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Facing the Challenges of the Globalizing World with the Use of Simulation and Gaming

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SUPERVISOR: A 3D SERIOUS GAME FOR HAZARD RECOGNITION TRAINING IN THE OIL INDUSTRY

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ABSTRACT

Hazard recognition in the oil industry is a key aspect to ensure safety at production and downstream work sites. This paper introduces a Proof of Concept for a Hazard Recognition Game built for one of the major oil companies. The POC should be a playable game that shows how static, complex as well as evolving (tripod) hazards could be represented in a first-person 3D game. For the oil company, the POC played an important role to steer and level the discussions about games for the learning portfolio. In short, the main high-level managers were convinced of the potential value. The decision to invest in the next pilot phase was based upon the success of the POC. The main sources of value identified include commissioning of new work practices, training for a new site under construction, and a possibility to avoid travelling costs for training when the game can run on generic hardware.

1. INTRODUCTION

The oil industry faces a massive training challenge with respect to safety and hazard recognition. A younger generation is growing up with different learning environments and experienced staff is retiring. Recent issues in the Gulf of Mexico, as well as the response in the world market when a facility has to cease operations make training even more mission-critical than it used to be. Currently, about 80% of relevant training is done in a classroom setting, supplemented by 20% e-learning. For a major oil company we built a 3D simulation environment to test the assumption that hazard recognition could be learned in a serious game. The current paper describes the design of the serious game, as well as the interaction and refinement over multiple versions of the serious game, making the design match the corporate standards and worldwide instruction set.

Refineries have high standards when it comes to safety; in many cases the standards are higher than obliged by government agencies, as most companies follow the American Petroleum Institute (API, 2011) regulations. The fact that the regulations are in place does not mean that they are justly reinforced or that the implementation is suitable.

The rationale for going to a 3D first-person game is found in the analysis of challenges in the specific company. Most accidents do not occur because of static failures but from process failures that could have been prevented when the correct way of operating had been followed. Classroom training and the current e-learning approaches in the company address these issues by describing the process and providing static (photorealistic and iconic) visualizations, using PowerPoint slides, short movies and photo books. A serious game would ideally enhance this type of learning with activity from the player/participant in the first person. This addition would ideally match the more widespread activities in emergency response and relief services training that have been widely documented.

2. THE CHALLENGE

At a large Dutch oil company, the learning innovation department received internal requests and a market push to adopt serious gaming in their curricula. A body of knowledge and focal point needed to be created to circumvent proliferation of serious gaming initiatives within the company and to be able to internally advise in this domain. Overarching companywide safety programs provided insight in some of the online learning and safety trainings classes that were not yielding the results intended and therefore immediately provided direction for serious gaming opportunities. Within the projects department some larger projects funded small interactive 3D visualizations but this was neither generic nor validated. Buying of the shelf serious games was out of the question because they were not available according to the specifics of the company.

The Delft University of Technology was approached to, as a first phase; create a proof-of-concept (POC) that shows the use of serious gaming to the learning department and adapts gaming technology to fit into the online course strategy. Our oil company, like many other large companies, has online course material to train and teach their own and third party personnel. Delft University of Technology (DUT) assembled a team, together with the learning department of the company to formulate the POC and to serve as a development team.

3. PROJECT ORGANISATION

Building a game that matches the expectations and responsibilities of the learning organization in a high-risk, high-profile organization like the oil company could not be done by game designers alone. The company assigned three main positions to the project team, this being an innovation manager, a learning designer, and an ICT development pioneer. The innovation manager was appointed to guide the process of the implementation of serious gaming in the learning portfolio in a managerial and facilitation role. ICT was added to look for internal technical solutions that would help in implementation in the ICT infrastructure and the learning designer functioned as a reference board for current developments and initiatives in learning. DUT assigned three main positions too, being an associate professor on the broad perspective of serious gaming, a methodological game researcher and a graphical engine and technology researcher. This team discussed on a weekly basis the content of the serious game and progress.

The main goal of the POC was to show, to likely internal clients (sponsors), the possibilities and capabilities of serious gaming in alignment with the wishes of the learning department. To be able to get a go ahead for future expansion the project team had to find and convince new sponsors.

4. REQUIREMENTS FOR THE POC

Initially, there were five overarching guidelines that the POC was to satisfy:

- First person perspective in a 3D environment.
- A means to measure the performance of the user.
- The environment should reflect and be recognizable as a real world company facility.
- Hazard recognition had to be the domain.
- A tripod analysis should appear.

