



University of Wales
Trinity Saint David

REPORT ***DIGITAL SURVEYING*** ***AND HIGHWAY DESIGN*** ***ACBA4017***

Course: HNC Quantity Surveying

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Table of Contents

Digital Building Survey	3
Objectives.....	3
Part 1: PLANNING THE SURVEY	3
Introduction.....	3
Purpose of the Survey	3
Survey Area Definition	4
Site Assessment.....	4
Risk Assessment Summary	4
Conclusion to Planning	5
Part 2: PRACTICAL SURVEY EXECUTION	5
Evidence of on-site Presence	5
Execution Survey Summary.....	5
Problems Encountered	6
PART 3: MEASUREMENT AND ANALYSIS	6
Extracted Measurements	6
Comparison with traditional Methods: How does this approach compare to manual measurement in terms of time, accuracy, and completeness?	7
Conclusion to Analysis	8
References	8
Appendices.....	9
Appendix A- On-site Survey Photographs.....	10
Appendix B- Field Notes and Sketches	12
Appendix C- Point Cloud floor Plan.....	13

Digital Building Survey

Dylan Thomas Centre, Swansea, Wales

Objectives

1. To plan a professional building survey
2. To gain hands-on experience in conducting a laser scanning survey on a real building
3. To interpret and extract accurate spatial data from processed scan outputs

Part 1: PLANNING THE SURVEY

Introduction

Now we have better Digital technologies that have transformed the way professionals approach complex building surveys, particularly in heritage and cultural contexts. One such technology is 3D laser scanning, which was used in this project as part of an assignment for the *Digital Surveying and Highway Design* module and is a type of terrestrial laser scanning device (TLS). It is part of geospatial surveying equipment and is designed to capture accurate measurement without physical contact producing detailed point cloud data. It has emerged as a powerful tool for capturing accurate spatial data and enabling detailed documentation and analysis of complex structures. This survey project focuses on the Dylan Thomas Centre in Swansea, Wales, a building of cultural significance housing exhibitions dedicated to the renowned poet. The survey aims to produce a comprehensive digital record of the building's geometry to support conservation, maintenance and future planning. This report essentially compares measurements taken using 3D laser scanning with those taken using a traditional method.

Purpose of the Survey

The main objective of the Survey was to accurately capture the internal and external geometry of the Dylan Thomas Centre. This involved recording the building's exterior facade and architectural features, as well as the internal layout of some spaces such as hallways and service areas. The use of 3D laser scanning is justified by its capability to generate a comprehensive point cloud database, which can be processed into highly accurate measurements and detailed digital models.

These outputs provide a permanent record of the building and are particularly valuable for heritage management, as they can support future restoration works, accessibility planning, and educational use. (*3D Laser Scanning for Heritage* | *Historic England*, 2018)

In addition to the digital survey, the measurements were also carried out using traditional methods, including the use of a measuring tape and handheld laser distance metre with all data manually recorded on paper.

Survey Area Definition

The survey addresses both interior and exterior spaces. Internally, it concentrates on exhibition halls, circulation areas, and significant architectural elements, including doors, windows and ceiling structures. Externally, priority is given to the façade and entrance areas due to their cultural and aesthetic significance. The required level of detail varies according to the element surveyed: millimetre accuracy is necessary for features such as window frames and doors openings, whereas centimetre accuracy is sufficient for overall spatial dimensions. This hierarchical approach ensures efficient data capture while meeting the objectives of precision and completeness. (Böhler, 2002)

Site Assessment

A comprehensive site assessment was undertaken prior to the survey. Access to the building was provided through the main entrance and the auditorium, facilitating the movement of equipment and personnel. Scanning positions were carefully planned to minimize occlusions and to ensure complete coverage of complex geometries. Within interior spaces, lighting conditions were evaluated; whilst artificial lighting was generally sufficient, reflective surfaces presented challenges that required precise scanner placement. Externally, natural lighting conditions were variable as it was raining a lot. Health and safety considerations included controlling visitor movements.

Risk Assessment Summary

The risk assessment identified a variety of operational and environmental hazards related to the survey activities. Although visitor movements were identified as a potential operational risk, there were no interruptions on the days when the measurements were taken. The survey team was divided into three groups, and the data collection took place over two consecutive Mondays. The first session involved the use of a 3D laser scanner, while the second session was completed using traditional measurement methods. When planning the survey, environmental risks related to external scanning, particularly weather conditions, were considered, and data capture was scheduled during dry periods. Health and safety risks, including operator fatigue and potential trip hazards, were controlled through the implementation of scheduled breaks and use of clear warning signage.

