contrast to a "virtual world," a "mirror world" is defined as "an online virtual world that mirrors data from the real world," as defined by Raph Koster, author of "A Theory of Fun Game Design." The distinction is that virtual worlds are not intended to be an exact replica of the world as in a mirror world. They are more an artist's conception, potentially including data from the real world. Some definitions make this same distinction by referring to the virtual world as being "fantasy." However, this does an enormous disservice to virtual worlds as a training medium by not depicting them seriously. For example, certainly a 30 foot tall larynx is not the real world, but to call it "fantasy" detracts from the message that the artist's conception is intended to achieve as a learning aide.

Operational Definition

An operational definition helps to ensure all parties have a clear understanding of what is being acquired. For the purposes of this paper, we will use the following operational definition:

A computer-simulated model world presenting a visual depiction to the user. The user can interact with elements of the world and with other users. Typical rules of physics (gravity, topography, movement, time) may or may not apply, based on their relevance to the learning objectives. The world includes sound effects and a minimum of a text-based communication system.

IS A VIRTUAL WORLD NEEDED?

Before setting your sights on acquiring a virtual world as a solution to your requirement, consider all the possibilities. Virtual worlds should be just one option among many. As you would in any project, weigh the pros and cons of various delivery methods. Do you even need a virtual world? The acquisition process compares costs as well as quantitative and qualitative evaluation criteria. The first criteria may be to determine if a virtual world is the best fit for the requirement. Often project managers with a perceived training gap will gravitate to the latest tool, regardless of whether or not it will solve their problem. This is one of the typical traps. In order to judge whether or not a virtual world makes sense, put the problem in the context of how you would conduct the training in person. Would it help to recreate the venue in an environment that you can modify to your needs and participants can manipulate and interact? Or, does the venue have little or no impact on the effectiveness of the training or learning situation. It would make little sense to calculate the ROI on a virtual world project where a virtual world was not needed.

Checklist

The following checklist will help determine if a virtual world is a reasonably good fit. Acquisition professionals need to be assured that a logical process was applied to selecting a virtual world as the solution.

- ☐ 1. **Group Participation:** Is group participation required? One misuse of a virtual world is treating it like typical web based training where the only interaction is between one participant and the computer. If group participation is the only requirement, consider using one of the synchronous web meeting tools, such as Web Ex, or simply using a conference call. Group participation alone is not enough to drive the decision to use a virtual world, some or many of the other following elements in combination would drive the decision.
- ☐ 2. **Distributed Participants:** Are the participants distributed (not a requirement, but takes advantage of one of the benefits of virtual worlds)? Virtual worlds can help reduce travel costs for distributed participants.
- ☐ 3. **Training Aide Replication:** Are the desired learning conditions difficult to replicate in the real world? (Why build a virtual world if the real world items will work fine as training aides?)
- ☐ 4. **Spatial Orientation:** Are their spatial orientation requirements where participants need to know their way around a place or equipment (i.e., inside of a tank or an aircraft)?
- ☐ 5. **Affective Objectives:** Is the virtual world impact needed to achieve objectives in the affective domain through immersion?
- ☐ 6. **Physics:** Is there a need to suspend or modify the laws of physics to illustrate a point or facilitate the learning process?
- ☐ 7. **Duration:** Does the length of the class or criticality make development in a virtual world worthwhile? There may be a ramp-up time for students to learn how to use the virtual world. You do not want to spend four hours getting oriented for a one-hour course.

If the answer to most of these questions above is "yes," then you may be able to meet your requirement by using a virtual world.

Virtual World Scenarios

For the sake of argument, assume that the media selection process for the requirement favored using a virtual world. In order to put the discussion in context, we will use the following three scenarios. After each scenario is an example of how the checklist could be completed for that scenario.

Scenario 1: Team Building

A leadership team is forming to deploy an expeditionary air base. The team is distributed and will not meet one another until they arrive in country. Your challenge is to get them to at least the "Norming" stage of the Team Handbook (Scholtes, Peter R., Joiner, Brian L. and Steibel, Barbara J., 2003). Applying the checklist above, the training would have most likely been conducted in the real world using exercises requiring the students to interact and solve a problem together. If this training is successful, it may be scaled to be used for other leadership teams.

