

Serious Game for Small Unit Counter Improvised Explosive Devices (IED) Awareness Training

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ABSTRACT

As the face of modern warfare changes, one of the biggest threats faced in asymmetric warfare are improvised explosive devices. With the increasing technological capabilities and introduction of new IED tactics it is becoming increasingly difficult to protect the personnel under IED threat. Counter IED effort can be gathered under three pillars; Defeat the device, attack the network and train the force. We believe current solutions of training the force can be improved by the utilization of serious games.

Military training solution are being widely used, but we argue serious games can be the next step on military training due to the ever increasing and ever so popular game technologies. With this in mind we have developed a playable, multiplayer Counter IED Training Simulation prototype where we test the effectiveness of serious games for counter IED training purposes.

We had three squads with previous IED training, as well as squads that have served in the field and encountered IED attacks test the BETA version of the serious game. For the purpose of the test, IED attacks that happened during operations were integrated within the scenario and user's reaction were tested for the purpose of fidelity. Secondly, a questionnaire was given to the participants to measure the effectiveness of the training course. Positive results and future suggestions for improvement given by the users are covered in this case study.

1.0 INTRODUCTION

Improvised explosive devices are one of the biggest threats in modern warfare. IEDs are typically the main weapon choices in asymmetrical war theatres. IED related deaths were increased in constant rate between 2001 and 2011.¹ After the introduction of three pillars of counter IED effort; "Attack the Network", "Defeat the Device" and "Train the Force".² There has been consistent decrease in the number of casualties in Afghanistan as it is shown in Figure-1.³

¹ Kotwal, Russ S., et al. "Eliminating preventable death on the battlefield." Archives of surgery 146.12 (2011): 1350-1358.

² Eisler, David F. "Counter-IED strategy in modern war." Mil Rev 92 (2012): 9-15.

³ <http://icasualties.org/oef/>

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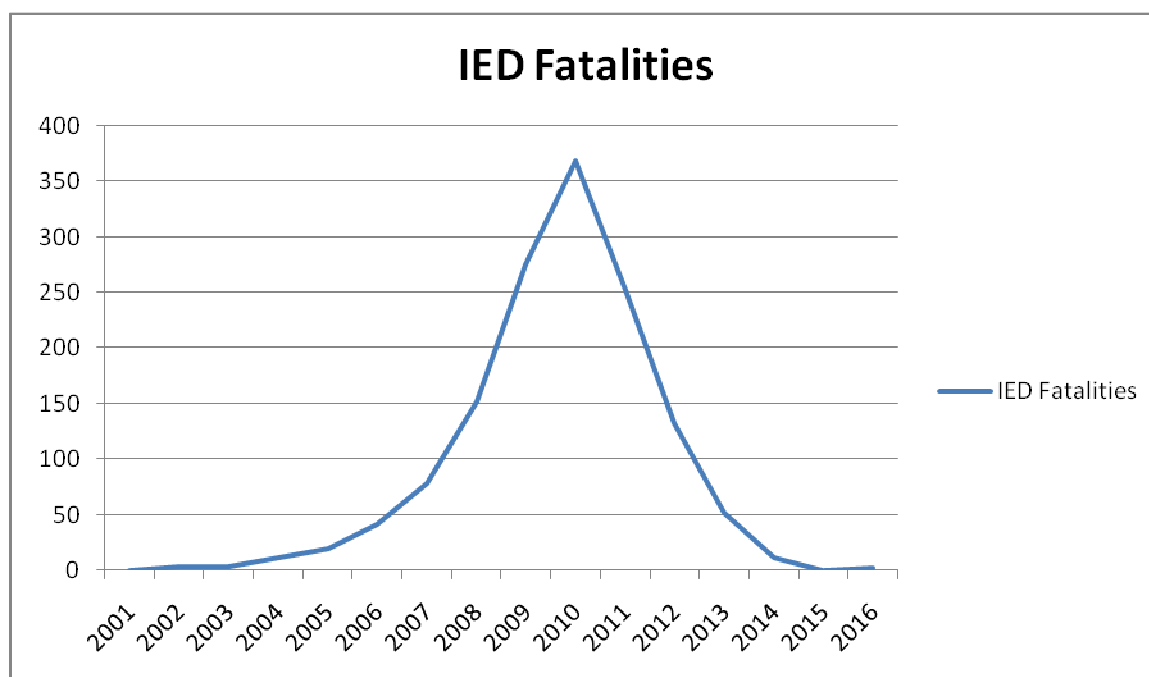


Figure 1: IED Deaths by Year.

