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UNMANNED AERIAL VEHICLE (UAV)-BASED PRECISION AS-BUILT SURVEYING FOR INSTITUTIONAL BUILDINGS

[1]Ogundele O.S., [1]Sulaiman A.D., [1]Ajadi, T.O., [1]Ayanwole Ridwan A., and [1]Godwin, G.O.

[1]Department of Surveying and Geoinformatics, The Bells University, Otta, Nigeria

*Corresponding author: osogundele@bellsuniversity.edu.ng, ogunsd2001@yahoo.com,

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Abstract

This study utilizes UAV-based photogrammetry to perform a high-precision 3D as-built survey of newly constructed laboratory buildings at Bells University of Technology. The approach integrates GPS-enabled UAV data acquisition with advanced photogrammetric processing using Agisoft Metashape Professional, AutoCAD Carlson 2021, and Agisoft Viewer to produce high-resolution orthophotos and accurate 3D spatial models. Comparative analysis between orthophoto-derived measurements and architectural design specifications indicates dimensional deviations predominantly within ±5 mm across most building elements, confirming construction accuracy. However, the roofing components exhibit deviations of 90 mm in length and 100 mm in width, exceeding international tolerance thresholds, thereby indicating non-conformance that may impact structural performance and envelope integrity. Positional accuracy was further validated through geospatial overlay on Google Earth. The findings demonstrate the technical reliability of UAV-based as-built surveys for construction validation, offering a robust tool for quality assurance, regulatory compliance, and facility management in institutional infrastructure development.

Keywords: As-built survey, Unmanned Aerial Vehicle (UAV), Orthophoto, Architectural design.

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1.0 Introduction

Land holds significant social and economic value, as its true worth is closely tied to the buildings constructed upon it [1,2]. Accurate documentation of these structures through as-built surveying is essential to protect ownership rights, support urban planning, and enhance economic benefits [3,4]. The use of graphical representations before construction has become a standard practice to ensure proper planning and management [5]. Thus, as-built surveys are indispensable for maintaining the integrity of land use and facilitating sustainable development [6].

As-built surveys, also known as record drawings, provide formal documentation of the actual installation of a construction project, reflecting the true outcome rather than the original design plan [7]. These surveys are critical for project closeout, ensuring that construction complies with the specified design and allowing engineers to confidently verify project completion [7]. Furthermore, as-built surveys play a vital role in updating plans to document changes on land caused by natural or artificial events, focusing on existing structures and urban development [8]. Such surveys are essential for remodeling, expansion, retrofitting, refurbishment, renovation, or visualization of structures [8].

Unmmaned Aerial Vehicle (UAV) photogrammetry serves as a critical link between classical unmanned aerial photogrammetry and traditional surveying techniques by operating within the close-range domain, combining both aerial and terrestrial photogrammetry approaches while offering low-cost alternatives to conventional methods [9]. The accuracy of UAV-based aerial mapping is essential for achieving professional-grade results, a capability that has been significantly enhanced by improvements in camera resolution [10]. Moreover, UAV systems have been demonstrated to reduce manpower, time, and costs associated with as-built surveys, while simultaneously improving the quality and quantity of data acquisition [10]. The rapid data collection capabilities of UAVs enable efficient inspections and surveys in areas that are otherwise inaccessible or hazardous, such as congested urban environments, flooded zones, and roadways. This technology offers a cost-effective and timely alternative for site management and surveying, making it a valuable tool for as-built surveys [10].

The physical planning department at the Bells University of Technology maintains a database of all buildings within the institution. However, changes in design due to renovations and additional ideas during construction have led to discrepancies that are not well-captured in the unit's database.

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Therefore, the rising need to "checkmate" these lapses cannot be over-emphasized. The main purpose of plan updates is to document any development or re-establishment on the land. Since natural and artificial events continually cause changes to objects on the earth's surface, such updates are growing because they are concentrated on existing structures and urban development. This can be continuously solved when an as-built survey is a regular phenomenon until the total completion of any building facility constructed [11].

