# AN APPROACH FOR CAPTURING PROJECT INFORMATION FOR THE DEVELOPMENT OF VIRTUAL REALITY TRAINING SCENARIOS

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*The new Advanced Construction Technologies (ACT-UK) centre in Coventry uses state of the art, innovative, virtual reality training in a simulated environment to train students and employees from the construction industry. However, before the training facility could become operational, it was necessary to collect as much information as possible from a specified construction project to help create scenarios to be used in the virtual reality training. Therefore, the approach used to capture the project information needed to be appropriate. It was the 'project monitors' role to obtain the necessary information by monitoring a construction project on a weekly basis. Data was collated in the form of photographs of the building during its construction and documentation from the site office was also collected so that trainees within the training centre could use it. In addition, the project-monitoring provided written descriptions of the activities that occurred during the construction of the building. The production of these activity sheets, which were used to help produce the virtual reality training scenarios, is outlined along with the data collection methodology. The success of the methodology undertaken is reviewed so that if the approach was to be replicated, for new virtual reality construction training scenarios, then the issues that the 'project monitor' encountered could be minimised.*

## 1  INTRODUCTION

The ACT-UK (Advanced Construction Technologies) project began in 2002 and opened for its first training course in September 2009. The centre is unique to the UK and is based on the virtual reality (VR) technology being used at the Building Management Simulation Centre (BMSC) in Leeuwarden in the Netherlands[1]. The centre aims to deliver situations that have all the pressures, issues and interruptions that are experienced on a real building site. The centre uses a form of 'semi-immersive' virtual reality simulation (VRS) as part of its training process where the users can feel as if they are in a scene and interact with actors as necessary[2]. It will offer learners a simulated learning environment based on the complexities of operating within a construction site. Within their 'site' huts, learners need to complete specific construction related tasks. Whilst undertaking these tasks, actors play a variety of roles that the construction manager would encounter during the day[3]. At the end of the training session the learner is able to review the process and discuss the consequences of the decisions that they undertook.

The simulated learning experience used within ACT-UK is based on two real construction projects, a domestic housing project and a city-centre commercial development. By basing the

simulated learning on two real projects, the overall aim of the centre, notably to make the training experience as close to reality as possible, is achieved. So that sufficient information could be obtained from each project to develop the VR and training scenarios, it was necessary to appoint specific people responsible for monitoring each project - the project monitor. The responsibility of the project monitor was therefore to monitor one of the designated construction sites and collate all the necessary data and descriptions of the construction activities that would be used to produce the VRS training. This paper outlines the project monitoring process of the commercial development, a speculative office development with commercial and retail accommodation at ground floor level. The building comprised of a curved 13-storey shoulder element and 15-storey tower within a tight city centre site.
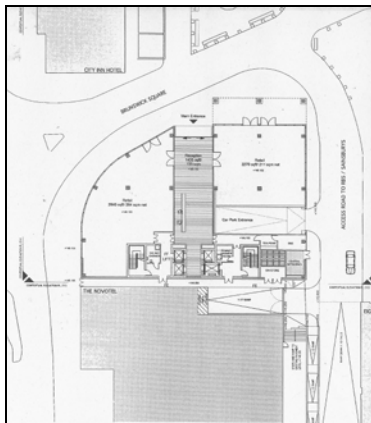
Figure 1: Site plan

Figure 2: View of completed building

The initial focus for the project monitor was taking photographs and collecting project site documentation. It was necessary to photograph the commercial building at every stage of construction so that a computer simulation of the site could be developed for the trainees to use during the training courses. In addition, the photographs were used to help describe the construction activities on site and therefore develop possible VR training scenarios. For this to be possible, it was necessary to visit the commercial site on a weekly basis to record the progress of the building photographically during its 18-month construction. These photographs were then used by a separate specialist company to make the 'simulation model' which is projected on to the large parabolic screen measuring 16m by 3m situated within the ACT-UK building. The trainees are able to use, and interact with, this simulation model, using a joystick to move through the building, along roads, inside rooms and on the scaffolding. This makes the trainees experience as close to reality as possible by enabling them to work, in essence, on a true construction. Whilst the VR computer simulation provides the context for the trainees, it is the site huts where the majority of training occurs. For the trainees to work in their site huts on VR training scenarios it was essential to provide all the necessary documentation that was in the original site huts for each project. The rational for this is that it provides the trainees with the necessary documentation when undertaking the VR training scenarios. It was therefore essential that the project monitor obtained the necessary information to allow this to be achieved. For these two processes to be successful, and provide the necessary documentation to produce the VRS, a clear methodology was developed for both processes.