Scenario 1 Checklist Responses

1. **Group Participation:** Yes – the training needs to be done as a group in order to build rapport and teamwork.
2. **Distributed Participants:** Yes – they won't meet until they deploy together.
3. **Training Aide Replication:** No – team exercises can be created with fairly simple props.
4. **Spatial Orientation:** Yes – spatially oriented exercises are more engaging when team building. Spatial orientation is one of the hidden benefits of using a virtual world. Participants experience relative position among one another and in relation to objects, both visually and through directional sounds. Consider another hidden benefit relating to memory cues. A common memory trick is to memorize a list by picturing them in a room and walking through the room in your mind in order to recall the list. In a virtual world you can actually create the room. Ask participants to walk through a virtual room while paying attention to the objects in the room. The participants should be able to list the objects in the virtual room after having walkedthrough without turning around to view them again. A similar application of spatial orientation is arranging reference screens in a sphere around an avatar. This has been applied as a reference for students taking a series of courses requiring intense research, and if the same spatial / memory rules apply, the participant should remember what references are behind them, out of site. This brings more reference material only one click away and could eventually be applied to situational awareness applications. In the end, this feature is relevant to the acquisition process because if it is applied effectively, training time can be reduced, potentially saving budget associated with the length of the course.
5. **Affective Objectives:** Yes – the virtual world will allow very graphic depiction of the results of right or wrong decisions of the team. For example, in the real world, the instructor would tell them to "imagine this rope represents a chasm 300 feet deep." Instead, the instructor can show the chasm and if the student's avatar wanders too close, the team just lost a team member. This visual image can really stick in their mind and rapidly move their achievement of objectives in the affective domain to the level of valuing.
6. **Physics:** Yes – While not a hard requirement, modifying the laws of physics could help create more interesting team exercises.
7. **Duration:** Yes – While at least an hour of virtual world navigation familiarization would be needed, it could be combined with a simple exercise and begin achieving some of the learning objectives.

Scenario 2: Aircraft Familiarization

An Army Company will have their specialized equipment deployed via C-17s and will be responsible for ensuring the load is ready for air shipment and securing it on the aircraft. The team is collocated at one base, but a C-17 will not be available for training. The first time they see the aircraft will be when they deploy. There are approximately four plane loads of equipment that must be shipped.

Scenario 2 Checklist Responses

1. **Group Participation:** Yes – preparation and loading will take teamwork. For example, one can position the portable scales while the other drives the vehicle.
2. **Distributed Participants:** No – the participants are all co-located. Since there is no advantage to being able to train distributed participants, you need to consider how heavily the other aspects weigh in my decision. You may consider using a blended approach of a virtual world for aircraft orientation combined with some hands-on props, like a 463L pallet, example load, available vehicles and tie down equipment.
3. **Training Aide Replication:** Yes – mostly due to the aircraft replication. It's difficult to bring an aircraft down from the flying schedule for the purposes of ground training.
4. **Spatial Orientation:** Yes – again a virtual world will help them get to know their way around the aircraft, where the tiedown equipment is, layout of the rings, rollers and restraint system.
5. **Affective Objectives:** No –motivation of the students through immersion in the virtual world is not a requirement.
6. **Physics:** Yes – since this will involve weight and balance, adherence to the laws of physics would help achieve the objectives.
7. **Duration:** Yes – the course is at least a day long, so the time it would take them to learn to navigate would be worth the benefits of the virtual world.

Scenario 3: War Gaming

New doctrine has been established and several senior leaders need to practice applying doctrine through wargaming. The senior leaders do not have time to meet in one place. Additionally, the war game could

become classified. After the validation phase, the throughput of this course will be approximately 240 students a year, 20 classes of 12 participants each.

