Implementation of virtual reality in solving crime scene investigation

Reshiwaran Jegatheswaran
School of Computing
Asia Pacific University of Technology and Innovation (APU)
Kuala Lumpur, Malaysia
TP038338@mail.apu.edu.my

Chandra Reka Ramachandiran
School of Computing
Asia Pacific University of Technology and Innovation (APU)
Kuala Lumpur, Malaysia
chandra.reka@apu.edu.my

Julia Juremi
School of Computing,
Asia Pacific University of Technology and Innovation (APU)
Kuala Lumpur, Malaysia
julia.juremi@staffemail.apu.edu.my

Abstract*— In Malaysia, crime scene forensics animations are becoming an increasingly important visual aid in courtroom situations, where complex data relating to a sequence of events is being visualized before a general public who may have little or no understanding of established forensic procedure or methodology. This paper will introduce and discuss a spectrum of new technology that utilize new developments of Virtual Reality (VR) for a range of incident investigation and presentation scenarios. The process includes a framework that is used as a guideline on what needed to be followed to get all evidences to be accepted in the court room. In this paper, the specific objective would be supported with journals with elaboration. The journals would not be so specific to the topics, but they will be related in small portion. This is where the discussion of the objective is made. This will allow the users to understand the specific purpose of utilizing VR in crime scene investigation.

Keywords*—Virtual reality, crime scene, 3-D model, unreal engine, court room

I. INTRODUCTION

Virtual Reality has become a tool that would be used in the computer technologies in order to develop an environment that is simulated [1]. Basically, it's a software that could allow users to develop situations. This Virtual Reality is being developed mainly to be used on developing games. Virtual Reality has always been developed and this has been growing drastically. The Virtual Reality has is being developed drastically that nowadays the Virtual Reality has evolved into many fields of job. The reason of having the Virtual Reality is that it has provide many types of possibilities. For example, taking the architect past days they would need to draw and develop the buildings, roads, bridges and many more that is required by the clients. By drawing they would be able to see the issues that would arise in the future. This may consume the time and would be solved by having the Virtual Reality. By having it, the Virtual Reality would allow the architect to develop the plan in the computer and this could save more time as the computer would do half of his job as they would integrate with older plans to propose an outcome.

The Virtual Reality could also be classified as a lifesaver tool. This is because, this virtual reality could be used to discover any sort of issues and also to view new possible solution. Tomasz Mazuryk and Michael Gervautz stated that Virtual Reality begin its development in the late 1990's [2]. As is was developed it became more popular within the computer users. This could be due to a new tool to the era and gives companies to take more precaution steps on construction, gaming, and many more. Having the Virtual Reality in the Crime Scene Investigation would be useful and cost saving as the Virtual Reality would be used for after crime.

Chris Woodford displayed that Virtual Reality has provide the users in the Internet Era to experience many sorts of activity that would not be able to be done [3]. For example, Visiting the Mars is something that could not be done by everyone, but with this Virtual Reality the users would be able to visit the mars virtually.

The Virtual Reality started off as Sensorama in the 1950's. This is where a large booth which was designed to combine multiple technology to give one to four people the illusion of being in a 3d immersive world by having smell and stereo sound together [4]. Then they introduced, The Sword of Damocles in the year 1968. This is the actual first virtual reality that has head mounted display [4]. It can be said, it was being designed by a computer scientist named by Ivan Sutherland. This HMD was actually connected to a stereoscopic display from a computer that represent a simple virtual wireframe shape.

It moved passed on to several virtual reality such as the super cockpit in 1970's, The Aspen Movie Map in 1978, Saga VR in 1991, Enter Oculus in 2019 and lastly its Virtual reality. This virtual reality has become much famous and more useful compared to the others. According to the Franklin Institute the virtual reality was founded by Jaron Lanier. He was the one who worked on introducing the gears which include the googles and the gloves[5].

II. VIRTUAL REALITY IN CRIME SCENE INVESTIGATION

The presence of Virtual Reality in Crime Scene Investigation would eliminate a number of steps in the traditional investigation method. Although having the Virtual Reality in Crime Scene Investigation and eliminating certain number of steps but they will never eliminate the spinal cord of the investigation which is preservation, processing and reconstruct. The Virtual Reality would save up time consumption in the processing and reconstructing. This process would be done mainly by using the evidence that is captured and then preserving them.