A similar study was conducted as a terror pattern study for Turkey in Turkish Military Academy, Defense Sciences Institute. IED attack numbers and casualties have been constantly rising from 2010 to 2013. IED threat in Turkey has reached its highest devastation in 2015. Asymmetrical warfare in home front compels armed forces into disadvantage of protecting everything.⁴ All the roads, country side, mountains and urban areas are considered as to be protected. When a threat is identified within the logic of domestic counter terrorism operation, immediate intervention is required. This causes arms race, armed forces are constantly coming up with new methods, tactics and technologies to counter IEDs, while new IED deployment and trigger methods are being developed by the terrorists.

This struggle is creating a huge data flow on new tactics and counter measures. This data could be used to gain an insight on future IED threats and possible preventive counter measures. This data is vital for training the force and turning these lessons learned to permanent information that can be updated and carried to the battlefield in the minds of new officers. With this idea in mind, two master thesis studies were started under the Turkish Military Academy, Defence Sciences Institute with the task of completing the need analysis and detailed design of training system for countering IEDs in the form of a serious game. Though Serious Games are not widely used, they possess a certain potential. In its essence, serious games could be a key visualization opportunity for years of IED experience.⁵

The research done under the Defence Sciences Institute stated that key problems with developing a serious game there is gap of communication and mutual understanding of terms among armed forces, defence industry and game developers. During the development process, there are three parties involved armed forces as customer, trainees as end users and IED experts as subject matter experts. Years of experience meant a long list of needs, and the development and usage restriction of the armed forces posed strong strains on the end product. Further, using game technologies for motivation and better learning opportunity has no strong framework to follow. Serious gaming has not been tried before in Turkish Armed Forces for training and education purposes. Given said problems to consolidate all the parties

⁴ Blank, Stephen J. "Rethinking asymmetric threats." Army War College Strategic Studies Institute Carlisle Barracks PA, 2003.

⁵ Kirkley, Sonny E., Steve Tomblin, and Jamie Kirkley. "Instructional design authoring support for the development of serious games and mixed reality training." Interservice/Industry Training, Simulation and Education Conference (I/ITSEC). 2005.

involved, System Engineering (SE) was decided to be implemented during the development process. The game development processes were incorporated to serious game development and System Engineering. In this paper, the nature of this new method and lessons learned from the development and test of the prototype and a beta version will be discussed, as well as the serious game design document that has been developed during this study.

2.0 SERIOUS GAMES

Serious games are simulations of real-world events or processes designed for the purpose of understanding problems. Although serious games can be entertaining, their main purpose is to train or educate users. Gamification is the use of game thinking and game mechanics in non-game contexts to engage users in solving problems and increase users' self contributions. Serious games are used for the purpose of creating new knowledge for a specific purpose.⁶ The 3D game engine technology, graphical user interface, physical models and artificial intelligence are defined as communication network technology in game development.⁷ Technological facilities, as well as games carry the story, theme, music; educational elements such as tasks and level recovery from a didactic structure are used for translation into an interactive structure.

A number of studies show improvement in student academic achievement through serious games.⁸ Due to field trainings cost, time and safety restrictions, serious games are considered as an alternative.⁹ Serious games, analytically different from traditional classroom instruction, questioning and strategic thinking skills, self-control, problem identification and solving, short and long term memory, helps in the visual processing skills and psychomotor abilities development.¹⁰

They were played for teaching purposes of planning and development of strategy. This was started first as the strategy war game.¹¹ The game board is based on serious games has maintained its dominance for a long time. Computer system has emerged with the development of computer-aided serious games. HUTSPIEL which is the first example of this kind of war game,¹² called computer-aided theatres in 1955. HUTSPIEL is a two-person computer-based training system to teach elements of nuclear war.¹³ 1961 T.E.M.P.E.R. Cold War conflict with the aim of learning at the international level of officer training system was established.¹⁴ SG Flight 1983 in this field is regarded as the first modern version of the aircraft simulator at the forefront of the industry.¹⁵ Then Harpoon 1989 was a multiplayer naval warfare simulator. 1998 3D tank tactics have emerged with spearhead training simulator.¹⁶ Serious games can be used as publicity and public relations purposes not only for education. One such game is, Americas Army. In 2002, the army has been developed to advertise and increase the participation of schools.¹⁷ Task level began to emerge with developing technology for virtual reality simulation titles. DARWARS Ambush 2003 is one of the successful examples of these simulations. While the convoy ambush indexed training, Tactical Iraqi DARWARS 2003, provides training to operational infantry unit.¹⁸ Serious games have