The first target participants are supervisors and 'persons in charge' at a work facility site of the oil company. This is the group that holds daily responsibility for safety and whose direct interventions can really make a difference in avoiding hazards. By default, supervisors work for the oil company. In addition to the supervisors, the POC should be playable by contractors who have to adhere to the same basic training of the oil company before they are allowed to work on a site.

Because of the characteristics of the target participants (usually aged between 40 and 50), the first person computer game is not the most logical choice for training. Generally, these people have little to no 3D gaming experience. The POC had to be playable for them.

In the real world, supervisors have to be familiar with; site introductions, job safety analysis and toolbox meetings, safety leadership programs, safety meetings, safety audits, work permits, amongst other topics. Putting in scenarios for all related topics that supervisors have to cope with was not considered necessary by the client and would be too much for a POC. In the scenario section we describe what was considered necessary and has been put in to the game.

5. HAZARD RECOGNITION

Hazard recognition is the identification of safety and health hazard types associated with a given job task. Hazard recognition is predominantly a consideration to operations. There is widespread attention paid to in literature on learning for perceptual skills in situations with a lot of tacit knowledge.

Kowalski-Trakofler and Barrett (2003), who worked on hazard recognition in mining, pose that in order to respond appropriately to danger from potential mine hazards, an individual must perform the following:

1. Detection of sensory cues: Detect the presence of potentially relevant sensory cues or features in the environment. In terms of signal detection theory, the hazard "signal" must be discriminated from the extraneous "noise" of operations.
2. Attentional selection: Selectively attend to a subset of those features either overtly or in an automatic fashion, favoring them with further processing. The amounts of sensory input that can be attended to will generally be limited by the automaticity with which the observer is functioning, the ability of the observer to time-share cognitive resources between tasks, and the mental workload experienced.
3. Recognition of the hazard: Correctly recognize the pattern of features that identify a particular hazard. Experience or training provides the information that cues have been differentially associated with the presence of hazards in the past and thus are "diagnostic" of that hazard.
4. Confirm or disconfirm the hazard: Test the initial hypothesis of the recognition or denial of a hazard by searching further for confirming or disconfirming evidence, the search being guided by some mental

representation or schema of the nature of the hazard and the general environment.

5. Select appropriate response: Consider and select an appropriate response to identified hazards. To a certain extent this depends upon the subjective evaluation of risk by the observer – simply because a potentially hazardous condition has been identified does not mean that the observer views it as a personal threat that compels avoidance. Objective danger does not always elicit an appropriate response if there is no personal, subjective assessment of danger (Benda and Hoyos, 1983).

Detection of sensory cues

↓

Attentional selection

↓

Recognition of the hazard

↓

Confirmation of the hazard

↓

Select Appropriate **Response**

Figure 1. Model of hazard recognition

Source: Kowalski-Trakofler and Barrett (2003).

In the world of virtual training environments for hazard recognition, multiple authors created related work. The previously discussed Kowalski-Trakofler and Barrett (2003) used degraded images of hazards to train mine workers and found very positive effects on the number of accidents. For our work this means that slightly less than photo-realistic representation of hazard in a 3D game will be sufficient to ensure people learn. Mayhew and Simpson (2002) proved that education/training programs for hazard recognition in driving might prove to be effective in reducing collisions if they are more empirically based, addressing critical age and experience related factors. Fisher et al. (2006) developed and tested such a PC program and found that PC based training really improves the hazard recognition skills of 16 / 17 year old drivers. Filigenzi et al. (2010) developed virtual reality training software using the Unreal engine for mine evacuation and procedure training. Their work differs from ours in the setting (open space versus a mine) and the modularity and integration with the learning portfolio in a real oil company. Filigenzi et al. (2010) believes that by developing realistic, affordable VR training software, miners will be able to receive accurate training in hazard recognition and avoidance. In addition, the VR software will allow miners to follow mine evacuation routes and safe procedures without exposing themselves to real-world danger. The increasing popularity of VR based training for hazard recognition, Tichon (2007) notes that across a variety of operational environments, virtual reality (VR) is being increasingly used as a means of simulating hazardous work conditions in order to allow trainees to practice advanced cognitive skills such as problem-solving and decision-making.