1.1 Study area

The project study area is in Bells University of Technology, Idi-Iroko Road, Benja Village, Ota, Ogun state. The university lies within Ota Township, the administrative headquarters of Ado-Odo/Ota Local Government Area, approximately 70km from Abeokuta, the Ogun state capital. The campus center is situated at approximately 6°40′58″N and 3°11′9″E. Since its commencement on July 1, 2005, the institution has grown, continually increasing its staff and student population and adding several departments, as documented by the records and data unit.

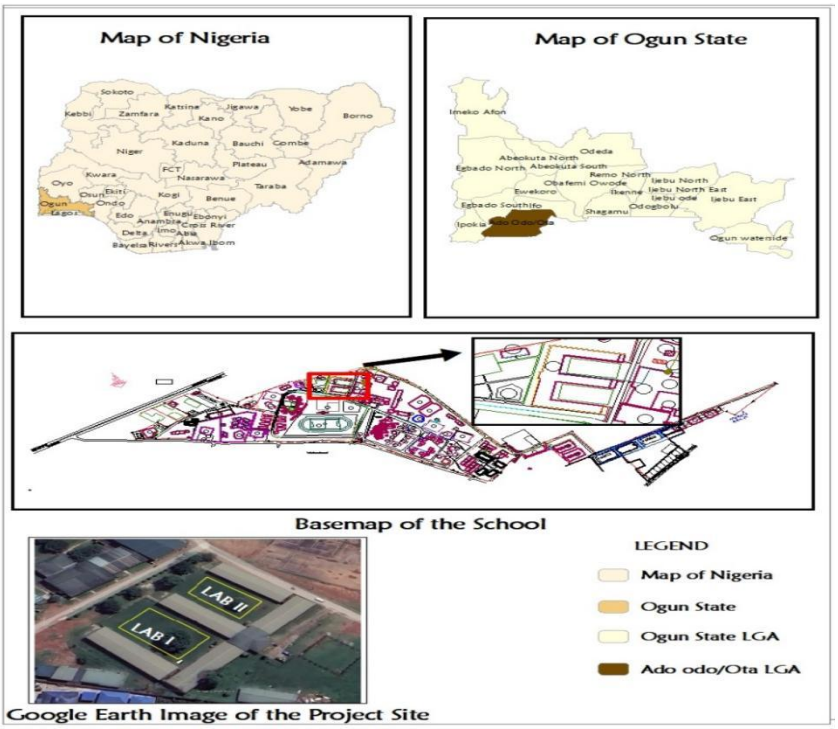


Figure 1: Study Area Map

2.0 Material and Method

2.1 Planning

The planning included office planning and field reconnaissance. Office planning such as gathering and studying data relevant to the project area, collection of nearby control information, acquisition of imagery covering the project area through Google earth, collection and checking of instrument, examining the project specification, finding the controls nearby the project area and collection of the school base map from the physical planning department were carried out.

Field reconnaissance involved the actual site visitation to examine the physical terrain of the study area and to determine how best to facilitate a successful and economical execution of the project. During this process, the project site was visited in order to have a general view of the area for better planning and execution and the connecting control pillars within the study area were located and confirmed if it corresponds with the given prefix/numbers from the department.

2.2 Data acquisition

The data acquisition encompassed geometric and aerial data collection. The geometric data acquisition were the coordinates of the Ground Control Points (GCPs) using Global Positioning System (GPS). GCPs are marked points on ground with known geographic locations and are required in aerial survey to enhance the accuracy of positioning and mapping outputs.

For aerial data acquisition, critical to UAV photogrammetry operation is flight planning which is done in the office before heading to the site for the actual flight operation where images are taken. The mission (autonomous flight and data acquisition) was planned using a web-based, dedicated aerial mapping software solution named Drone Deploy and complemented with DJI GO 4 flight control and monitoring app in creating flight template of the Area of Interest (AOI).