Scenario 3 Checklist Responses

1. **Group Participation:** Yes – collaboration will be essential to understanding the overall impact of applying new doctrine.
2. **Distributed Participants:** Yes – in this case, the most critical participants do not have the time to travel to one spot.
3. **Training Aide Replication:** Yes – the virtual world creates a shared situational awareness. The training aides to replicate from the real world would be maps, PowerPoint briefings and situational awareness displays, such as maps or even existing command and control systems.
4. **Spatial Orientation:** No – this factor refers more to a psychomotor task that requires participants to know their way around a physical space, such as the interior of an aircraft or building.
5. **Affective Objectives:** Yes – one affective objective is that the participants respond appropriately to the impact of their decisions. A virtual world can simulate the "fog of war" better than a paper-based war game.
6. **Physics:** Yes – enough to show the impact of doctrine decisions.
7. **Duration:** Yes – the course will most likely last several days, so the time it would take them to learn to navigate would be worth the benefits of the virtual world.

Scenarios Summary

As you can see by the checklist response, each scenario has unique strengths and weaknesses with regard to using a virtual world. These must be taken into consideration during the evaluation process.

COMPARING VIRTUAL WORLDS

"The Big Blue Book, A Consumer Guide to Virtual Worlds" (Association of Virtual Worlds, 2008) lists over 250 virtual worlds, yet is not exhaustive. In order to evaluate virtual worlds, you first need establish an "apples to apples" comparison. There is a tremendous variation in the cost of virtual worlds. They can range in price from free downloads to $500,000 just to deploy one instance of the virtual world. The tendency is to focus solely on the price. However, virtual worlds that are free to download may not have the quality and quantity of features needed to achieve your training objectives. Before comparing prices, first rate the features of the various solutions under consideration in order to determine the relative value of each solution for the price you will need to pay. A "free" solution may actually end up costing you thousands of dollars due to a failed project vs investing thousands or even millions of dollars to get the needed ROI associated with a successful project.

Features as Evaluation Criteria

The features of virtual worlds are many and varied. The ones that are important depend on the desired outcome. Unfortunately, there are no widely accepted standards for virtual worlds that acquisition professionals can reference in the requirement in order to ensure all the solutions being considered meet a common standard. For example, training procurements often stipulate that the training must be Shareable Content Object Reference Model (SCORM) conformant. Without a common standard such as this, we have to establish some general criteria. The specifications for each virtual world on the market can be very technical and specific to the particular application. In order to summarize them to a less technical level that would apply generally to multiple virtual worlds the following list is a high level summary of those features that would best apply to training and education.

1. Visual Fidelity – For the purposes of this paper, assume the visual system will be a typical PC and monitor. Given this, you have to decide how important fidelity is to you. High fidelity with a great deal of animation can slow some sims (simulations) down. The question becomes a trade off between learning value and practicality. The visual system can have a ripple effect on the entire procurement. Higher fidelity graphics may mean that in addition to the virtual world, you will need to set aside budget for upgraded graphics cards and monitors. If you need fine detail, consider using a texture over a wire frame (some sims call this a polygon or prim (SL short for primitive)). The trick in gaining the greatest efficiency is in keeping the polygon count low. The more polygons the processor needs to manipulate, the more calculations per second and the more you will bog down your sim. The term used by programmers is optimization. You want to ensure in your requirements that you ask your provider to optimize the sim. This will make it as efficient as possible. You can establish high level metrics, such as how many meters away the avatar will be able to see or how fast the scene in use needs to come completely in focus for the avatar. In a high speed scenario, such as flying, this could be a real challenge. In a scene where the avatars are only

walking or even static, the demands on the processor are much lower in order to create the same level of detail. In the end, don't get caught up in the race to have the best looking graphics. Consider the impact on your learning objectives. Do you even need visuals? Consider how for decades, radio stations have created a world completely through sound effects? Could your students interact with one another simply by voice within an environment you have created solely via sound effects? However, if your students would benefit from a shared visual experience in order to achieve the objectives, then you need to pay attention to the visuals. This fidelity extends to the avatars as well. Do faces need to be near photo realistic so participants recognize one another when they meet in the real world or will something more cartoon-like be acceptable? Do the avatars need to display fine movements in order to achieve the objectives? For example, if you are teaching sign language, not all avatars can move individual fingers.