While the number of training prototypes increase less focus is being given to appropriate evaluation of the training provided via this technology. Increasing skills acquisition and performance does not depend solely on the appropriate design of simulation training. Of equal importance are strong performance measures which can ultimately give feedback on the success or otherwise of training and highlight any deficits to guide ongoing improvements. To ensure cognitive skills acquired in a virtual training environment (VTE) are transferable to the real world, training objectives need to be tied directly to realistic scenario events which in turn are directly linked to measures of specific required behaviors.

The finding of Tichon is similar to Gosen and Washbush (2004) who concluded after reviewing papers on learning in games that most evidence is from self-reports and not measuring actual learning results. The papers that do so tend to use a specific test setup, for which they become not comparable.

Our approach adds to this spectrum a case describing how we developed a prototype for a real client, with the purpose to show the value and convince internal stakeholders.

6. PROCESS

The project team met weekly outside the oil company. The weekly meetings were used for multiple purposes:

- Getting acquainted with the domain jargon of hazard recognition in the oil industry, specifically with regards to usability in our POC;
- Technical discussions for integration in the organization and aligning with current courseware;
- Planning and milestone discussions.

Getting acquainted with the domain jargon of hazard recognition functions in multiple ways, the researchers of the DUT needed to know the jargon of the company and the learning staff of the company needs specifics themselves as well. This resulted in 16 interviews within the organization. Interviewees on different responsibility levels within the organization were selected, ranging from the overall safety officer worldwide to the location manager of a training site. The interviews were arranged to accomplish multiple goals:

- Align the POC with current safety programs, and programs in the making.

- Learn specifics about the domain to create scenarios that are in line with the expectations
- Detect the most likely scenarios that fit the need of the company and set it apart from current training
- Educate the company staff in the possibilities of serious gaming
- Find internal company sponsors that would vote for the product and are willing to reserve time for further discussion.
- Prepare the company for future use of a serious gaming tool.

Technical discussions for integration in the organization were part of the weekly discussions too. Large organizations in general have strict IT rules to abode by, this was no exception. PowerPoint presentations or image sets are relatively small to distribute over an intranet in comparison to a 3D serious game. Even so, downloading the serious game for users was not the biggest issue, the minimal system specifications, the tracking of scores and the type of training asset were! Therefore technical sessions to open closed parts of the intranet, to use thin clients and sub networks such as geology were the topics of discussion.

Planning and milestone discussions were part of every meeting. For most of the meetings the milestones were aligned with "big boss" meetings at the company. The milestones changed over time, but the bigger milestones are as folllows:

1. 3D Reconstruction of the site
2. Interaction demo in 3D facility
3. Written scenario
4. First demo, proof of concept
5. Decisive scenario
6. Delivery of proof of concept and validation session

The entire project ran for approximately 1 year with periods of more and less intensity.

7. BUILDING THE REAL-WORLD FACILITY

To be able to prototype quickly, decisions on the engine and 3D data acquisition were first in line. Time constrains and budget hindered the possibility to build a serious game engine from scratch. Moreover, a leisure game engine does not differ from a serious game engine and commercial of the shelf (COTS) engines with advanced editors are available.

Requirements for a COTS engine reflect the initial overall requirements. 1) A distributable version should be possible for internal use 2) Capable of handling large 3D models with textures for a recognizable facility. 3) Networking capabilities to demonstrate logging of scores on a server. 4) Quickly adoptable by the development team. At the moment of choice the engine Unreal by EPIC (EPIC, 2010) fitted our purposes best because there was experience with the engine and the required capabilities were available.

Next, a digital copy of a real world facility had to be created to support hazard recognition scenarios. The team decided on a facility that was used for training and not in active production anymore. This paved the way for later comparisons with physical training could be conducted. There were three leads for source material, first, getting copies from 2D and 3D CAD data. Second, surveying the site for metric data i.e. tape measure, laser scanning or photogrammetry or thirdly, photographing the site to acquire indicative references. It appeared that because the facility was 30+ years old some old 2d drawing in A0 format where available that where not even up to date, because of that, we could use them only as indicative in the 3D modelling process. We did not use accurate surveying data because precision was not one of the demands only appearance was important. To build the 3D model, a group of 3D modellers, was sent to the site to acquire photographic material that could be used to digitally build the facility. Interviews with the site's manager and trainers already provided a list of possible hazards and guided in taking photographs of artefacts.