A low flying height of 45 meters at 8.8mm camera focal length was set in order to achieve a very high spatial image resolution (1.5cm/pixel). The forward overlap between successive images on the same flight path was set at 65% while the side or lateral overlap between images on adjacent flight paths was 35%.

2.3 Data processing

Image processing was performed with **Agisoft Metashape Professional** (Agisoft LLC) to generate a high-resolution orthophoto of the project area. The orthophoto was further visualized and

analyzed in **ArcGIS 10.5** (ESRI), where building footprints were digitized and boundaries delineated. Final visualization and verification were carried out in **Agisoft Viewer**.

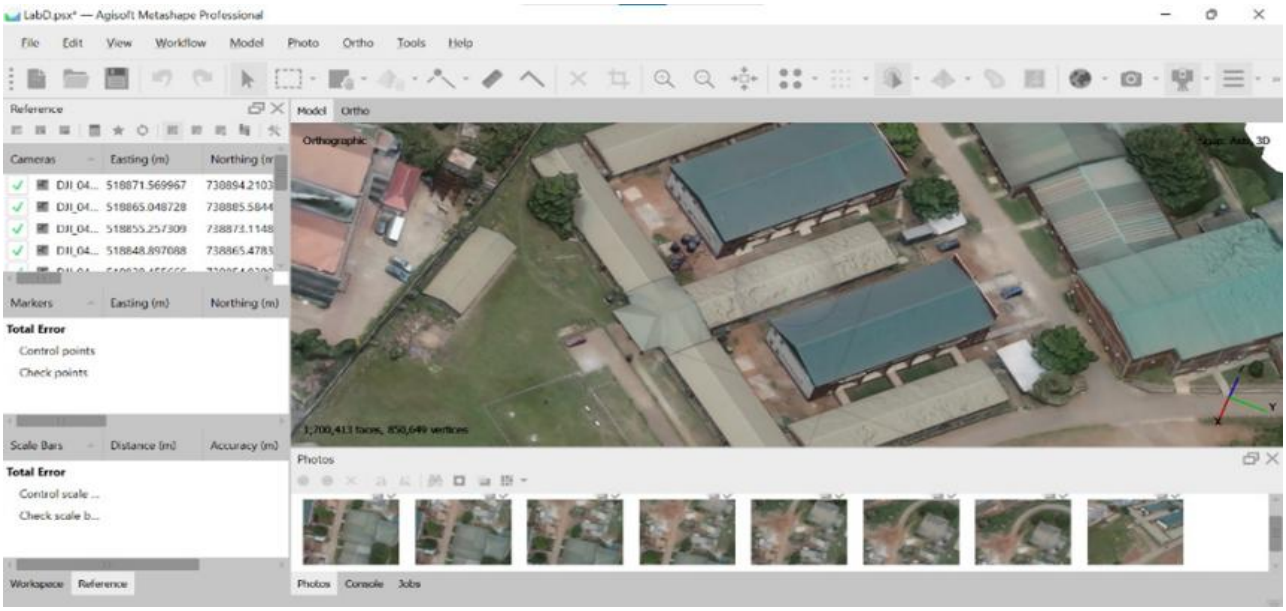


Figure 2: Agisoft Metashape Professional Software Environment

3.0 Results and Analysis

3.1 As-built site plan on Base map

In the course of the research, four buildings were surveyed; however, this paper focuses on two laboratory buildings, as the results across all structures demonstrated a consistent pattern. The as-built site plans of the selected buildings were overlaid onto the existing campus base map. With the exception of the roofing components, all recorded dimensions showed strong alignment with the original architectural design specifications. as shown in Figure 3.