2. Physics – Do the real world physical laws need to apply in order for your training to be effective? Most virtual worlds provide some kind of gravity, but what about other effects such as temperature? For example, if you want to model the movement of a plume of gas across a battle field, most virtual worlds would not have the physics built in to illustrate the effect close enough to real world. In some cases, a lack of physical laws or the ability to suspend them can be a training advantage. For example, student mobility is improved by the ability to fly enabling you to reduce training time due to travel or movement that would have been required otherwise in the real world.

3. Ease of Participant Use – Can the participants function easily in the virtual world? Most virtual worlds require that you download a client application to your computer. Understandably, your Information Assurance officials may get nervous when you tell them you want clients to download software and access various ports. The concern is that the client application could open up a security vulnerability, allowing harmful files into the network (worms, viruses, Trojan horses etc…). One objective virtual world providers are pursuing is browser-based virtual worlds. Browsers with proven plug-ins such as Flash are considered reasonably secure by most organizations. On the other hand, Active X plug-ins commonly found associated with browser-based applications have been known to create security vulnerabilities. Therefore, just being "browser-based" does not make the virtual world secure. Once the client application is uploaded, the user needs to learn how to use it. They are not all that obvious in their function and it may take several hours to get comfortable with navigating around. Consider creating a job aid that gives them tips on how to function in the virtual world.

4. Ease of Development, Operations and Maintenance – This can potentially be a major factor. Some virtual worlds have development environments designed for creating content in world, such as a graphical user interface with menus and libraries of ready made content that require little or no programming skills (also known as "What-you-see-is-what-you-get" or "WYSIWYG" pronounced "whizzy – wig"). Others have no development environment designed for that world, requiring advanced object-oriented programming skills and an understanding of multiple programming languages, architectures and graphics packages. As an example, an instructional systems developer, who had no programming experience, was tasked to develop a simple kiosk in Second Life® that would connect users to an external web site. She had it done within a few hours. Conversely, the best programmers were tasked with getting Joint Semi-Automated Forces (JSAF) to generate forces in another model and their initial attempts ended up with the troops entering 45 feet above the ground. Similarly, while JSAF can generate forces in virtual worlds, they may not get the feedback needed from the virtual world to create realistic interaction and may create effects such as troops moving through objects and terrain, rather than avoiding them. In the end, there may be a trade off between complexity and ease of maintenance. More robust virtual worlds that can readily interface with external models may require engaging the time and skills of object oriented programmers. On the other hand, if the purpose is strictly training, it is very powerful to allow the Instructional System Developer to create things on the fly using a WYSIWYG as the requirement evolves and the developer sees the impact of his changes to the virtual world. In some cases, organizations are eager to apply virtual worlds and even though they have never worked in a virtual world, they make a significant investment up front and risk being disappointed in the end. To avoid this disappointment, start with a small prototype. Request storyboards and mock ups early in the project time line. The stakeholders may all think they have the same concepts in mind, but you don't usually work out the details until it begins to become something visual that they can all experience and come to a consensus on. Therefore a phased or spiral approach to development helps you make course corrections early on, before you make a large investment.

Another aspect of development and maintenance is the issue of transferability of work between virtual worlds.

This means that once you commit to a virtual world, it is very difficult to move to a different virtual world. For the most part, work built in one virtual world must be recreated from scratch in order to move it to another virtual world. While there is some transferability and the trend appears to be toward more of an open source standard, the transfer capability is currently limited. One way to mitigate the transfer impact is to model and support the virtual world using common third party applications. For example, rather than program behaviors entirely within the virtual world, create queries back to a database. If you later decide to move to another virtual world, you could potentially use the same database. While it's still a substantial amount of work to change worlds, you would not be starting completely from scratch. Another technique to preserve work outside of the virtual world is to render objects in a 3D modeling application, such as 3ds Max, and import them into the virtual world. This is not as simple as it sounds but can help create an inventory that can, at a minimum, provide a prototype that can guide the transfer process. An added benefit is that the 3D animations can be used as rapid prototypes for review and approval before they are created in the virtual world. While this appears to be added work, it can actually save rework in the end by ensuring buy-in to the design.