Having the Virtual Reality in Crime Scene Investigation would mainly be similar to the process if Virtual Museum. T.P. Kersten, F. Tschirschwitz and S. Deggim has developed a Virtual Museum that would include 4D Presentation of History Building's [6]. Basically, they took the Old- Segeberg town house and developed a 3-D model. This would save up space and they could preserve the town house. This concept will be the best solution to take the Crime Scene Investigation

to another level. Investigators would be able to transform the Crime Scene into a 3-D model or a simulation that would allow the stakeholders to explore it on getting possible solution of how the Crime Scene took place.

Fig 1. displays a replica on having Virtual Reality in Crime Scene. Donna Robey stated that Unreal is a recommended tool that would work well as they are free and have good quality on the rendering engine [7]. Eventually the Fig.1 is being rendered by the Unreal engine. This would be used for the Virtual Reality. It can be said, a crime scene would most likely look as the Fig 1. There is presence of AI in the process of transmitting the Crime Scene into a simulation. We can see that the whole scene is being transformed into the Virtual Reality from bit to bit with the help of AI on scripting it in Unreal scripting language. The officers will need to input the images of the scene and with that the scripting will be begin and we can link this process to Image processing.

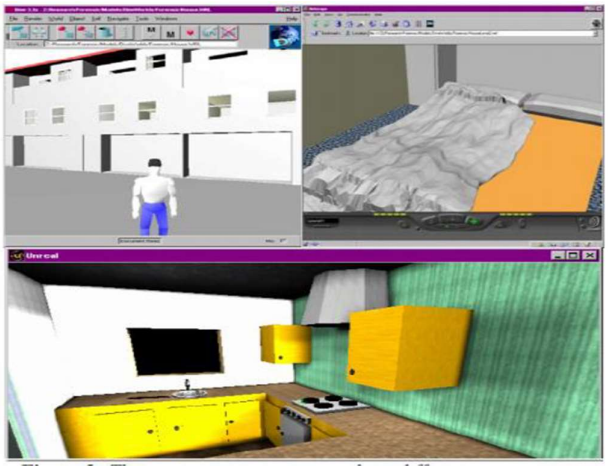

Fig. 1. The test Scenario using the Virtual Reality[7]

Figure 2 displays a window that runs the shell. This shell allows the investigator to investigate the case easily as the shell plays a role as an expert system that help investigator to discover hidden solution. The Expert System would be using the Limited Memory AI which observe from past case and it shall come out with possible outcome for the investigator. This would allow the investigator to set the proper situation being done which will allow them to get the right situation. After going through this stage then only they could get the proper and perfect Crime Scene in the Virtual Reality.

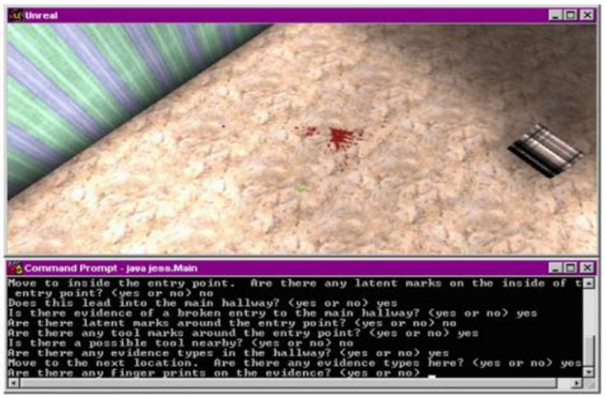

Fig. 2. The Expert system shell running in separate window[7]

Figure 3 display the final outcome after the scripting and expert system being used as a helper for the investigator. As we can see there will be sign indicating the evidence that has been incurred during the crime scene and it may be, and certain perspective would be recommended by the Expert system for the investigator to look into the case from a different angle.