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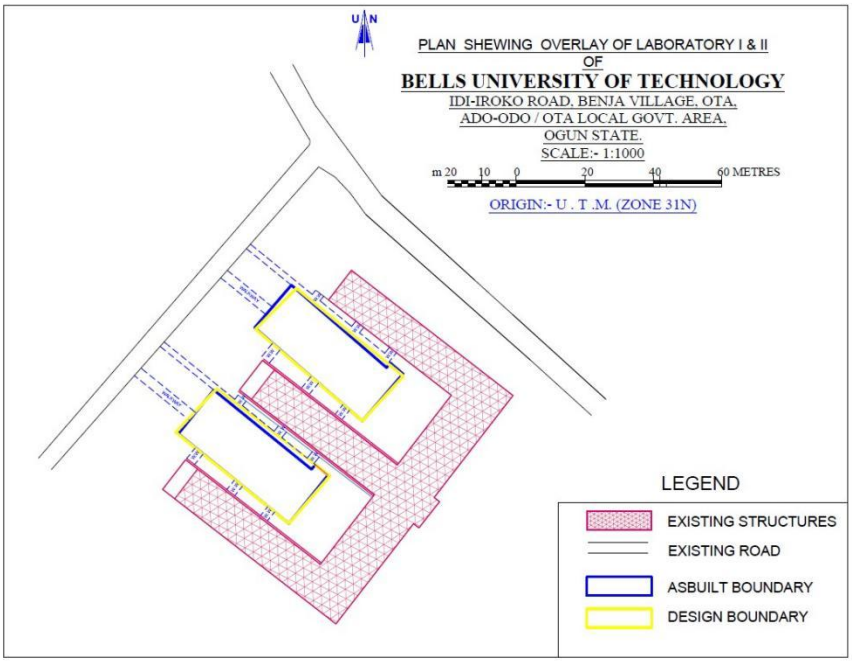


Figure 3: Plan Showing Overlay of the Laboratory I & II on the School Base map

3.2 Analysis of the different views

Some major components like doors, windows, roof dimensions of the different sides or view of the architectural design and as-built survey plans were compared to assess conformity or disparities. Findings were subject to Industrial/International tolerance standard to determine level of tolerance/accuracy (acceptable or not acceptable). Table 1 and 2 respectively show the general and concrete Tolerance standards for Building construction while Figure 4 shows the different views of the Architectural Design for Laboratory I & II.

Table 1: Adopted International/industrial Tolerance standard for general building construction

Level of Accuracy (LOA)	Detail Level	Tolerance
LOA 10	Basic representation	±25.4 mm (±1 inch)
LOA 20	Moderate detail	±12.7 mm (±1/2 inch)
LOA 30	High detail	±6.35 mm (±1/4 inch)
LOA 40	Very high detail	±3.175 mm (±1/8 inch)
LOA 50	Fabrication-level	±1.5875 mm (±1/16 inch)

Source: [12]

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Table 2: Typical Tolerances for Long-Span Roofing Sheets (Based on International Practices)

Parameter	Typical Tolerance	Reference
Length	±5 mm to ±10 mm	EN 14782 (Steel sheet products - self-supporting metal roofing sheets
Width	±5 mm	EN 14782
Alignment (Overlap / Joint position)	±10 mm	BS 5427 (Code of practice for the use of profiled sheet for roof and wall cladding)

Source: [13,14]

Acceptability Rule (for Table 1 and 2)**:** If the difference between as-built and design measurements fall within the defined LOA/typical tolerance for the project, it is considered acceptable, otherwise, it is not acceptable. Hence, Table 3 and 4 show the application of the rule.