⁶Tawadrous, Mina. Kevan, Sherrere D. Kapralos, Bill. ve Hogue, Andrew, A Serious Game for Incidence Response Education and Training, The Technology Collection, 178

⁷ Smith, Roger. (2009), A History of Serious Games, I/ITSEC 2009 Tutorial, 58

⁸ Ibid.

⁹ Ibid.

¹⁰ Smith, Roger. (2009), A History of Serious Games, I/ITSEC 2009 Tutorial, 58

¹¹ Raybourn, Elaine. Smith, Peter. (1961) Global Force Serious Gaming: History, Theory, Pedagogy & Military Application, 7

¹² Raybourn, Elaine. Smith, Peter. (1961) Global Force Serious Gaming: History, Theory, Pedagogy & Military Application, 8

¹³ Djaouti, Damien. Alvarez, Julian. Jessel, Jean-Pierre. Rampnoux, Olivier. (2011) Origins of Serious Games, 2

¹⁴ Djaouti, Damien. Alvarez, Julian. Jessel, Jean-Pierre. Rampnoux, Olivier. (2011) Origins of Serious Games, 6

¹⁵ Raybourn, Elaine. Smith, Peter. 1961 Global Force Serious Gaming: History, Theory, Pedagogy, and Military Application, 11

¹⁶ Raybourn, Elaine. Smith, Peter. Global Force Serious Gaming: History, Theory, Pedagogy, and Military Application, 12

¹⁷ Smith, Roger. (2009), A History of Serious Games, I/ITSEC 2009 Tutorial, 69

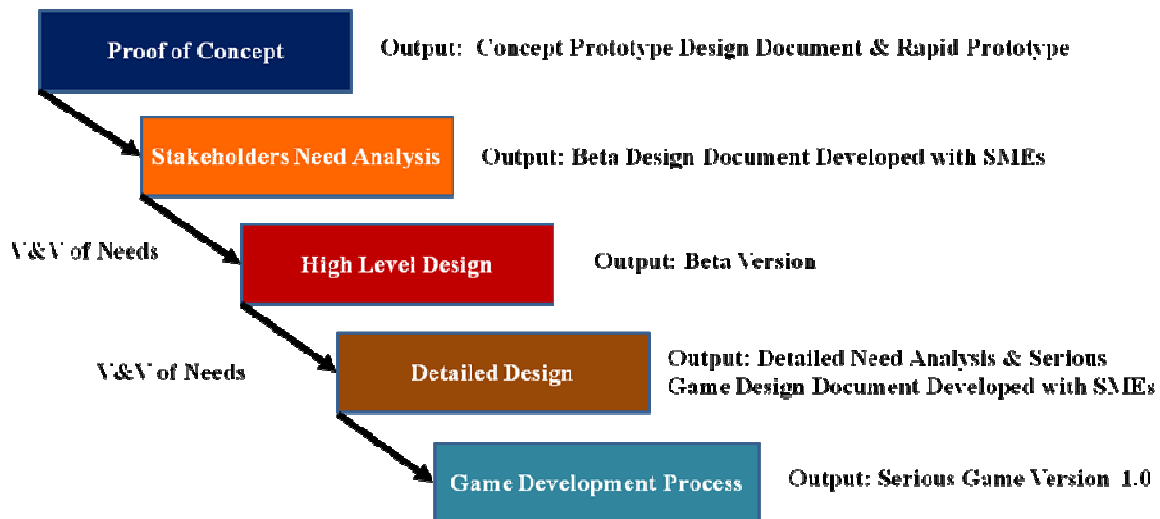
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created versions according to the characteristics of not only directed to specific tasks and areas of expertise.