The facility was built with a level of detail (LOD) that would allow for discrepancies that are easily noticeable, i.e. if a hole in the ground sticks out because the LOD is much higher than the environment the riddle is easily solved. The client agreed on a LOD that was accepted by the people who train hazard recognition.

8. SCENARIOS FOR THE POC

To acquire scenarios various meetings with experts were arranged. Three types of hazards needed to be acquired. First, hazards standing on themselves that can be distributed around the scene. Second, hazards which evolve over time and can be used to add complexity to the recognition. Thirdly, tripod analysis hazards that can be used to show that many small mistakes summed up can cause greater disasters.

Every scenario starts with the selection of the right work clothes and personal safety equipment (PSE). The first person starts in the office and gets a message on the PC in front of him. Then he can walk to the room with clothes and PSE and has to select the right items (Figure 2). If he decides wrong, the door of the office won't open to go outside.

In the first 'explorer' scenario only the static hazards are present. They are a damaged fence, a leaking safety shower, a dropped fire extinguisher, a full gutter system, a misplaced barrel with chemicals, damaged scaffolding and an unsafely piled crate. Figure 3 shows the HSE report that the player can make to fulfil the last 2 steps of the Hazard Recognition framework from Figure 1.

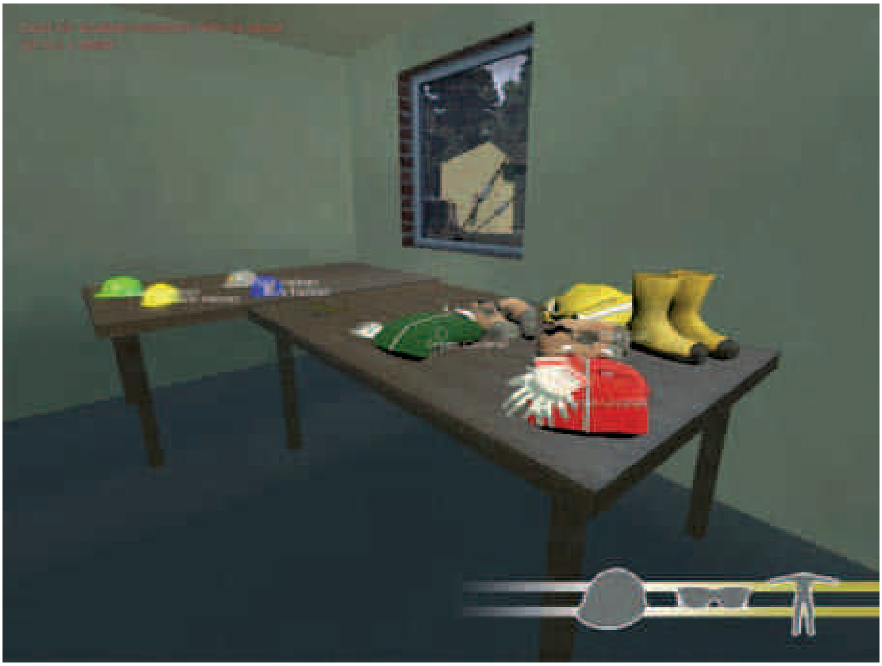

Figure 2. Room to select clothing and PSE

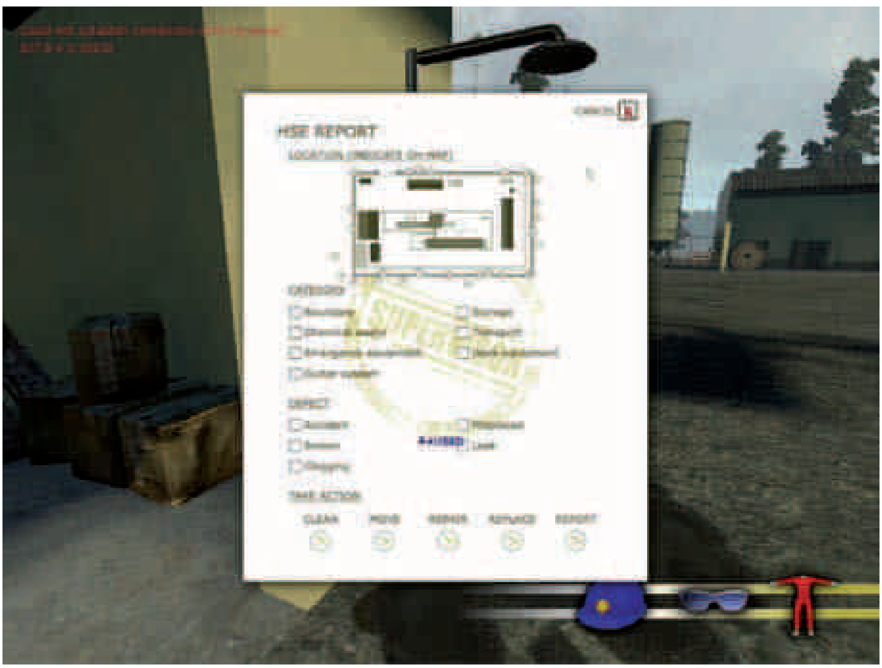

Figure 3. HSE report to correctly confirm the hazard and select a response

In the second scenario, both a complex hazard and a tripod hazard are added. In the complex hazard a truck arrives at the work site and starts unloading drill piping. If the supervisor does not pay sufficient attention, several events will occur resulting in either a pipe falling on a groundsman, or the complete tilting of the truck including the crane because of unsuspended side support stamps. Figure 4 shows the truck unloading pipes.

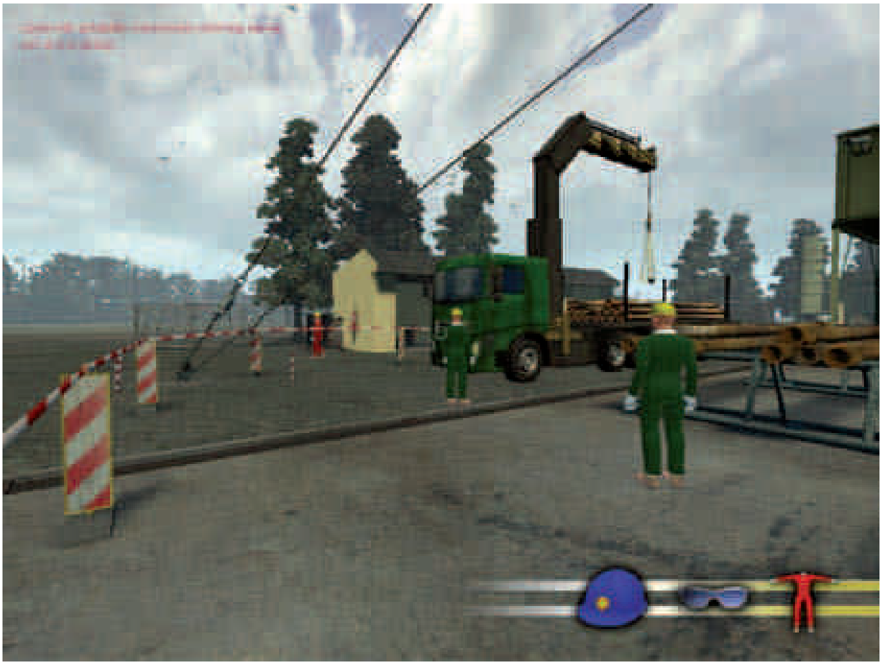

Figure 4. Truck unloading pipes in the complex hazard

Meanwhile a tripod hazard builds up. The damaged scaffolding is the workplace of a painter who comes to ask for a work permit. If the supervisor grants the permit he should pay attention to the weather clause. Halfway through the scenario it starts to rain. If the scaffolding is still damaged and the painter is not asked to stop his job an accident will occur, injuring the painter. Figure 5 shows the painter asking for a work permit.