Overall, the risk assessment ensured that the survey was carried out in a safe and efficient manner, in accordance with professional guidance. (*Measured surveys of land, buildings and utilities: RICS guidance note, global*. 3rd edition, 2014)

Conclusion to Planning

During the planning stage, a clear framework for conducting the survey was presented, taking into consideration technical, practical, health and safety needs. This approach helped to ensure that the site work could be completed effectively and with minimal issues by establishing clear objectives, identifying the areas to be surveyed and considering potential hazard. Thanks to this preparation, the survey crew was able to enter the practical phase with greater understanding of the site and techniques to be used.

Part 2: PRACTICAL SURVEY EXECUTION

Evidence of on-site Presence

Some photographs were taken on site during the survey; we used terrestrial scanning equipment consisting of a 3D laser scanner and a tablet for data collection. We also used conventional measurement equipment: measuring tape, a laser distance metre, paper and a pencil. *See Appendix A.*

Execution Survey Summary

The Dylan Thomas building, located in a publicly accessible urban environment, was chosen as the location for the study. As part of the Digital Surveying and Highway Design module, the study aimed to learn how to use digital measurement tools, such as 3D laser scanners, to record the dimensions and geometric characteristics of the building. The exercise involved applying and comparing traditional and digital measurement techniques, and evaluating their respective accuracy, efficiency and suitability for use in an urban environment. Site conditions were favourable, with no typical limitations such as reduced working space, pedestrian movement or physical obstacles interfering with instrument placement and data acquisition. The weather and lighting conditions were generally suitable for both traditional and digital measurement methods.

As mentioned previously, two main measurement methods were employed. On the first day, basic linear dimensions, such as wall lengths and accessible heights, were obtained using traditional measurements with a tape measure and laser distance meter. This method provided reference data, which was then compared with data obtained using digital measurement techniques.

On the second day of the survey, a 3D laser scanner was used to create a detailed 3D model of the building. To minimise occlusions and shadowing effects, multiple scan positions were planned and executed. The collected data was processed to generate a dense point cloud, from which accurate dimensions and geometric features could be extracted.

Overall, the survey was executed in accordance with the planned methodology. Traditional tape measurements and terrestrial equipment were used as expected, allowing for the efficient collection of key dimensions. Most of the planned scan positions for the 3D laser scanner were achieved, resulting in comprehensive point cloud coverage of the building.

Cross-checks were performed between traditional and digital measurements to ensure consistency and identify potential discrepancies. The main outputs were verified building dimensions, traditional measurement records and a 3D point cloud model derived from laser scanning data.

Certain limitations were successfully managed, including access restrictions, occlusions affecting laser scan coverage and the possibility of human error in manual measurements. Thus, the study demonstrated the efficiency and accuracy of digital surveying techniques while highlighting the continued relevance of traditional methods for validation. This approach reinforced the fundamental surveying principles applicable to infrastructure development projects.

Problems Encountered

During the laser scanning survey several practical issues arise, including moving people, reflective surfaces, variable lighting, weather conditions, occlusion, alignment errors and access limitations. These factors can affect the completeness and accuracy of the point cloud and often require additional scan positions or on-site adjustments. Fortunately, we did not experience any of these issues during the survey due to the good organization of the three teams and the favourable conditions inside the Dylan Thomas building.

On the other hand, using the traditional method of surveying can result in human error in measurement. As such errors include:

- Incorrect readings from a tape measure or distance meter.
- Measurements recorded incorrectly on the sketch.
- Confusion between units or numbers.

PART 3: MEASUREMENT AND ANALYSIS

Extracted Measurements

The 3D laser scanner obtained measurements with a minimal margin of error from the data processed in the point cloud. The overall dimensions of the components on the second level of the Dylan Thomas Building were captured with great precision, providing reliable space planning data. Door and window dimensions were extracted to enable a detailed analysis of the building's architectural features. Floor to ceiling heights were measured in different rooms to provide information on structural consistency and spatial variation. These measurements demonstrate the ability of laser scanning to provide accurate, comprehensive datasets.

Comparison with traditional Methods: How does this approach compare to manual measurement in terms of time, accuracy, and completeness?