3.0 COMBINING SYSTEM ENGINEERING PROCESSES WITH GAME DESIGN & DEVELOPMENT PROCESS

By including subject matter experts during need analysis phase creates a simultaneous opportunity to validate the needs as it has been developed. One of the contradictions with SE processes with game development is, SE waits for the complication of the product to start the verification phase.¹⁹ While in game development constant verification is the key element on a successful game launch.²⁰ Game developers have noticed some aspects of game mechanics cannot be captured on paper.²¹ Therefore they have started to use design documents as means of keeping them grounded and enable for version tracking and justification features as well as forming the story elements.²² Therefore game development is a build oriented and iteration based system.²³ In order to combine both, during the concept design phase a prototype was developed and shown to the leadership of Turkish Armed Forces Academy as well as tested by various end user groups.

As for the high level design another version was developed but this time with the lessons learned from the prototype, this new build was considered as beta version. This Beta version was also demonstrated and tested; this created a great opportunity to validate the system from very early stage of development. Thus testing out ideas and functions were checked before any great funds were committed. With this method by the end of high level design and before detailed design many of the functions, mechanics and assumption were validated and verified. The flow chart for the first part of the combination of two methodologies is given in Figure 2. The flowchart shows how this new method is integrated with the classic system engineering approach.



¹⁸ Raybourn, Elaine. Smith, Peter. 1961 Global Force Serious Gaming: History, Theory, Pedagogy, and Military Application, 11

¹⁹ Yu, Eric SK. "Towards modelling and reasoning support for early-phase requirements engineering." Requirements Engineering, 1997., Proceedings of the Third IEEE International Symposium on. IEEE, 1997

²⁰ Moreno-Ger, Pablo, et al. "A documental approach to adventure game development." Science of Computer Programming 67.1 (2007): 3-31.

²¹ Ibid.

²² Ibid.

²³ Cockburn, Alistair. Agile software development: the cooperative game. Pearson Education, 2006.

Figure 2: Serious Game Iteration Based Development Methodology-1

The first step in this methodology is to provide a proof of concept. This is like a pre-feasibility study to show stakeholders how the serious game concept is beneficial. The Concept Prototype Design Document and Rapid Prototype must be delivered at this phase. The Concept Prototype Design Document must have the following sections.

- Game Mechanics
- Environment Design
- Scenario Design
- User Control Interface
- Sound and Effects

Stakeholder Need Analysis must be done after the rapid prototype developed. Then Beta Design Document must be prepared. The sections in Concept Prototype Design (CPD) Document will be expanded and more clarified in Beta Design (BD) Document. The following additional sections will also be included in BD Document.

- Game Features
- Graphic Models
- After Action Review.

To show the difference between the levels of details in terms of information in two design documents, “**Game Mechanics**” section was presented as an example below. Game mechanics section of CPD Document includes the following items;

- In game character tracker camera has to move.
- Character movement animation will not be modeled
- In certain points on the map certain audio files will be played
- Audio files will be activated when the user find a IED indicator
- If a character activates an IED, there will be explosion and the screen will turn black

“**Game Mechanics**” section of Beta Design Document includes the following items;

- Character movements will be modeled
- Users will be able to see 15 and 25 meters’ transparent sphere
- Focused looked will be modeled: User will be able to activate a small zoom ability
- In game mission map
- Dummy IED detonator attackers will be hidden in the map in order to keep the players vigilant
- In the case of an explosion a real life IED events photo will be displayed
- Users will be able to choose roles upon entering the game
- Remote control IEDs will not detonate under the jammers effect radius
- Jammer personnel will be able to see the jammers effect radius
- Detector personnel
- If the detector moves above an IED it will make a warning voice
- User will be able to mark the IEDs location

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- Different Types of IEDs
- Mines: Does not get affected by jammers
- Remote controlled IEDs: Does not explode under the jammers effect radius

The next phases are High Level Design and Detail Design. Beta Version will be developed at the end of the High Level Design. Detailed Need Analysis and Serious Game Design Document with Subject Matter Experts must be prepared after the Detailed Design. The final stage in this first part of the methodology is to implement Game Development Process. Serious Game Version 1.0 must be developed after this process. The systems engineering stage that follows the detailed design stage is believed to closely influence the success of the project. However, as in the design process, the systems engineering steps need to be combined with the game development process, as opposed to direct stand alone application. Game Development Process is an iterative process that targets only the build version. The game development process is presented in Figure 3.