## 2   TAKING OF PHOTOGRPAHS

The main focus for the project monitor was to take as many photographs as possible. The pictures needed to cover two broad aspects, the whole site and specific details. The photographs were supplemented with notes describing the photographs and associated construction activities. These were used to help write the construction activities which formed the basis of the VR training scenarios.

A clear process for taking the photographs needed to be devised that could be easily followed by all parties using the photographs and especially the specialist company responsible for producing the VR computer images.  The first stage in devising a suitable methodology was to visit the site. During the first visit it was evident that the compact nature of the site, as illustrated in the site plan, might have an impact on taking site photographs that showed the complete site. There was very little space around the site and not enough distance from which to photograph the entire site. The initial site meeting also allowed the plans for the building to be reviewed. It was necessary to study the plans to know what needed to be photographed and to also help in being able to describe the construction process being captured in the photograph and possibly developed into a VR training scenario.

### 2.1  General site photographs

The general site photographs needed to be taken in a logical manner. Following the review of the drawings undertaken during the initial site visit, the following methodology was identified:-

1.  External - views of the building from all neighbouring streets. This ensured that a complete $360^o$ view of the building could be seen and replicated in the VR.
2.  Main building – entry to the site was usually via the delivery yard. The reason for entering here was that it provided direct access to the basement and therefore the photographs started in the lowest part of the building and worked upwards through the various floor levels as they were constructed. For each floor level photographs were taken along the perimeter of the building showing views across the floor level. In addition, photographs were taken from the centre of the floor to give a $360^o$ view of the floor level being photographed.
3.  Aerial shots – where possible.

Initial visits, which started when the basement was being constructed, could be captured in around 100-150 photographs. However, as the building progressed, the number of photographs needed expanded to nearly 1000 photographs per visit. To help the users of the photographs distinguish between the different floor levels, a photograph was taken showing the specific floor level before starting to photograph each floor. This helped to compartmentalise the photographs into specific floor levels when being used to create the VR projection.

### 2.2  Detail photographs

The above methodology concentrates on views of the site and building whilst being constructed. However, to develop training scenarios for the simulation centre, specific problems and issues also needed to be recorded. As it was not possible to specify these beforehand, a clear methodology for taking them was not really possible. However an approach was developed. When visiting the site, and before undertaking any photographs of

that particular visit, the project monitor would meet with the site manager and discuss any issues that had arisen over the previous week. Then, when the general site photographs were being undertaken, any issues that had been identified during the informal meeting were also photographed. Crucial to the success of this approach was a good working relationship between the project monitor and the site manager. This needed to be developed early on so that information would be available to produce a complete record of the building.

## 2.3 Problems with photograph collection

The general photograph methodology outlined was a guide for taking the photographs to be used to help create the VRS. However, as with any methodology, it was not perfect. The methodology altered as the building progressed. Initially, during the basement construction, a lot of aerial photographs were possible from the site manager's office, which was raised on scaffolding above the external pavement. However, no external photographs were possible. When the structural frame of the building was complete external views were possible but no aerial views could be achieved. It was not always possible to enter the site from the delivery yard due to its constant use. In addition, as the construction process developed, it was not always possible to produce the same views each week. Therefore, the aim of the methodology was to try to replicate the views each week if possible, but also to acknowledge that, as the building progressed, the views might need to alter to accommodate the limitation of the construction site. However, for the benefit of the users of the photographs i.e. to create the computer VR and training scenarios, the main philosophy of the methodology was followed with as few alterations as possible to accommodate the changing building site. However, issues regarding the construction process arose in between the visits. To overcome this problem, a good rapport with the site manager was developed. The site manager was enthusiastic towards the project monitoring process and agreed to take photos in between the project monitoring visits of anything of importance to the simulation process. These were then downloaded on the weekly visit by the project monitor.

Having outlined the process for taking and recording the photographs, it is now necessary to look at the second initial aim of the project monitor role, the collection of all necessary documentation.