5. Hosting – How is the instance of the virtual world being hosted? If not hosted by a vendor, where will you host the server application? Some virtual worlds supply the server application for free while others may have a substantial cost. Also, consider if you host it internally, will all the participants be able to access your virtual world? Even if you have it hosted by a vendor, it may not be accessible to all participants. For example, some virtual worlds cannot be accessed from a .mil account. Consider what it will cost for servers, internet connectivity and housing the servers. One option may be to use a hosting facility such as the Acquisition Logistics and Technology Enterprise Systems and Services (ALTESS). ALTESS provides cost-effective IT support and services to a growing list of customers, including Army Human Resource System/ Deployed Theater Accountability Software Support Program Executive Office Ammunition, Joint Program Executive Office Chemical Biological Defense, Science & Technology Enterprise Management (RDECOM), and U.S. Army Medical Research Institute of Infectious Diseases e-Business Suite. As of this writing and to my knowledge, ALTESS does not host any virtual worlds and it is only presented here as an example of a hosting facility. For more about ALTESS, see their web site at http://www.altess.army.mil/.

6. Points System – If you are going to be using a gaming approach to achieve any of your training objectives, ensure the virtual world has some kind of points system. Some will advertise that they have a system of commerce (i.e., Second Life® use Lindens as their currency). While it is feasible to include some form of commerce as a part of your training strategy, it is not the same as a points system.

7. Application Sharing – For the purposes of evaluation, this aspect will encompass a great deal. Technically, application sharing relates to the question, "if I'm in the virtual world, can I pull up a presentation in a PowerPoint® format and all the participants see the same thing at the same time?" The application basically behaves the same way it would as if the instructor was in the same room with people using a PC and a projector to display the application. However, you could expand that to include things like Learning Management Systems (LMS). In some cases, the LMS will link seamlessly into the virtual world. The participant's avatar proceeds through participating in the event while the virtual world automatically tracks their activity and gives them credit for achieving objectives on the fly. By the same token, if they attempt to begin a lesson, the virtual world can query the LMS to determine if the prerequisites have been met. If not, it automatically directs the participant to where they can complete the perquisite. Going beyond the LMS into a Learning Content Management System (LCMS), can the virtual world allow you to manage and deliver content using your existing LCMS? Another aspect, that may or may not be considered application sharing, is various forms of media. For example, in some virtual worlds, if an avatar initiates a video stream, the other avatars in the virtual world may or may not see the same thing.

8. Communication – Most virtual worlds have some kind of text chat between the participants. Many either have Voice Over Internet Protocol (VOIP) or have plans to add it in the near future. There are different approaches to VOIP. Some virtual worlds provide their own VOIP and others use a third party, such as Vivox (www.vivox.com). Regardless of the solution, take into consideration the testing to ensure VOIP will work with your architecture reliably and meets the objectives. It may require additional bandwidth and encounter some reliability and clarity issues. One question to ask is, "is it stereoscopic?" Stereo sound can be helpful in making the environment more realistic in that stereo allows you to tell from what direction a sound or voice came from. When another participant speaks to you, you hear their voice coming

from their relative physical position and know to turn in that direction. Depending on how you intend to use the virtual world. You may want to forgo VOIP altogether and communicate completely by text chat and a conference phone line. This will remove one potential failure point in your project and reduce risk to project success.