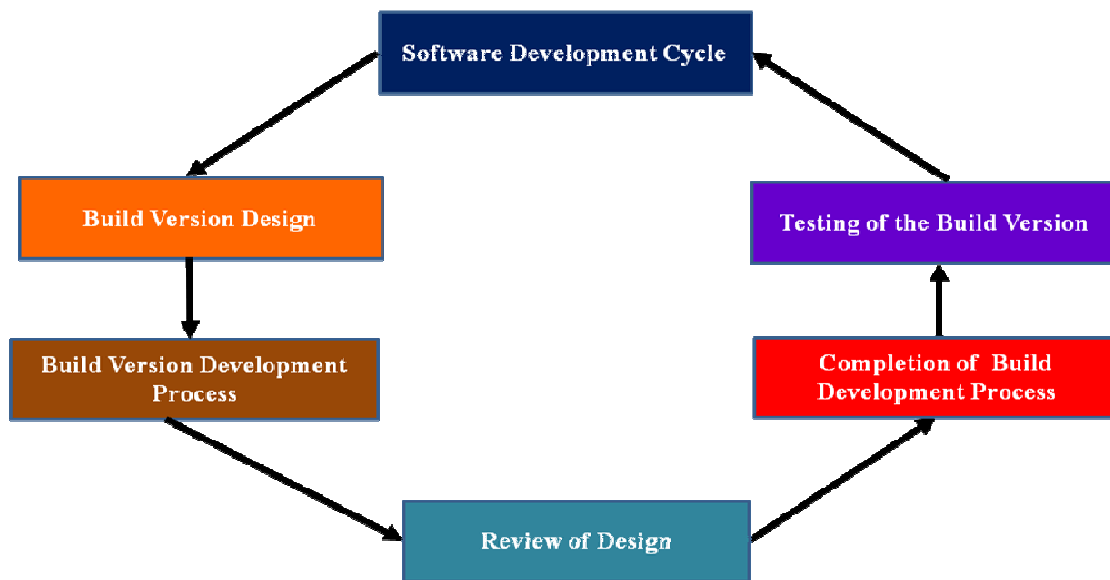


Figure 3: Game Development Process.

During the game development process, intermediate versions are designated based on milestones in the design document. In **Build Version Design** phase;

- Test results of the previous version are examined from the field expert, end-user and customer perspectives at the 1st Meeting.
- Next version is planned based on the detailed design and added function is determined at the 2nd Design Meeting.
- Development plan is created and priorities are determined at the 3rd Meeting.
- Development team reviews the plans; sub-plans are created. Possible problems are identified at the 4th Meeting.
- Review of the plans and issues of project development teams are considered by management at the 5th Meeting.
- Resolution of the problems will initiate the development process again.

In **Review of Design** phase;

- Development process is reviewed, the final version is examined, changes and solutions are finalized at the Review Meeting
- Development teams review the decisions internally at the 2nd Meeting.
- Plans and issues of project development teams are reviewed by management at the 3rd Meeting.

After the implementation of Game Development Process, the development process of the version will be completed. The stakeholders will test the coming version to validate the developed version of the serious game. Whenever possible, or in intermediate versions appear, testing by end users and by the clients or potential clients must be accomplished. After all, the game will be in use, maintenance must be provided and patches must be developed when it is required. The following flowchart in Figure 4 shows iterative based serious game development methodology by including right hand side of methodology.