## 3   COLLECTION OF ALL THE DOCUMENTS IN RELATION TO THE SPECIFIC SITE

As previously outlined, for the simulation process to be fully effective, a full set of construction documents was needed. All documents were of interest and needed to be indexed. So that the simulation can be effective, it was also necessary to understand the relevant contractor's document management procedures. A complete set of all the documents/materials that were in the site hut were needed, including alterations as they happened. To aid the simulation process, it was also preferable to have all documents in a digital and paper format.

## 3.1 Approach for collecting project site documents

As with the photographs, a clear methodology needed to be developed for the collation of the documents. The first stage to the methodology was to meet with the Project Manager for the commercial project to discuss the documentation required. During this initial visit the

contractor agreed that it was possible to provide this information for the simulation process. The next stage was to understand the contractor's document management procedures. By understanding this process, a clear methodology for the collection of necessary documents could be arrived at. The Project Manager confirmed that the document management process used was to have all the documents for the project available for everyone to access by extranet. This would allow the relevant parties to have access to all the documents while the building was being constructed and, at the end of the construction process, create a 'paper free' set of documentation. With this management process understood, it was easier to create a documentation methodology. The original methodology planned before the meeting was to photocopy all of the documents at five points in time during the construction of the building. These five time points, or 'slices', were to linked to the five time slices that were to be used for creating the VR computer images. This photocopying process would have been time consuming and would have required the undertaking of more than just the project monitor. The revised methodology was to request access to parts of the contractors extranet so that the necessary documents, as previously outlined, could be obtained. The project manager in principle was happy with this. However, a proviso was stated that certain documentation would not be accessible due to their confidential nature in terms of finance. This was not unexpected. The use of the contractors extranet made the collection of the necessary documentation a simpler process than first imagined. However, the methodology was not without issues.

### 3.2  Problems with methodology

The first problem with the methodology was confirmation of the information. There was a requirement to have copies of the documentation at five points in time for the construction of the building. However, at these specific time points, it was not always possible to be sure that all the documentation produced had yet been downloaded on to the extranet. The decision was taken to download the documents at the given time points but also at the end of the project to revisit the documentation to see if different versions of documents, applicable to the various time slices, had subsequently been added. This raised two issues that seem to conflict but are valid. When revisiting the documents and looking through the various document versions, the amount of documents available was vast. This created the problem that it was not always easy to locate the necessary documents needed for the training scenarios. Extra help was needed other than the project monitor to go through the system to try and locate the required documentation. The second issue arose from the number of documents. It was not always possible to find the document needed for a training scenario, as it appeared that not all documents had been downloaded onto the extranet. The main documents on the extranet originated from the project office, which was located separately from the site office. It appeared that not all of the documents and files within the site office were scanned onto the extranet as had been previously advised. However, this issue only came to light after the site manager's office had been removed from site. It was therefore not possible to alter the methodology to include photocopying files within the site mangers office as well as using the companies extranet.

### 4   PROJECT MONITORING AND VR TRAINING SCENARIOS

Having captured the project information, it was then used by the specialist company to create the computer images and in the development of VR training scenarios. As the

generation of the computer images was undertaken by a separate specialist company it was mainly done separately to the development of the VR training scenarios. The starting point of the VR training scenario development was the production of construction activity sheets.

## 4.1  Activity sheets

The production of the activity sheets comprised of a number of different stages. The VR training scenarios used within the simulation centre are based on five key points in time during the monitored buildings construction, namely Substructure, Superstructure, First fit & M&E, Second fit & M&E, Commissioning and completion. Therefore, activity descriptions were produced according to the five time slices listed. The activity description sheets were produced as the starting point in the development of VR training scenarios. Having confirmed the overall stages that were to be captured in the five time slices, the master construction programme was reviewed to choose specific dates when the five main stages would be happening on site. These five time slices were vital in terms of the processes previously outlined, and the production of activity sheets. Having confirmed the five specific dates that these stages were to be monitored, a review of the possible construction activities that might occur on each of these five time slices was produced. This review was formalised into a general activity document outlining the possible construction activities on site for each of the five time slices, and covered in detail the following areas: -
1.  Key technical work activities on site (in form of brief headings)
2.  Who is on site and what are they doing? (Including the main contractor and, sub-contractors
3.  What visitors are there likely to be today and what is the purpose of their visit? (Including the main contractor, sub-contractor, clients team an professional advisors, suppliers and external)
4.  What preparation and organisational work is the site manager doing?
5.  Who does the site manager need to communicate with and what is the subject? (Including meetings, discussions on site, telephone conversations, written communications)
6.  What is the 'local flavour' or atmosphere like on site?