9. Non Player Characters (NPC) – NPCs are essentially animated characters that are not driven by a real person and can be referred to as BOTs or automated avatars. Not all virtual worlds support NPCs, but most do in one way or another. For example, in Second Life® there are at least two ways to create an animated character. One way is to shape an object to look like the character and then drive it with a script that runs within the virtual world. This is much like JavaScript running in a browser, except with a great deal more capability than JavaScript. However, it is sometimes difficult to approach the level of detail found in most avatars by using an object and functionality can be limited. Another way to achieve NPCs is to establish an avatar as if it is being driven by a person and then animate it by driving the avatar's user interface through software. Using this approach, you get the full functionality of any other avatar and can focus on the desired behaviors rather than the look of the NPC. The down side is that unless the virtual world supports scripts to drive the NPC in the virtual world, you will need to plan for processors to handle the software that animates the NPC. NPCs can also take advantage of existing artificial intelligence (AI) software to become extremely robust. However, they can be limited by the ability for the NPC to receive feedback from the environment and from other participant avatars. For example, the NPC can pick up on text chat traffic in the virtual world in order to formulate a response, but as in other AI applications and search engines, it must take into account that the question may be asked in a multitude of different ways. From an acquisition standpoint, one way to combat this is to specify a "learning NPC." A learning NPC will monitor anomalies and establish some way to improve the quality of the response. This ranges from being as simple as collecting the text chat stream for later analysis by the software programmers to a more complex algorithm that automatically updates the AI software as the NPC encounters new variations of the query or problem. Some NPCs are capable of responding to voice (via VOIP). However, this complicates the system in that voice recognition software is not as well refined at text processing software. There is a great chance that the message will get distorted because of the way the voice recognition software processed what it heard. If using voice response, the next variable is the synthetic voice. This is less of an issue in recent years in that synthetic voices have improved dramatically. However, in the end, even the best NPC may have a difficult time passing for a real person. Set reasonable expectations. NPC's are a good 80% solution, but the cost to go the additional 20% to perfect them could be considerable. Finally, one trick used to keep participants guessing about whether players are NPCs or actual participants is to switch off between letting the software drive the NPC and having a real person drive the NPC. Not only is this a great way to keep participants on their toes, but creates an opportunity to learn ways to improve the performance of the NPC.

10. Cost Estimation – The cost of a virtual world can vary greatly. Some might require a large investment and not meet your requirements, while others may be relatively inexpensive and yet be more than adequate to meet the need. In order to make a fair evaluation of cost, you must first refine the requirement as much as practical. You may want to release a Request For Information in order to better understand capabilities at the time and refine your requirement before venturing into costing. A well defined Statement of Work (SOW) or at least a Statement of Objectives (SOO) should narrow the field of competitors. Take into consideration that the technology is changing rapidly and that a very detailed SOW may be prescriptive of outdated capabilities, where a SOO will allow the providers to recommend the optimal approach to achieve the goals. In the end, you would rely on the same ISD principles as used for evaluating any other medium and focus on the metrics you will use to determine success. For example, the metric might be in the case of Scenario 1, that at the end of the training the participants display at least 90% of the behaviors described as "Norming" in the Team Handbook (Scholtes, Peter R., Joiner, Brian L. and Steibel, Barbara J., 2003). Without measures of success, it will be difficult to determine the return on your investment, no matter what the price.

Here are some of the cost elements to consider.

- Server software – you may need to pay for more than just the server application. Some virtual worlds are fed by external databases, models and even real time data feeds.
- Server hardware – you could be supporting anywhere from fifty participants on one server to several hundred. Check with the vendor to find out how many participants can be supported by one server. If you need to scale up, this will determine at what point you need to buy another server and the associated hardware.

- Client application – make sure that you inquire if there is a separate cost for each instance of the client application. This could limit your ability to scale the virtual world.
- Hosting costs – consider how your participants will gain access. It may be through a local area network or it may be through the internet. Hosting options may be limited by the particular virtual world. Your Information Assurance division will have concerns about what port will be open and how participants will safely access the virtual world. These considerations all play into your viable hosting options. If the vendor hosts the application, ensure your participants will be able to access it (some sites are blocked), and be sure to take into account set up fees and all recurring fees for the projected life of the project.
- Licensing fees – beyond any fees for the server and client applications, there may be fees for supporting applications, such as gaming engines or databases.
- Virtual world design, development and maintenance – This is where having a WYSIWYG development environment can be beneficial. Even with a WYSIWYG, you may want to consider budgeting hours for professional designers to initially create your virtual world.
- Staffing – Once the virtual world is developed, who will man it? Unless the virtual world is completely automated, it will need to be manned much like you would any other instructor-led training environment. While a great deal can be accomplished using NPCs, artificial intelligence software still cannot quite replace human interaction. Just as you would in a classroom, consider what instructor student ratio you will need. You must also consider any staff required to perform administrative duties, very much like a webmaster for a 2D site.
- Supporting software – Consider any additional costs for databases, middleware, artificial intelligence, and modeling.