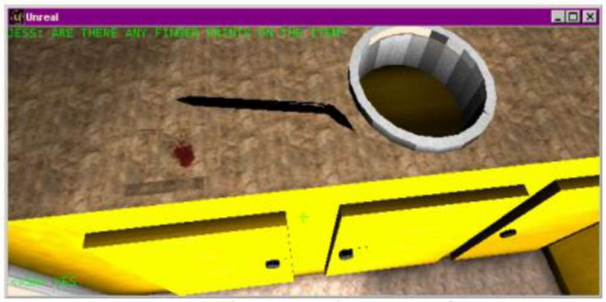

Fig. 3. The integrated system interface[7]

III. SIMULATION ON CRIME SCENE USING VIRTUAL REALITY

Xu Feng, Shan Daguo and Yang Hongchen developed a suitable simulation on crime scene based on the UDK [8]. The Unreal Development Kit (UDK) is being used to transmit the Crime Scene into a simulation. They also add on the 3-D reconstruction along with the Unreal Development Kit (UDK) to develop the simulation of the Crime Scene. The 3-D reconstruction plays a useful role of producing images into 3-D. This shall allow the Crime Scene Investigation to develop themselves from the traditional method.

Transforming the Crime Scene into a simulation would prevent any sort of evidence from being overseen. As a Crime Scene takes place the investigator will need to collect as many of evidence they could in a faster motion as they will need to clear the area of the crime. Due to this, there is high chances of the investigator of overseeing evidences. Having the transforming process would allow the investigator to view the scene as many as they would want in order to discover evidences.

A framework was developed for the Crime Scene Investigation. The Framework would begin with the Input of Data. This would be related to the images that is captured at the Crime Scene. This would be in an image based. It will be needed to be input into the virtual engine for them to configure accordingly. Secondly, they would move into loading data and building scenes. This means, the virtual engine will load the file and reconstruct the possible simulation.

Then, they would load the static model and the texture. This means, the virtual engine will load all the objects in the crime scene area that is input in a file into the virtual engine. Next, hardware initialization and software configuration. This means, simulation-channel is established, and the graphic pipeline is designated. Moreover, main simulation proceeding. At this moment the program will access the external I/O, or it may read the script file. The information would be altered according to the simulation events. The Virtual engine would also save the raw logs and the simulation information. Lastly, view rendering and display. This means, the programs would integrate with the functions and the result

will be sent to the display. Fig 4. below shows the flow chart of the framework for proceeding the simulation using the virtual reality.

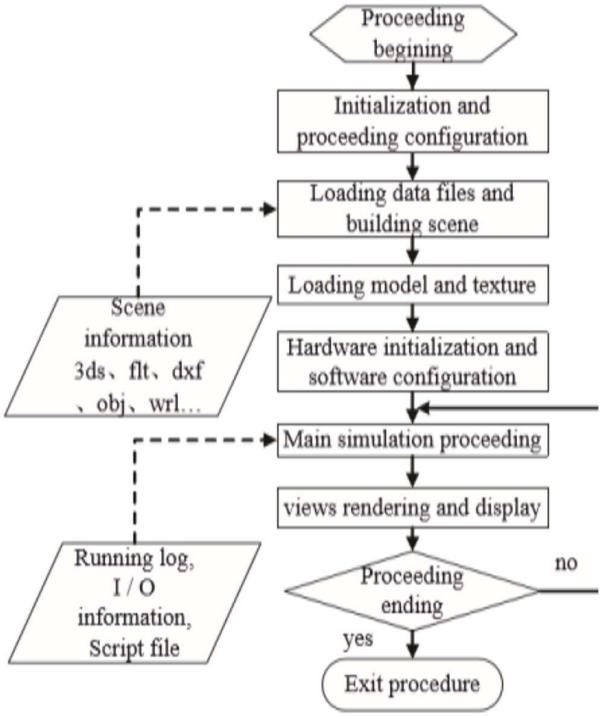

Fig. 4. The flow of virtual reality [8]

Prosecutor and judges would run the case based on the evidence and the witness testimony [9]. Eventually evidence and witness is not sufficient enough to solve a case in a professional manner. This is due to the evidence, as in every investigation the evidence that is collected would not be complete their checklist. This shows that out there at the Crime Scene the investigators would have missed out many minor evidences.

This evidence could also be transmitted into the simulation in the form of 3-D model along with the Crime Scene. Having the exact simulation would keep the case on its originality without any tempering.

The Swiss police has been generating 3-D models since 2004 for many kinds of Crime Scene by using their laser scan[10]. The 3-D model is being used to analyses and present the evidence in the court room. This 3-D model will be checked by the prosecutor and judges in order to investigate the case and learn what eventually happened. The simulation also allows the investigator to view the simulation from different angles and gain in dept knowledge of the case.