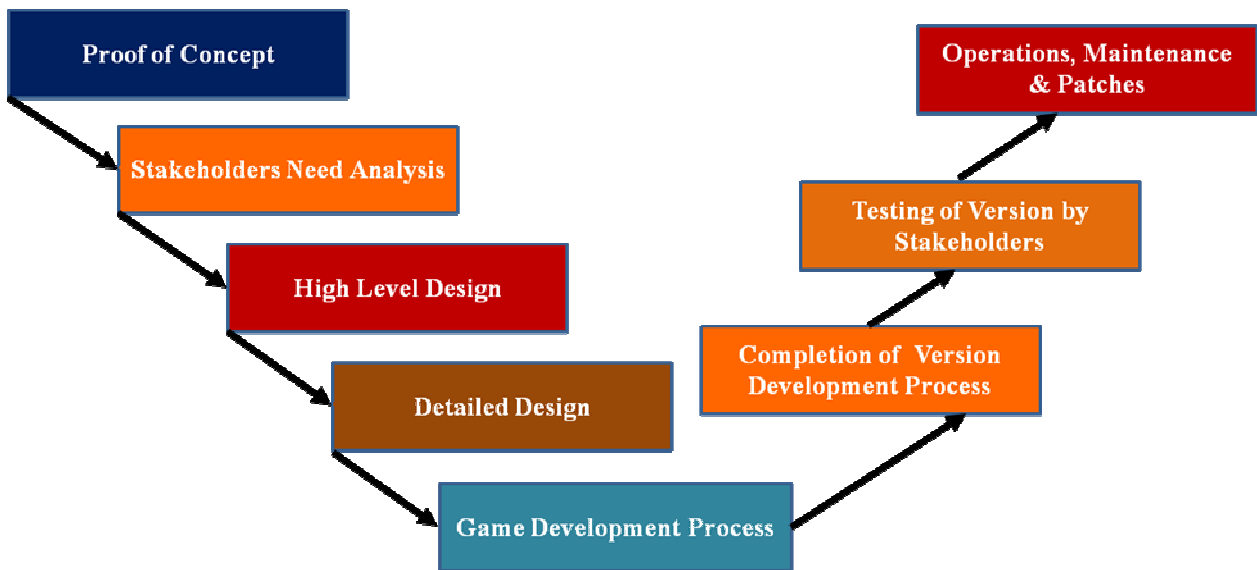


Figure 4: Serious Game Iteration Based Development Methodology-2

4.0 C-IED SERIOUS GAME DESIGN

Experience from prototype and the beta version indicated, detailed design should be based on five main need topics; (I) C-IED training requirements, (II) performance and work environment requirements, (III) instructor's module requirements, (IV) after action review module requirements, (V) scenario development module.

4.1. Counter IED Training Requirements

In order to capture requirements two main field manuals was used. Further Training and Doctrine Command IED lessons learned magazines, Distant Training Center training videos and interviews with subject matter experts were used. System engineering processes were used for need and requirement analysis.²⁴ Below the list of requirement topics for counter IED training can be seen;

²⁴ Yildiz A. Emrah, Developing Serious Game with System Engineering Approach Within the Scope of Struggle Against Improvised Explosive Device During Movement Towards Team-Level Units: Needs and Requirement Analysis, MSc Thesis, Turkish Military Academy Defence Sciences Institute, 2016.

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- a. Possible locations for IED placement
 - Open fields
 - Forests
 - Rocky terrains
 - Military positions
 - Water sources and river surroundings
 - Corpses
 - Caves surroundings, entrance and interiors
 - Roads
 - Urban Areas
- b. Possible reference points for the IED detonators
- c. Recognizing signs for IED and mines
- d. Preparation procedures for small squad operations
 - Personnel procedures
 - Equipment procedures
- e. Procedures for on foot small squad operation
- f. Procedures for dangerous territory crossing during on foot small squad operation
 - Roads and rivers that cuts the operation routes vertically
 - Moving up the high points
 - Routes or pathways that allow movement on steep slopes
 - Crossing valleys, narrow passes, breaches
 - Forest and bush fields and surrounding environment
 - Narrow cliff routes
- g. Preparation procedures for small squad winter operations
- h. Procedures moving in a suspected IED zone and reactions to identified IED threat during on foot small squad operation
- i. Procedures after and IED attack
- j. Counter IED procedures during occupation of a temporary field base
- k. Preparation procedures before a motorized operation
- l. Counter IED tactics during a motorized operation
- m. Procedures for suspected IED zones and after an IED threat is identified during a motorized operation
- n. Procedures after and IED attack motorized operation
- o. Procedures acting against road blocks and crossing danger zones
 - Crossing valleys, narrow passes and tunnels
 - Road blocked by trees
 - Rocks and piles of earth
 - Roads blocked by herds

- Road side cars that are trying to flag down help
- Vehicle break downs and failures
- Security during breaks
- Precautions and procedures during motorized night operation