Laser scanners are gaining acceptance and usage in the AEC/FM industry for creating as-built BIMs because they can rapidly and accurately measure the 3D shape of the environment. The process of creating an as-built BIM using laser scanners can be divided into three main steps:

- 1) Data collection, in which dense point measurements of the facility are collected using laser scans taken from key locations throughout the facility;
- 2) Data preprocessing, in which the sets of point measurements (known as point clouds) from the collected scans are filtered to remove artifacts and combined into a single point cloud or surface representation in a common coordinate system; and
- 3) Modeling the BIM, in which the low-level point cloud or surface representation is transformed into a semantically rich BIM.

Data collection Laser scanning technology has made the creation of as-built BIMs tractable. Other methods, such as using a total-station, measuring tapes, or even ordinary cameras, are too time-consuming or inaccurate to be practical on a large scale, though recent results using images are promising. Laser scanners measure the distance from the sensor to nearby surfaces with millimeter to centimeter accuracy at speeds of thousands to hundreds of thousands of point measurements per second. A single scan may contain several million 3D points. Since no single scanning location can visualize all surfaces within a facility, scans must be obtained from multiple locations. Often, a digital camera is used to capture images of the environment, which can be later fused with the 3D data to aid in the modeling process. So, when comparing traditional manual measurement methods with 3D laser scanning, we can assure that the latter offers significant advantages. In terms of time, laser scanning reduces the duration of the survey; building parts can be captured in minutes, whereas manual methods can take hours or days. Accuracy is another advantage, laser scanning achieves millimeter precision, minimizing human error compared to tape measure or laser measurements. (Tang *et al.*, 2010)

Completeness is equally important, point cloud data provides a complete record of the building, including tiny details that can be ignored by human eye, as well as areas that may be difficult to access in person. This ensures that no details are overlooked and that the data set can be reviewed for future analysis. However, laser scanning requires equipment and professionals with the necessary expertise in processing point cloud data. In contrast, manual methods are simpler and more accessible, although less accurate.

Finally, the advantages of laser scanning outweigh its limitations, especially in heritage contexts where accuracy and comprehensiveness are essential.

Conclusion to Analysis

The measurement and analysis phase demonstrates the transformative potential of digital technologies for building surveys. 3D laser scanning provides accurate, efficient and comprehensive data, surpassing traditional methods and offering a robust foundation for conservation and planning. The survey of the Dylan Thomas Centre exemplifies how such innovations can benefit heritage building, ensuring their preservation for future generations.

References

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Appendices

Appendix A- On-site Survey Photographs

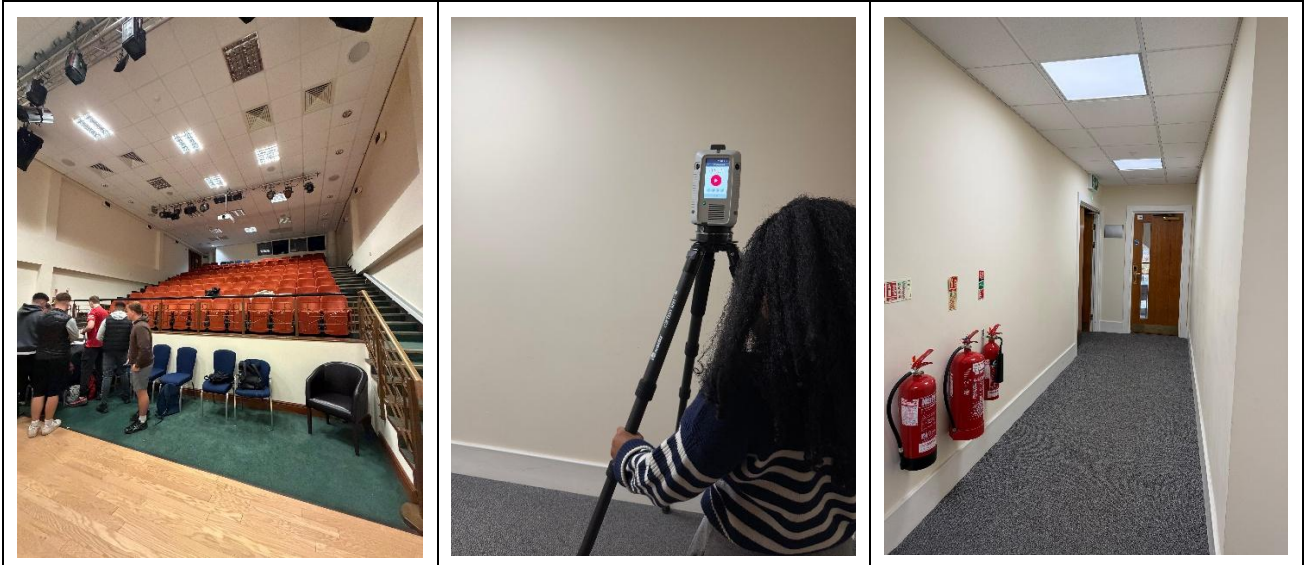


Figure A1. These photos show the organisation team and the digital equipment required for the survey, including a scan position in the middle hallway.