One good summary figure is the total cost of ownership. Consider all the costs above and divide them by the number of participants. If you are doing a small prototype that you do not expect to scale up, you may want to sacrifice some features or convenience in order to lower the cost of ownership. If you intend to scale up in increments, be sure to take into account jumps in costs as you reach the limit of servers and need to pay for additional servers, licensing and hosting.

11. Return on Investment (ROI) – Just like any other investment in technology, you need to consider the cost benefit of the potential solution. To calculate ROI use the following formula, ROI = (return on investment - initial investment)/Investment * (100). Using metrics to determine training effectiveness is not a new concept, including one method popularized by Donald Kirkpatrick. In applying Kirpatrick's model of measuring training effectiveness that breaks measurement into four levels Reaction, Learning, Behavior and Results (Kirkpatrick, D. & Kirkpatrick, J., 2007), some refer to ROI as the fifth level. Probably the most impactful ROI is at the mission level. For example, participants who use this system are expected to increase their efficiency by XX% which equates to a savings of $XX per participant, compared to a cost of XX per participant. Some more tangible return for the military may be from travel costs saved by using distributed learning rather than making participants travel. This is a fairly standard argument applied to web-based training. The difference in the case of virtual worlds is in applying the initial checklist to determine if you really need a virtual world or you just need some form of distance learning. In order to calculate a return, you would need to compare the cost to the savings using the formula above. One way to do this is by adding up the entire cost and dividing it by the number of participants. This is sometimes referred to as "Total Cost of Ownership." Then compare this to the travel savings for each participant. Therefore, if total cost of ownership per year is $200 per person and each participant saves $400 per year the ROI is 100%. Using this model, your ROI will increase the more you add participants within the capacity of the system you have built. However, in the Aircraft Familiarization scenario, the participants are not geographically distributed, so the number may be limited, therefore limiting your ROI when calculated. In this case it may be better to calculate the overall savings generated, such as the total cost of the virtual world against the cost of delaying a flight if the load is rejected or the loading process is longer than usual due to the participants' lack of familiarization with the aircraft.

Features Summary

Table 1 displays a summary of the features to consider as evaluation factors in comparing virtual worlds as a part of the acquisition process.

Table 1. Feature Evaluation Factors

Feature	Evaluation Factors
Visual Fidelity	View distance, time to focus, details (e.g., hand and facial gestures, instrumentation)
Physics	Real World vs Non-Existent (gravity, weather, density)
Ease of Participant Use	Client application, security concerns, browser-based, Flash-based, intuitive design allowing rapid user familiarization.
Ease of Development, Operations and Maintenance	Does it have a development environment that can be used by most people, or does creating content require higher order programming such as object oriented software skills?
Hosting	Is the server hosted with the vendor or will your organization need to supply that? If you plan on scaling up, what are the limitations? How many participants can be handled on one server before the need for another server? At what point does server response begin to degrade to the point where your objectives are compromised?
Points System	How are scores tallied and managed, can they be exported
Application Sharing	Microsoft Applications, LMS and/or LCMS integration, video streaming, audio streaming, command and control applications
Communication	Text chat, VOIP (Note: Not all VOIPs perform the same, specify and test)
Non Player Characters	Object driven by scripts within the virtual world, automated avatar, third party application
Cost	Server hardware, client application, hosting, licensing, design and development, staffing, support software, total cost of ownership
Return On Investment	Mission impact, lives saved, efficiency, cost savings, ROI = (return on investment - initial investment)/Investment * (100)