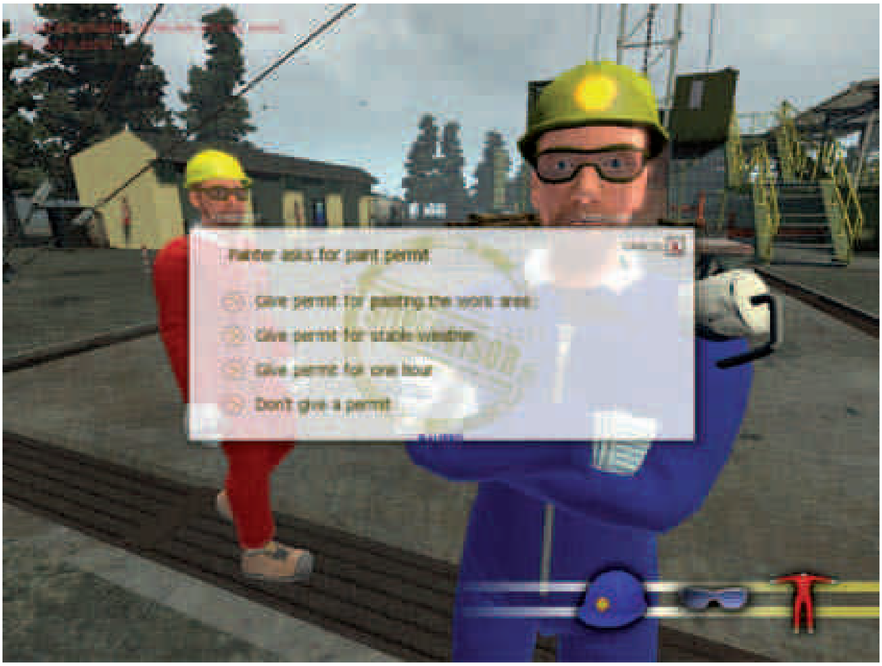

Figure 5. Painter asking for work permit

9. TECHNICAL IMPLEMENTATION

Implementing our scenarios and 3d content was straightforward, bringing up only two unforeseen challenges, one of a technical nature and one artistic. Because photographic material was used to create the 3D models and image projection was used to texture, the texture load became too heavy. A lot of textures had to be redone as tile-able and procedural textures. Furthermore the logging of scores proposed a technical challenge. During runtime of the game its less evident to provide other information that user location, damage etc. Some hacks where necessary to circumvent that problem. A custom webserver was created to, on a network to, keep track of who was playing and what his score was so it could be published for later use.

10. RESULT

The result of our effort was a POC in which a supervisor would be judged on multiple criteria, such as; was the supervisor able to detect static hazards, was he able to quickly respond to changes in planning on the site and could he oversee the consequences of multiple things going wrong resulting in something catastrophic. A bonus level was added related to recent toxic regulations.

10.1. Short serious game description

The serious game would start with a level to teach navigation for the staff that was not acquainted with 3D first person gaming. Following, the supervisor would log in and receive a status report written by the shift manager before him to explain the happenings of the day and the likely things to come. He would need to go onsite and inspect the site. This parts main purpose is for getting used to the site and finding defects. After five minutes, he is called back to the onsite office to receive instructions on the arrival of a truck bringing pipes, in this part the supervisor needs to be sharp on procedures during the offloading of pipes. Next the supervisor would be called back to the office because the weather is changing, because the conditions change he has to act accordingly.

The deliverable was a from DVD installable serious game that could be easily distributed. When connected to a network with a serious game server, a networked version of the game could be played. The results are logged and a score list of the participants is constantly updated.

10.2. Evaluation

The POC was evaluated during a midday session with 6 clients who could play the full version. Notes were kept during the session and speaking out loud un-purposely occured.

- Realism of the game was more than suitable for the purpose
- People that were used to 3D first person games quickly became bored because they were not kept busy enough.
- The potency of the concept to train people this way clearly took hold
- Participants that were less accustomed with 3D navigation and gaming principles clearly had more trouble to accomplish the task
- The stress to keep people under pressure was missed; there was a lack of pressure.
- A clear indicator of the progress that a participant makes is missed according to the more experienced users.
- The amount of distracting elements was considered too low, according to the experts, in real life there is much more to keep you occupied.

11. CONCLUSION

The POC delivered a working prototype of a serious game for hazard recognition in the oil industry. For the oil company, the POC played an important role to steer and level the discussions about games for the learning portfolio. In short, the main high-level managers were convinced of the potential value. The decision to invest in a next pilot phase was based upon the success of the POC. Main sources of value identified include commissioning of new work practices, training for a new site under construction, and a possibility to avoid travelling costs for training when the game can run on generic hardware.

On the design of the game we can conclude that validation of models and processes is crucial for acceptance at the skilled player level. However, we not always need people from the field to validate, as trainers from the company that facilitate hazard recognition sessions proved suited to detect ill-created 3D models in the 3D environment. If a valve was connected on the wrong location or a crane was turning in the wrong direction or missed his support they would point that out immediately.

The results from the POC guaranteed the next PILOT phase, in which the types of learning, the match between design parameters and learning outcomes and the best way of delivery will be researched. Delivery of the PILOT application to start this research is scheduled for the summer of 2011.

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