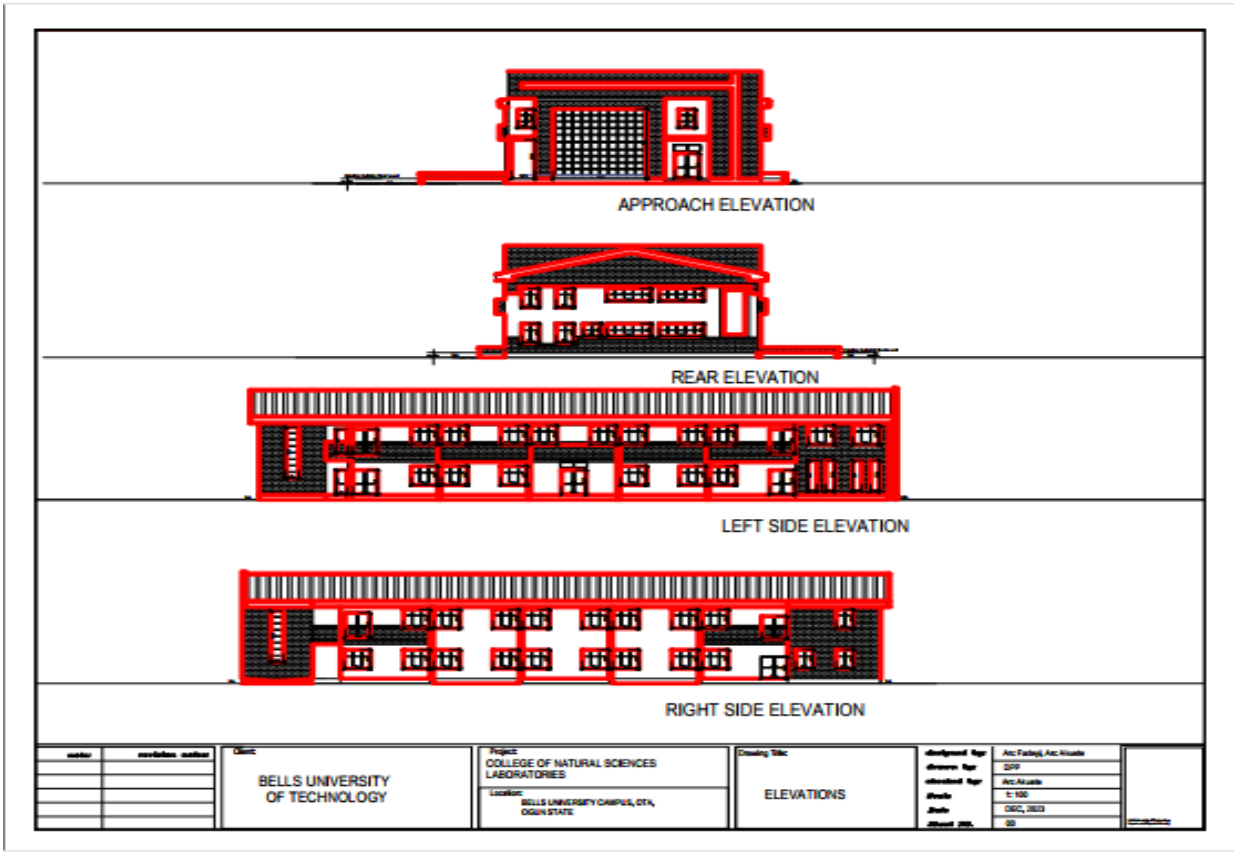
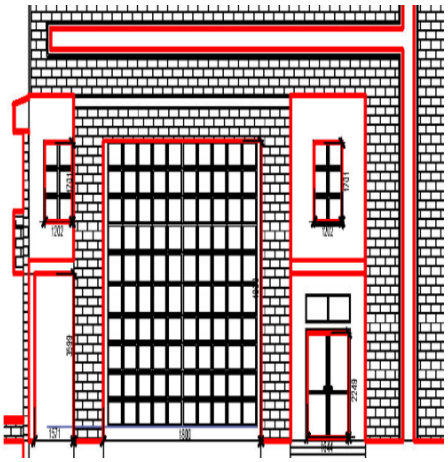
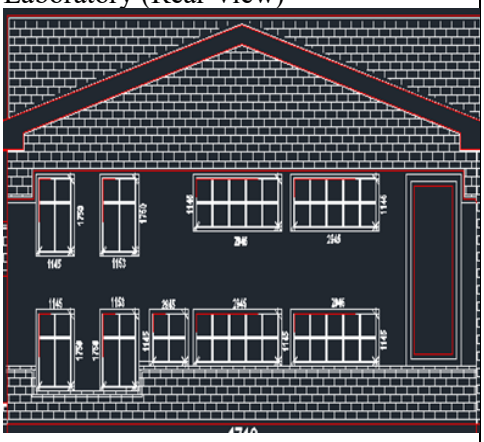
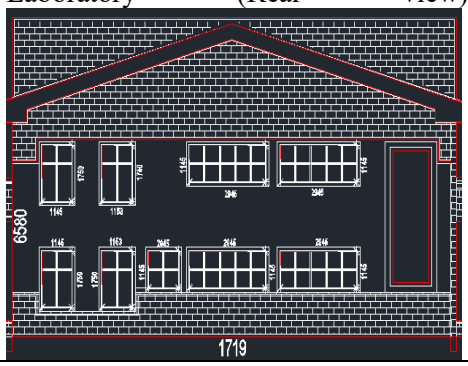