Weighing Evaluation Factors

In researching for this paper, several virtual world providers were polled in order to get their input. A few of them generously volunteered to provide a retail price list in order to populate the comparison below. However, prices vary greatly depending on what the goal is for the project and there can also be a significant difference between the retail price and the actual price for the particular application, once the work is on contract. Also, the intention of this paper was to provide tools, techniques and observations that would help make an objective comparison of solutions and not to endorse one solution over the other. One of the important lessons that emerged while compiling this paper was that it is essential to accomplish the due diligence necessary to survey the market at the time. One discovery during this research was that a spiral approach to requirements development appears to be effective. For example, start out with some broadly defined goals expressed as mission or performance objectives. The more measurable these goals are the easier it will be to determine success and ROI. In the first few spirals, you will start with a broad list of potential virtual worlds and rapidly narrow them down to a reasonable number of candidates that have the features and provide the value needed to produce maximum ROI. One way to do this might be to take the list of virtual worlds and divide it amongst several evaluators, grading the advertised features of each against the requirements. After an initial pass at the list, evaluators can meet to discuss their scores, compare reasons for their evaluations and suggest refinements to the requirements.

Evaluation Scoring Matrix

In order to use the evaluation tool below in Table 2, start by weighing the features based on their contribution to meeting the particular requirement. The table below was populated based on the requirement in Scenario 1 above. Note that the weighting is more of a scoring than a rank, with the more important features being assigned higher numbers. Features of the same importance will have the same weight. The end result of the overall table is a weighted score for each solution. The solutions with the highest score should better meet the requirement. The quality of the result will depend on how thoroughly you research the various solutions. The matrix in Table 2 starts by weighing the things that were most important to fulfilling the requirements and then least important and ending with the items that had a neutral impact. Ease of use and ease of development were the two most important things for Scenario 1. The participants have little time to learn to use the interface or work out access issues. Also, since easily updating and maintaining the team building exercises

is a requirement, it's important that the development environment be user friendly. Maintaining a staff of software engineers just to keep the training fresh would be an undesirable lifecycle cost. On the other end of the scale, the points system and application sharing are not all that important to Scenario 1, because the real value is in the interaction between the participants and won't require points or external applications. Oddly enough, ROI was not weighted very high, because in this case it would be difficult to measure. The mission results of increased team work will be subjective and, like most soft skills training, difficult to draw a causal or even corollary relationship.

With regard to Scenario 2, Cost, ROI and Development would be ranked highly. In this case, Scenario 2 barely qualifies for needing a virtual world, so the cost would need to be very low for a virtual world to be selected.

Scenario 3 would weigh heavily in areas such as application sharing and physics. However, it would also take into consideration that a WYSIWYG development environment is less important because the technical aspects will require object oriented programmers.

Table 2: Evaluation Scoring Matrix (Scenario 1 Example)

		Features																					
		Visual Fidelity		Physics		Ease of Use		Development		Hosting		Points		Sharing		Communication		NPCs		Cost		Return on Investment		**Totals**	
Virtual World	Weight	3		4		5		5		3		2		2		3		3		4		2			
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
	VW 1	3	9	3	12	1	5	1	5	1	3	3	6	3	6	3	9	3	9	1	4	1	2	23	64
	VW 2	2	6	2	8	3	15	3	15	2	6	1	2	1	2	2	6	2	6	2	8	2	4	22	78
	VW 3	1	3	1	4	3	15	2	10	3	9	1	2	1	2	1	3	2	6	3	12	2	4	20	70

Conclusions

Virtual worlds can be very compelling visually and yet become a complete waste of effort if not thought through and executed with the same acquisition discipline we would any other medium. When project managers brief the leadership team in order to secure budget for a virtual world project, the visual appeal will garner attention and may help secure the funding. However, the critical work is in applying a thorough and objective acquisition strategy, considering multiple evaluation factors as a comprehensive package along with cost and ROI. This includes a rigorous examination of whether a virtual world is even required. Acceptable ROI must be established early in the process to ensure a measurable definition of success.

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