IV. USING VIRTUAL REALITY USED TO IMPROVE JUSTICE

In the Technology Magazine it has been stated that it is in order to improve the justice and support a fair judicial process it recommends on using the Virtual Reality as the Forensic tools[11]. Virtual realities bring some sort of improvement in the process of justice and it shall make the process of judicial to be easier and faster. This is an advantage that would prevent any sort of loophole and evidence from being overseen.

Firstly, revisit the crime scene. This means, by having the crime scene in virtual reality it allows the user to experience the scene as many times they want. This will allow them to learn the scene deeply and understand the scenario. This will also allow them to experience it when they want. If the scene were not in the virtual reality then, the investigator will only have one chance to examine the crime scene compared to the virtual reality simulation of the crime scene. For instance, by having the virtual reality simulation the investigator could be able to quickly and cost-effectively to go back to the crime scene. They could also walk through the scene as many times they want in order to prevent any overseen evidence.

Secondly, Collaboration. This means, the investigator could get help from the experts by having the virtual reality being shared. In some cases, the experts would not be available during the crime scene so they could collaborate during the virtual reality to seek advice from the experts. This would also allow the investigator to get more idea and also the investigator could get some idea from the criminal characteristic. This would also prevent any miss out steps. For instance, a murder took place in a motel and at that point of time their usual expert is not available, and he would be available after a week. The solution is by transforming the crime scene into virtual reality and it could be run with the expert when he or she are back. This will allow the expert to take their own time to learn and understand the case and advise the investigator to solve the case properly.

Next, Knowledge acquisition. This means, the judiciary and persecutor could learn the facts around the scene that is being investigated. This would also allow the judges to experience the genuine scene. This will allow both the prosecutor and the judge would also give them the knowledge on the case more detail as they do not just need to read the case, but they could see it. It can be said, seeing would give more understanding then reading. For instance, taking the petrol station murder the judge and the prosecutor of the case could visit the case using the virtual reality in order to understand the case in detail and they could work on giving a proper judgement and a fair judiciary.

Lastly, compliance. This means, these virtual reality simulations could not be tampered, and it will enable agencies to be better in observing, controlling and reporting on the investigation task. This also shows that, the case would be solved in a proper manner and not in a negative manor or consist of some shortcuts to solve the case.

Having these four aspects as an advantage would give a better future for the investigators and it may give them to solve more case in a faster time taken as this virtual reality could be seen again and again. This virtual reality could reproduce multiple scenes which given by the users. This scene could be the exact 100% genuine and that is what is needed in all crime scene. This virtual reality simulation could also be used by different investigators from different geographical locations.

V. REAL LIFE EXAMPLE CASE USING VIRTUAL REALITY

Rebecca Pool has discussed a real-life crime case using the Virtual reality [12]. Back in 2017, there were, and hijack took placed in the Stockholm Shopping Centre. Eventually the hijackers took a lorry and drove it right into the store department which result on killing approximately five human and hurting almost fourteen.

The 3-D laser scanner is used to reconstruct the Crime Scene. The Virtual Reality then is used to develop the simulation of the Crime Scene. SPIE member and the head of sensor technology group in Swedish National Forensic Centre were appointed to develop the whole hijack activity into a simulation. Approximately 100 lasers were used to scan the whole location. 800 million of data point were discovered and this result on having a number of possibilities. The final outcome was then being broadcasted at the Swedish courtroom.

In order to gain a proper and perfect simulation of a Crime Scene it needs at least hundreds of scanners to capture the detailing in the scene. With the collected evidence the experts would come out with the possible simulation. The evidence is important as, upon having those scanners taking the crime scene there would be plenty of data and the possibilities would be more. There would be more simulation. This evidence would shortlist the possible simulation and they could get the perfect simulation.

The perfect equipment in the Crime Scene Investigation would be the Virtual Reality. This is because, the Virtual Reality can get the scene, and this would make the process in court to be easier. This simulation would be used by the judge and prosecutors on learning and understanding the crime scene and getting the case solved.

This real-life example could show how the virtual reality could get success rate on the having them implemented on the crime scene investigation. This would bring more easy time and quick solving of case in future. As we can say, the current situation there are cases not being solved or they might take some time. This is because, most of them would not be able to revisit the crime scene as how it is, and they might miss out certain things and they only take pictures as evidence to continue the investigation. Just think, if there is this virtual reality in the crime scene, they could visit the scene as they wish, and they could get more clues on solving the case.