Figure 4: Architectural Design for Laboratory I & II

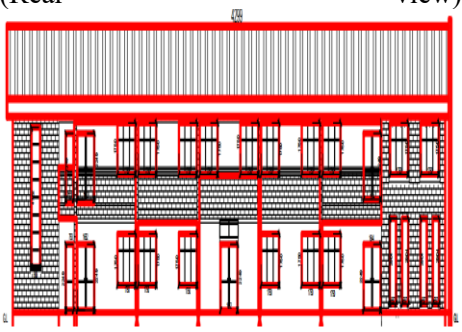
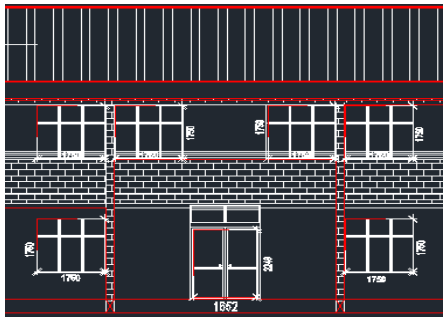
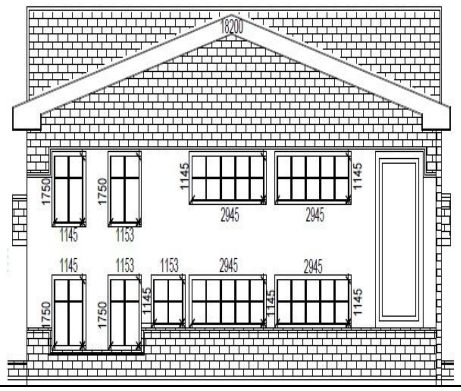
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3.2.2 Analysis of Dimension Comparison

Table 3: Comparison of Orthophoto and Architectural Dimensions

S/N	UAV (3D) As-built (orthophoto)	Architectural Drawing	Discussion
1.	Window (1) analysis of the Laboratory front view 	Window (1) analysis of the Laboratory Front View 	The measured length of the highlighted window side is 1.202 m in the architectural drawing and 1.20 m in the orthophoto, resulting in a 2 mm difference. This discrepancy is within acceptable tolerance limits, indicating that the window dimensions on the ground conform to the intended design specifications.
2	Window (2) length analysis of the Laboratory (Rear View) 	Window (2) length analysis of the Laboratory (Rear View) 	The measured length of the window side in the architectural drawing is 1.145 m, while the corresponding measurement from the orthophoto is 1.15 m. The 5 mm difference between the two is within acceptable tolerance limits, indicating that the on-site measurement complies with the architectural specification.
3	Height analysis of the building /Laboratory (Rear view) 	Height analysis of the building/ Laboratory (Rear view) 	The building height measured in the architectural drawing is 6.58 m, which matches the measurement obtained from the orthophoto. As there is no discrepancy between the two, it can be concluded that the on-site building height aligns precisely with the architectural specification.