The general activity documents gave an overview of what could possibly be happening on site for each time slice and were produced using the specific construction programme and general construction knowledge of possible activities and roles that a site manager could be undertaking during each time slice. They were not meant to be fully accurate but gave a clear foundation of possible activity development.

The next stage in the activity sheet development required a meeting with the site manager to review the general activity document. It has to be commented at this stage that the site manager of the construction project was very enthusiastic about the project-monitoring role and was therefore willing to make time to discuss the activities that were taking place during the five time slices. The site manager would review the general activity document with the project monitor correcting any inaccuracies and providing further detail where required. During the first meeting, whilst reviewing section 1 "Who is on site and what are they doing?" the use of site manager's diary became vital to confirm the accuracy of the activities being undertaken on site. The decision was therefore taken that, during each weekly project monitoring visit, detailed notes from the site managers diary would be taken so that a complete picture of the activities that were taking place on site were captured. This enabled any vital activities that could be used for possible VR training scenarios were captured outside

of the five main time slice dates. In addition, the site manager's diary was used to refine the general activity documents before meeting with the site manager.

Reviewing the general activity document with the site manager allowed an accurate picture of the construction activities taking place around the specific time slice to be obtained. This then needed to be turned into specific activity description sheets, which were to be used to write the specific VR training scenarios. However, before these could be produced a full analysis of the revised general activity document had to be undertaken. This analysis focused on listing the activities taking place in a chronological order. When complex activities were listed these were broken down into further sub-activities so that a comprehensive and detailed list of all the activities taking place on site had been produced. For the first time slice, the analysis of the general activity document produced around 20 activities taking place. This rose to over 40 for time slice three to five. In all, over 187 major activities were listed from the five time slices.

Having produced the chronological list of activities, following the analysis of the general activity document, the individual activity description sheets could be produced. These activity sheets used a standardised template that linked with the writing of the VR training scenarios.

The first section of the activity sheet outlined basic information including the activity number, the specific time slice, the week beginning and the title of specific activity description. This information was used to cross reference to the VR training scenario sheets. To help in identifying the activity being described, photographs were included in the title of the specific activity description. These were taken from the weekly photographs previously outlined.

The second section of the form concentrated on the people and process. The people involved with the activity were identified from the main contractor and sub-contractors in terms of manager, foreman or site operative and therefore indicated the possible number of people needed to simulate the VR training scenario. The process was where the main description of the activity took place and was divided into two sub-sections.

- The first sub-section concentrated on providing a clear description of the process being undertaken to complete the specific activity. It just provided the process and no other information.

- The second sub-section concentrated on the issues involved with the process previously described in the first sub-section. The issues identified any problems that had occurred in undertaking the process and highlighted both positive and negative issues. This was the main focus when reviewing the activity sheets to see if a viable VR training scenario could be developed.

The third section of the activity sheet focussed upon what competencies and outcomes the activity could be used to achieve in relation to the VR training. ACT-UK has looked at existing training programmes, professional qualifications and the views of industry. From this exercise, ACT-UK identified a list of competencies which it believes it can deliver: - Leadership; Understanding client needs and contract requirements; Planning and organisation; Monitoring and controlling performance; Problem solving & risk management; Team and people management and Communication. The activity sheets were therefore marked against the opportunity to demonstrate these competencies. If an activity sheet failed to match against any of the competencies, it was not developed into a VR training scenario. In addition to the possible competencies, ACT-UK has produced a set of outcomes that could be achieved from undertaking the VR training. These are: - Time; Quality; Cost; Information; Organisation and

Safety. Again, the activity sheets were marked against the possible outcomes that could be demonstrated. The competencies and outcomes when marked were rated using a level system of 0 to 5, with 5 being the highest possible chance of the competency or outcome being demonstrated by the activity. When each set of activity description sheets had been produced for each time slice, the data from the competencies and outcomes was transferred to a master activity competency and outcomes matrix sheet. This clearly showed which competencies and outcomes were possibly being achieved from the activity descriptions and the level of occurrence.

Having produced the activity sheets, they were comprehensively reviewed for their potential use in developing VR training scenarios. The process involved the scenario development team, which included the project monitor, industry consultants and a member from the BMSC, verbally reviewing the activity sheets. Naturally some activity sheets were easier to develop into VR training scenarios and it was not possible to convert each activity description sheet into a scenario. From the 187 activity sheets produced a total of 65 training scenarios were developed.