VI. PROCESS ON VIRTUAL REALITY

Implementing Virtual Reality in Crime Scene Investigation requires method that is different than the traditional forensic reconstruction [13]. Although they are different, but the method will have the backbone of the traditional forensic reconstruction. This is because, the virtual reality is a technology designed method will need to be bring a different to the Crime Scene Investigation method, but they will need to have the base from the traditional method. A proper process framework would make the Virtual Reality in the Crime Scene Investigation would make the process easier and low time consumption. Fig. 5 shows the Process framework in Virtual Reality.

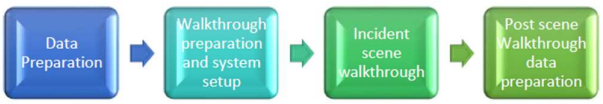

Fig. 5. The Process on Virtual Reality[13]

It begins with data preparation. This means, after getting all the 3D data from the laser scanning, photogrammetry, PMCT and other type of scanning method will have to be converted into surface data which will produce millions of faces. This is where before they transform the result into data for possibilities, they will need to prepare the whole area and capture all items in detail in order to get the perfect possibilities. For instance, they will need to use 100 of scanner to get a detailed outcome and they will need to reconnect it to the photogrammetry. This process is much needed as it needed to be paid more attention on getting the proper simulation. This will also decide on having high frame rate to prevent any simulation error. In this process they will also include on picking the proper hardware and software to get a better visualization.

Walkthrough preparation and system setup is where the user will check run the simulation. This is important as they will need to know if it is functional properly. In this step, they will use the HTC Vive virtual reality headset with lighthouse and controllers that is driven by a VR- ready gaming laptop. This will all them to setup the system and this setup of system will keep on several point considered.

This action needs to be done in order to prevent any misplace of small items. For instance, this walkthrough will need to be done in to prevent any small changes in the simulation such as, tables, chairs, and screen. This is important as this very important it will determine how exact the simulation is perfect. Having this will prevent any small details miss place.

Under this step they will also need to prepare the area to practice the simulation. This is much needed as the users could need an exact area to work on the simulation. For instance, they will need to get a setup area to walkthrough the simulation. Referring to Fig. 6 in every virtual reality simulation they will need to design a space area for the users to move around and they may display the situation.

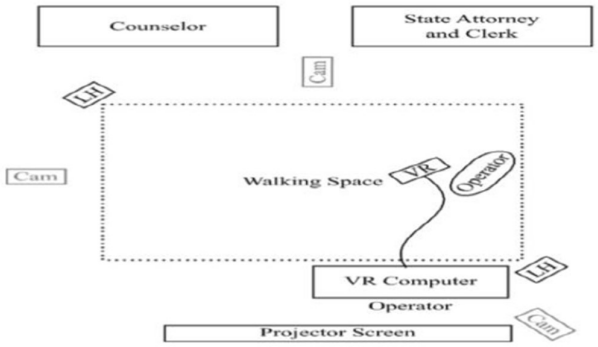

Fig. 6. The Setup of Scene Walkthrough [13]

Incident Scene Walkthrough is where the simulation is used for the interview. This is very important as one of the reasons to use the simulation for the investigation. This will keep the investigator to see a clear image and recognize every small information. This incident scene walkthrough is also used by the interviewee to allow them freely to see and move around the scene. They could also have the eyewitness in to use the walkthrough to descript how it happens and what happens. For instance, the eyewitness will be invited to the simulation area to wear the gears with along with the investigator to give their statement and this time they could also story how the incident took place and the investigator could move around the area to look for other information.

Post scene walkthrough data preparation is where an autosave should be done on all recorded data is downloaded from devices and secured them well. In this part, having big data would keep the data away from being tempered. This data is from what the users are viewing. The data could be more as it will increase if there were more people viewing the crime scene simulation. For instance, there will be investigators and eyewitness viewing the simulation. As they use the gears, they will view the scene and whatever they scene and where there see will be recorded and being store for court use. This is important as it may be used in the court to allow the judges to understand the case and maintain the justice well.