Figure A2. These photos show the areas that are being surveyed.



Figure A3. These photos show the surveying with the traditional method.

Appendix C- Point Cloud floor Plan

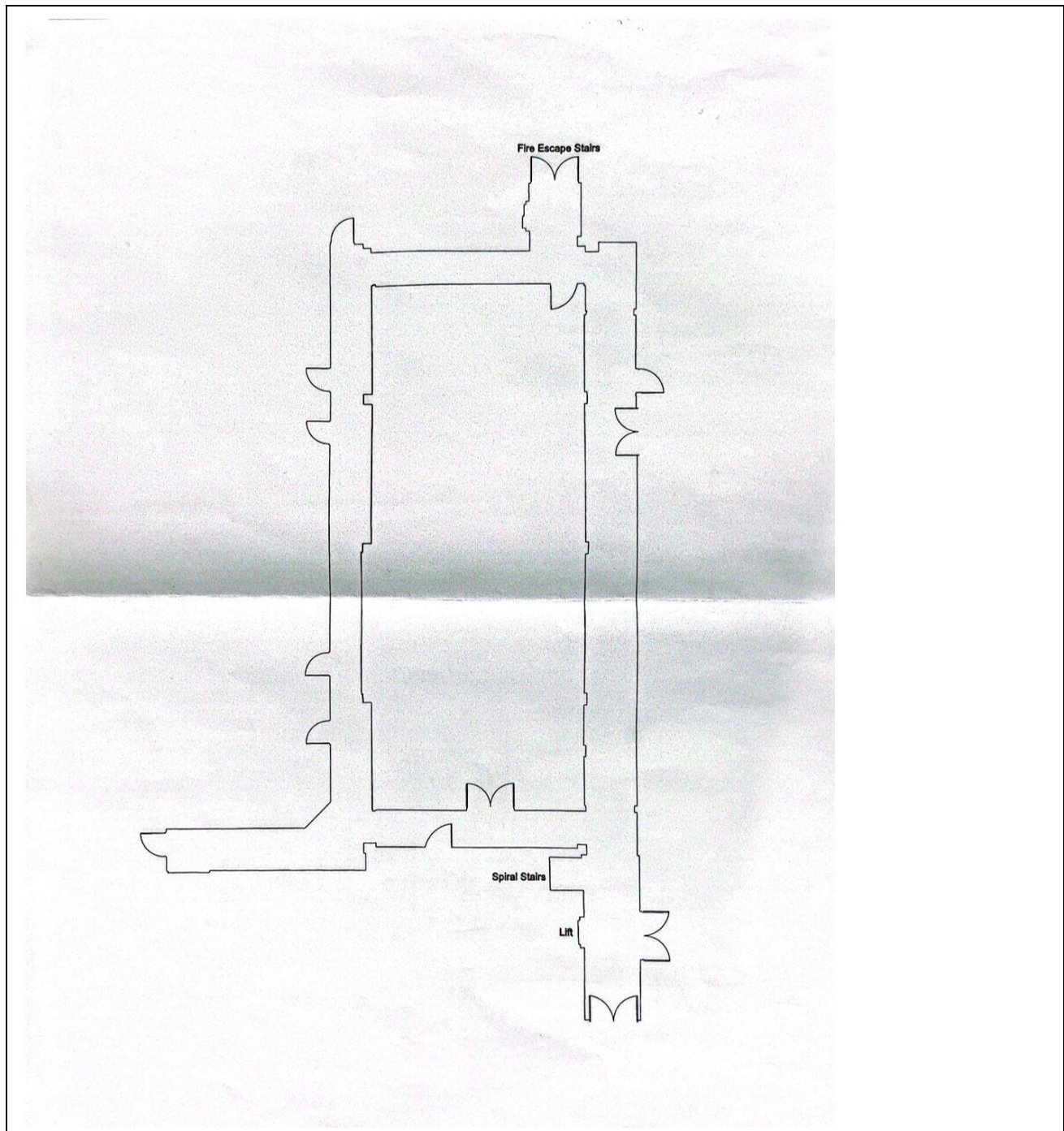


Figure C1. This figure shows the floor plan extracted from the registered point cloud, accompanied by the reference drawing provided by the instructor.