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4	Roof (1) length analysis of Laboratory the (Rear view) 	Roof length analysis of Laboratory the (Rear view) 	The building roof length is specified as 42.99 m in the architectural drawing, while the orthophoto measurement indicates 42.90 m, resulting in a 0.09m deviation. This discrepancy exceeds acceptable tolerance limits, confirming non-compliance with the intended design specifications.
5	Door width of Lab 	Door width of Lab 	The door width measurement of a major entrance for architectural design is 1.652m while the orthophoto is 1.650m. this falls within acceptable tolerance.
6	Roof (2) width of Lab (side view) 	Roof width of Lab (side view) 	The measured roof width from the architectural drawing is 18.20m, whereas the orthophoto measurement is 18.10m, indicating a deviation beyond acceptable tolerance limits. This discrepancy clearly demonstrates that the constructed roof does not conform to the intended design specifications.

3.3 Summary of findings

The summary of the results from the analysis carried out on different parts of the buildings are shown in Table 4.

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Table 4: Results of Analysis

S\N	BUILDING COMPONMENT	DIMENSION ON ARCHIT. DRAWING	OBSERVED DIMENSION USING UAV	DIFFERENCE	TOLERANCE FINDINGS
1.	Window 1	1.202m	1.200m	0.002m/(2mm)	Acceptable
2.	Building height	6.580m	6.580m	0.000m/(0mm)	Acceptable
3.	Building roof 1	42.990m	42.900m	0.090m/(90mm)	Not Acceptable
4.	Window 2	1.145m	1.150m	0.005m/(5mm)	Acceptable
5.	Door	1.652m	1.650m	0.002m/(2mm)	Acceptable
6	Building roof 2	18.20m	18.10m	0.1m/(100mm)	Not Acceptable

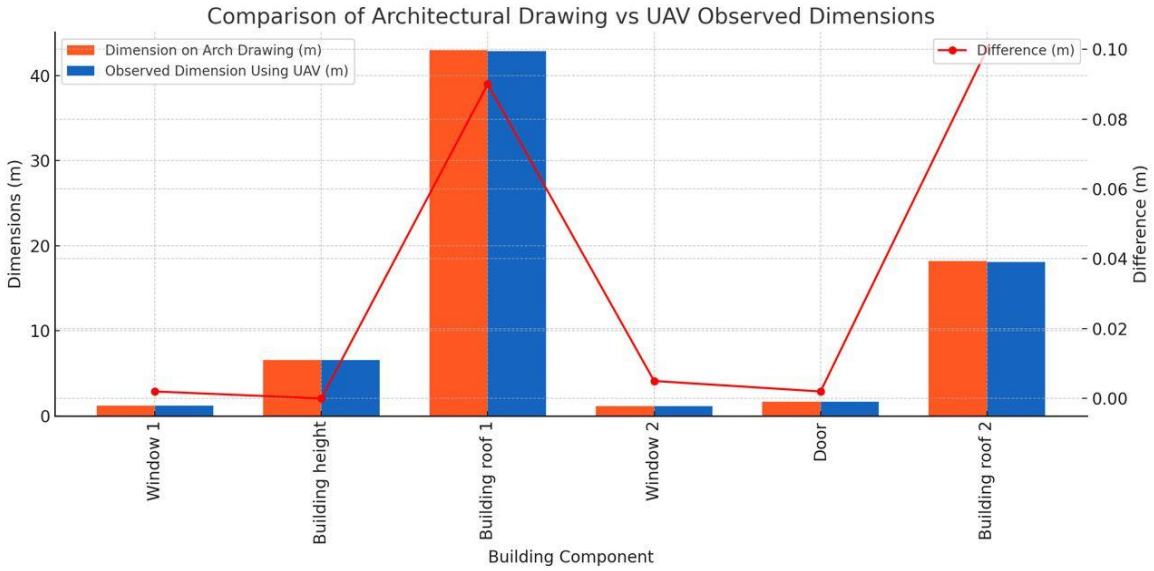


Figure 5: Chart Showing Comparison of Architectural Drawing Dimensions and Observed Field Measurements using UAV