The scenario development forms cross reference to the activity forms initial information and description. The objectives for the scenario are outlined and refined competencies and control factors possible within the VR training scenario are highlighted. In addition, possible solutions/outcomes from the scenario are noted along with the number of people need to create the VR simulation. Finally, linking with the computer VR images, a note is outlined of any special requirements which might be needed within the computer VR.

Having produced the outline of the VR training scenario, the next stage was to act out the scenario. This was initially done within the scenario team and later to a wider industrial audience focus group for feedback and revision. During this process, a number of initial scenarios were not developed any further due to a variety of reasons ranging from staffing levels needed to undertake the scenario to the ability to achieve the specified competency and control factors. Having been reviewed the VR training scenarios were available to be included into bespoke training programmes.

## 5   RECOMMENDATIONS

Having outlined the role of the project monitor in terms of the photographic production, documentation collection and construction activity descriptions, it is important to draw key recommendations for if the process was to be repeated for the production of new VR for the simulation centre.

### 5.1  Co-operation of site staff

The willingness of the site staff to cooperate with the project monitor has a direct bearing on the number of possible VR training scenario produced. As recommendations, for future project monitoring roles, the following needs to be considered: -

- A good, friendly and informative relationship needs to be developed between the project monitor and the site manager for the chosen project. If this is achieved the flow of information regarding the particular site being monitored is easier to obtain.
- The project monitor needs to ensure that the process being undertaken does not threaten the site manager. It is the project monitor's role to discuss activities with the site manager

that could be used in VR training scenarios. However, it is also important for the site manager to have a veto over activities that have gone wrong.

## 5.2 Development of the methodology

The photographs and documentation collection methodology needs to be adaptable. Therefore, the following recommendations should be considered for any future project-monitoring role: -

- The photographic methodology needs to be constantly reviewed as the project develops and different construction trades start on site in the different areas to ensure the correct photographic data is being collated.
- The methodology for the documentation collection needs to be constantly reviewed to ensure that all the necessary documents are being collected for use in the VR training programmes.

## 5.3 Activity sheet production and VR training scenarios

The development of activities and subsequent VR training scenarios was contained within one development team. This benefitted the process of producing the VR training scenarios. Therefore, the following recommendations should be considered for any future project-monitoring role: -

- The project monitor needs to be the first person to produce the activity sheets due to the knowledge they accumulate concerning the project whilst undertaking the photographs and documentation collection.
- The project monitor needs to work closely with the scenario development team to help provide verbally any additional information that has not been covered within an activity sheet. This resulted in a number of small VR training scenarios that could be used in conjunction with the main VR simulation training scenario

If the above recommendations are followed then the collation of the necessary information should be easier for the project monitor, resulting in better VR training scenarios in the simulation centre.

The above recommendations should allow for the successful collection and production of clear activity information that can be developed into good VR training scenarios. However, this has to be balanced against the fact that it is not just the project monitor involved. The site manager from the site being monitored and a scenario development team were all required. As a consequence the hours required to develop the VR activity scenarios over an 18-month period were significant. The project monitor put in approximately 1 day a week over 18 months visiting the site at an approximate cost of £40,000 and over 275 hours developing the activity sheets. The level of hours required means that there was a major capital cost to ACT-UK in developing the VR training scenarios. This factor could possibly hinder the monitoring of more real-life construction projects to be used as training scenarios within ACT-UK.

## 6   CONCLUSION

The capturing of information for the development of VR training scenarios has been a fairly unique process due to the ACT-UK simulation centre being only the second in the world. The projects monitored for the development of the VR training were chosen by the centre to represent general construction sites. As the courses that the centre offers are bespoke

to the particular companies needs, then the need for more specific projects to be developed in VR might arise. However, this has to be balanced against the significant capital cost involved in just monitoring a project. In addition, the issues and recommendations that have arisen through the process need to be considered. A clear methodology needs to be developed for the collection of photographs and documents. However, these need to be constantly reviewed to ensure that they are producing the correct data. In addition, the success of the project monitor greatly benefits from a good working relationship between the project monitor and the site staff. Finally, regarding the production of the activity sheets, these greatly influence the production of good VR training scenarios.

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