4.2. Performance & Work Environment Requirements

Military education systems and training hardware environments needs to be especially cost effective for widespread adoption. Furthermore, it is imperative that the system is portable and can easily be installed; and that it will run on hardware already in inventory or hardware that can be purchased within the allocated budget. The system should also be able to work independently and isolated from the existing military network for information security.²⁵

- The developed system needs to be able to run at 30 fps in a machine with the following specifications:
- 8 GB or more RAM
- Intel i7 or equivalent, 2.2 GHz processors with higher core speed
- Nvidia GT 770 graphics card or equivalent
- A monitor 17 inches or greater in size, supporting at least 1920 x 1080 resolution
- The developed system must be able to work well in notebook systems with the features mentioned above.
- The developed system must be able to support multiplayer via a local area network. It will not require an Internet connection.

4.3. Instructor Module Requirements

Instructor module requirements are listed below:

- Must have the ability to select a scenario, and stop or pause the script.
- Must support video capture.
- The training session should allow spectators.
- Must be able to change weather conditions in real time.

4.4. After Action Review (AAR) Module Requirements

4.4.1 Central Database Requirements for After Action Review

Central database requirements for after action review are listed below:

- In order for the data to be transmitted without an Internet connection, the database will be able to compile the output from local AAR modules.
- Central AAR module will store all data regarding user training.
- Central AAR module will provide digital output for user data.

4.4.2. Requirements for AAR Module Connected to Serious Game

Requirements for AAR module connected to serious game are listed below:

- Will record performance metrics and statistics for each user in real time
- Will record training metrics and parameters in real time

²⁵ Capli L. Berke, Developing Serious Game with System Engineering Approach Within The Scope of Struggle Against Improvised Explosive Device During Movement Towards Team-Level Units: Detail Design, MSc Thesis, Turkish Military Academy Defence Sciences Institute, 2016.

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- Will provide digital output to the central database after each training session.

4.5. Scenario Development Module Requirements

Tactics of asymmetrical warfare change almost daily. Keeping the training subjects up-to-date is the main problem when it comes to asymmetrical warfare. That was the main reasons why an IED serious game was considered as an effective training tool. Therefore it was very important that the developed serious game would have scenario development capabilities which provide enabling rapid change and high adaptability.

Using a game engine for level design gave us the opportunity for a scenario development toolkit. Rather than developing our own game engine we chose to use Unity 3D game engine as an off the self commercial software. There were several reasons behind this decision. **First**, Unity 3D is optimized to gaming needs thus it was a very cost efficient solution. **Second**, prototyping and adaptability was made possible by Unity 3D's scenario mode. **Third**, Unity 3D community supplied a strong problem solving tool thus helping with the development process. **Fourth**, Unity asset store was curial in obtaining high quality and realistic graphic packages with low costs, where as developing each one would take large graphic design team a long time.

Due to the fact that no simulation computation was used and the game and multiplayer functions where limited to any other first person shooter game, Unity 3D served as a great facilitator thus enabling the development team for the Beta version to remain at one graphic designer and software engineer.

For a successful scenario development toolkit for the IED serious game's beta version, game elements such as terrain, IED places and area of trigger, jammer area of influence, starting points, number and places of IED indicators had to be adaptable and changeable. With the help of Unity scenario mode and adaptability achieved with key game elements even from the beta stage we were able to achieve powerful scenario development toolkit.

5.0 CONCLUSION

A serious game for small unit counter improvised explosive devices awareness training was developed by two master studies that were accomplished in Defence Sciences Institute of Turkish Military Academy. During the development process there are three parties involved armed forces as customer, trainees as end users and IED experts as subject matter experts.

We had three squads with previous IED training, as well as squads that have served in the field and encountered IED attacks test the BETA version of the serious game. For the purpose of the test, real life IED attacks were integrated within the scenario and user's reaction were tested for the purpose of fidelity. Secondly a questionnaire was given to the participants to measure the effectiveness of the training course. Positive results and future suggestions were given by the users.

System Engineering methods were decided to use during the development process. Though this is the case to incorporate game development processes a new method of serious game development mixed with system engineering process were tired.

In this paper nature of this new method and lessons learned from the development and test of the prototype and a beta version will be discussed. Verification and validation studies with this beta version proved that serious game will be one of the cost efficient tools for training purposes.