The table (Table 4) and chart analysis (Figure 5) describe the comparative analysis between orthophoto-derived measurements and architectural designs revealed minimal deviations of 0 to 5 mm across most building components, demonstrating a high level of construction accuracy. However, the roofing wings exhibited deviations of 90 mm and 100 mm, surpassing the international tolerance limits of ±5 to ±10 mm for length and ±5 mm for width, respectively. These significant discrepancies suggest potential non-compliance that may compromise the structural integrity and weatherproofing of the roofing system. This study underscores the effectiveness of UAV-based as-built surveys in early detection of critical deviations, thereby enhancing quality

control, ensuring regulatory compliance, and supporting the long-term durability of construction projects.

4.0 Conclusion

This study demonstrates that UAV-based 3D as-built surveys offer a reliable and accurate method for evaluating construction conformity. The analysis confirms that the constructed structures closely align with the architectural design, with the exception of roofing components, which exceeded standard tolerance limits. The findings highlight the value of high-resolution orthophotos processed through specialized software (e.g., Agisoft Metashape) over general-purpose platforms, providing greater measurement precision. Overall, UAV-derived 3D data serves as a dependable tool for improving basemap accuracy, informing future construction planning, optimizing resource allocation, and enhancing infrastructure management.

5.0 References

1. Sahely, H. R., Kennedy, C., & Adams, B. J. (2005). Importance of land in economic and social development. *Land Use Policy*, 22(2), 123-131.

2. Campbell, S., & Marshall, A. (2000). *Land Valuation and Urban Development*. Urban Studies Journal, 37(4), 525-540.

3. Dale, P. F., & McLaughlin, J. D. (1999). *Land Information Management: An Introduction with Special Reference to Cadastral Problems in Third World Countries*. Oxford University Press.

4. Smith, R. (2010). Legal implications of as-built documentation in property ownership. *Property Management Review*, 28(1), 78-89.

5. Brown, T., & Wyatt, J. (2015). *Building Information Modeling and Construction Management*. Construction Press.

6. Lee, H., & Park, S. (2018). The role of as-built surveys in sustainable urban planning. *Journal of Urban Technology*, 25(3), 45-62.

7. Mitch, J. (2020). Understanding as-built surveys: Record drawings for project closeout. Construction Management Review, 35(4), 56–63.

8. Alausa, A. O., & Adaradohun, S. O. (2021). *As-built survey: A check for compliance of buildings. Journal of Nigerian Institute of Surveyors, 28*(3).

9. Carvajal, F., Agüera, F., & Pérez, M. (2011). Surveying a landslide in a road embankment using unmanned aerial vehicle photogrammetry. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XXXVIII-1/C22*, 201–206. https://doi.org/10.5194/isprsarchives-XXXVIII-1-C22-201-2011

10. Kaamin, M. A., Idris, N. A., Bukari, S. M., Ali, Z., Samion, N., & Ahmad, M. A. (2017). *Visual Inspection of Historical Buildings Using Micro UAV*. MATEC Web of Conferences, *103*, 7003. EDP Sciences.

11. Williamson, I., Enemark, S., Wallace, J., & Rajabifard, A. (2010). *Land administration for sustainable development*. ESRI Press Academic.

12. U.S. Institute of Building Documentation. (2020). *Level of Accuracy (LOA) Specification Version 3.0*. Retrieved from https://usibd.org/level-of-accuracy-loa-specification

13. European Committee for Standardization (ECS). (2006). EN 14782: Self-supporting metal roofing sheets of steel — Product specification and requirements. CEN.

14. British Standards Institution (BSI). (2016). BS 5427:2016 - Code of practice for the use of profiled sheet for roof and wall cladding on buildings. BSI