VII. GAME SCENARIO

The Virtual Reality in Crime Scene Investigation could run in the form of Game Scenario. In this method the users would be able to change the settings according to them. For instance, Maria Drakou and Andreas Lanitis has discussed on a case which include an old lady who was found dead in her living [14]. It has been discovered that there and they could pick the method of murder do they fit. This method would make the case more accurate in solving it, but it may consume a little longer time as the investigator will need to put one by one to compare and contrast it. are eight suspects in the house when the old lady died. Having the game scenario there will be option to change the suspect.

VIII. CONCLUSION

As a conclusion, the Virtual Reality would work well in the Crime Scene Investigation as this shall bring an advancement in the process of investigation. Investigator will be allowed to simulate the Crime Scene when there is Virtual Reality. This shall allow the investigator to revisit scene. It would also judge and prosecutor to visit the crime. They do not need to physically visit, and they could use the Virtual Reality simulation. By doing this, is may save up more time and cases could get solved quicker.

In different country the police department is using the virtual reality in crime scene investigation and it has been a successful. There are certain method or process needed to be followed to keep the virtual reality more useful in case investigation.

ACKNOWLEDGMENT

This research was supported by Asia Pacific University of Technology & Innovation under the Research Grant Scheme (Grant no. FRGS/1/2019/ICT02/APU/01/1). All opinions, findings, conclusions and recommendations in this paper are those of the authors and do not necessarily reflect the views of the funding agencies. We thank the anonymous reviewers for their comments.

REFERENCES

[1] Bardi, J., 2019. *What is Virtual Reality.* [Online] Available at: https://www.marxentlabs.com/what-is-virtual-reality/ [Accessed 29 March 2020].

[2] Mazuryk, T. & Gervautz, M., 2019. History, Applications, Technology and Future. *Virtual Reality -,* 0(0), pp. 1-72.

[3] Woodford, C., 2019. *Virtual Reality.* [Online] Available at: https://www.explainthatstuff.com/virtualreality.html [Accessed 05 April 2020].

[4] Dormehl, L., 2017. *8 virtual reality milestones that took it from sci-fi to your living room.* [Online] Available at: https://www.digitaltrends.com/cool-tech/history-of-virtual-reality/ [Accessed 29 March 2020].

[5] The Franklin Institute, 2020. *HISTORY OF VIRTUAL REALITY.* [Online] Available at: https://www.fi.edu/virtual-reality/history-of-virtual-reality [Accessed 29 March 2020].

[6] T. P. Kersten, F.Tschirschwitz & S.Deggim, 2017. DEVELOPMENT OF A VIRTUAL MUSEUM INCLUDING A 4D PRESENTATION OF BUILDING HISTORY IN VIRTUAL REALITY. *Virtual Reality,* XLII (2), pp. 361- 367.

[7] Robey, D., 2000. From Crime Scene to Computer Screen: The Use of Virtual Reality in Crime Scene Investigation. *virtual reality crime scene investigation,* 1(1), pp. 1-12.

[8] Xu Feng, Shah Daguo & Yang Hongchen, 2010. *Simulation Research of Crime Scene Based on UDK.* China, IEEE.

[9] Suncksen, M., Hamester, F. & C.Ebert, L., 2019. *Preparing and Guiding Forensic Crime Scene Inspections in Virtual Reality.* Germany, ACM, pp. 755-758.

[10] Eeden, C. A. v. d., 2016. Forensic expectations: Investigating a crime scene with prior information. *Science & Justice,* 56(6), pp. 475-481.

[11] Neeter, E., 2018. *Exploring Virtual Reality as a Forensic Tool.* 1 ed. s.l.:Evidence Technology Magazine.

[12] Pool, R., 2019. *Virtual and Augmented Reality Tech Joins the Fight against Crime.* [Online] Available at: https://spie.org/news/spie-professional-magazine-archive/2019-january/ar/vr-tech-joins-the-fight-against-crime?SSO=1 [Accessed 04 April 2020].

[13] Siebert, T., Dobay, A., Affolter, R. & Ebert, L. C., 2018. Applying virtual reality in forensics – a virtual scene walkthrough. *Forensic Science, Medicine and Pathology*, 06 December, pp. 41-47.

[14] Drakou, M. & Lanitis, A., 2016. On the Development and Evaluation of a Serious Game for Forensic Examination Training. Lemesos, Cyprus, IEE.