RUBENS LAGE LOPES

I have over 20 years of experience in the construction industry, including a background in Civil/Structural engineering and an MSc in BIM Management from Technical University Dublin.

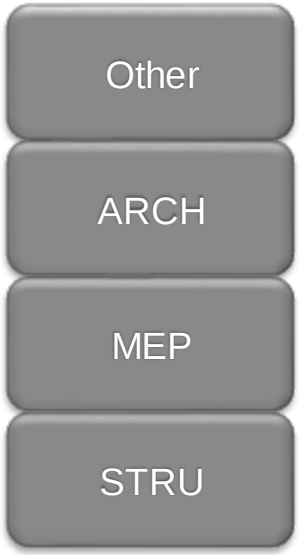
This study was conducted as part of my master's degree at TU Dublin while I was working at BAM UK & I.

I would like to express my gratitude; it would not have been possible without their support.

INTRODUCTION

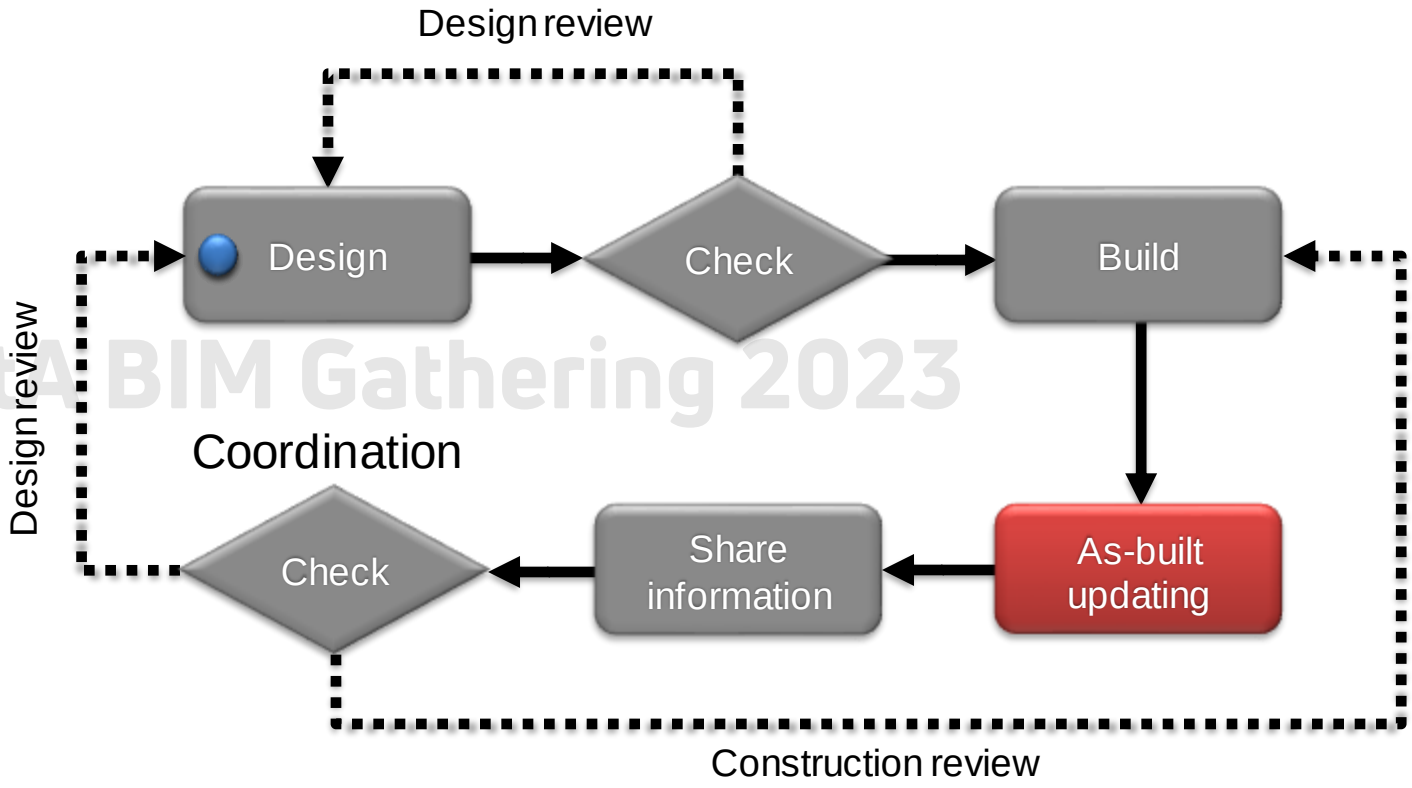
In the BIM life cycle, the as-built model is delivered to the appointing party after the Collaborative Production phase.

All disciplines are interdependent and can be coordinated during the design and construction phase.



CONSTRUCTION PHASE

Updating the as-built model during the construction phase to check deviations from design. It will support design review coordination, progress tracking, and construction quality assurance.



The speed and accuracy of data flow are crucial for maintaining construction timelines and information quality.

PROBLEM STATEMENT

How to enhance the speed and accuracy of the collaborative process of updating as-built models?

Disciplines

- STRU
- MEP
- ARCH
- Others

Data sources

- Design model
- Laser Scan
- Total Station
- Others

Data processing

- Coding languages
- Visual programming

How can Visual Programming scripts enhance the speed and accuracy of the collaborative process of updating structural reinforced concrete as-built models using data from point cloud surveys?

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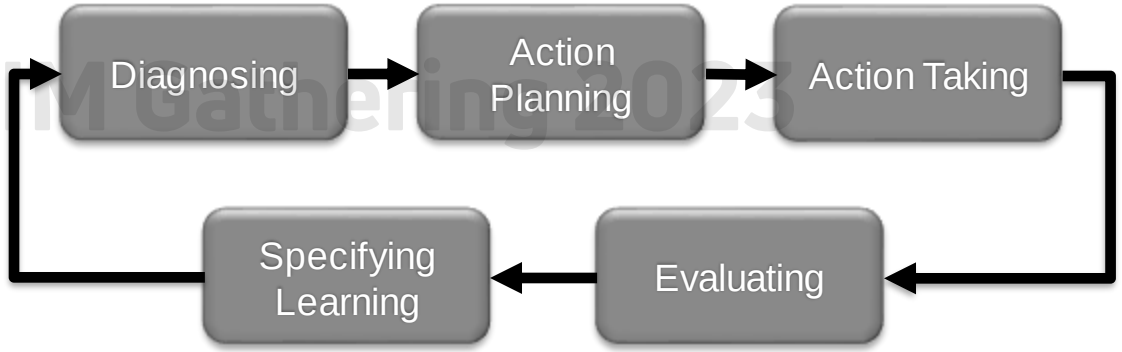
A critical analysis of speed and accuracy when updating structural as-built BIMs with visual programming and point-cloud survey data

Authors: Rubens Lage Lopes and Davitt Lamon

METHODOLOGY WORFLOW

This research addresses the as-built workflow update issue by introducing a VP script for task automation. The action research methodology was chosen for its iterative stages of diagnosing, planning, acting, evaluating, and learning. This cycle is repeated to refine the process and yield improved results.



RESEARCH OBJECTIVES

Objective 1

Conduct a literature review to critically assess the state-of-the-art in algorithmic computing for updating structural as-builts using point cloud survey data.

Objective 2

Critically evaluate how introducing Visual Programing (Dynamo) can enhance the speed and accuracy when updating structural as-built models.

Objective 3

Compare the time and accuracy percentages of tasks using Dynamo scripts with those performed using the established software in the market.

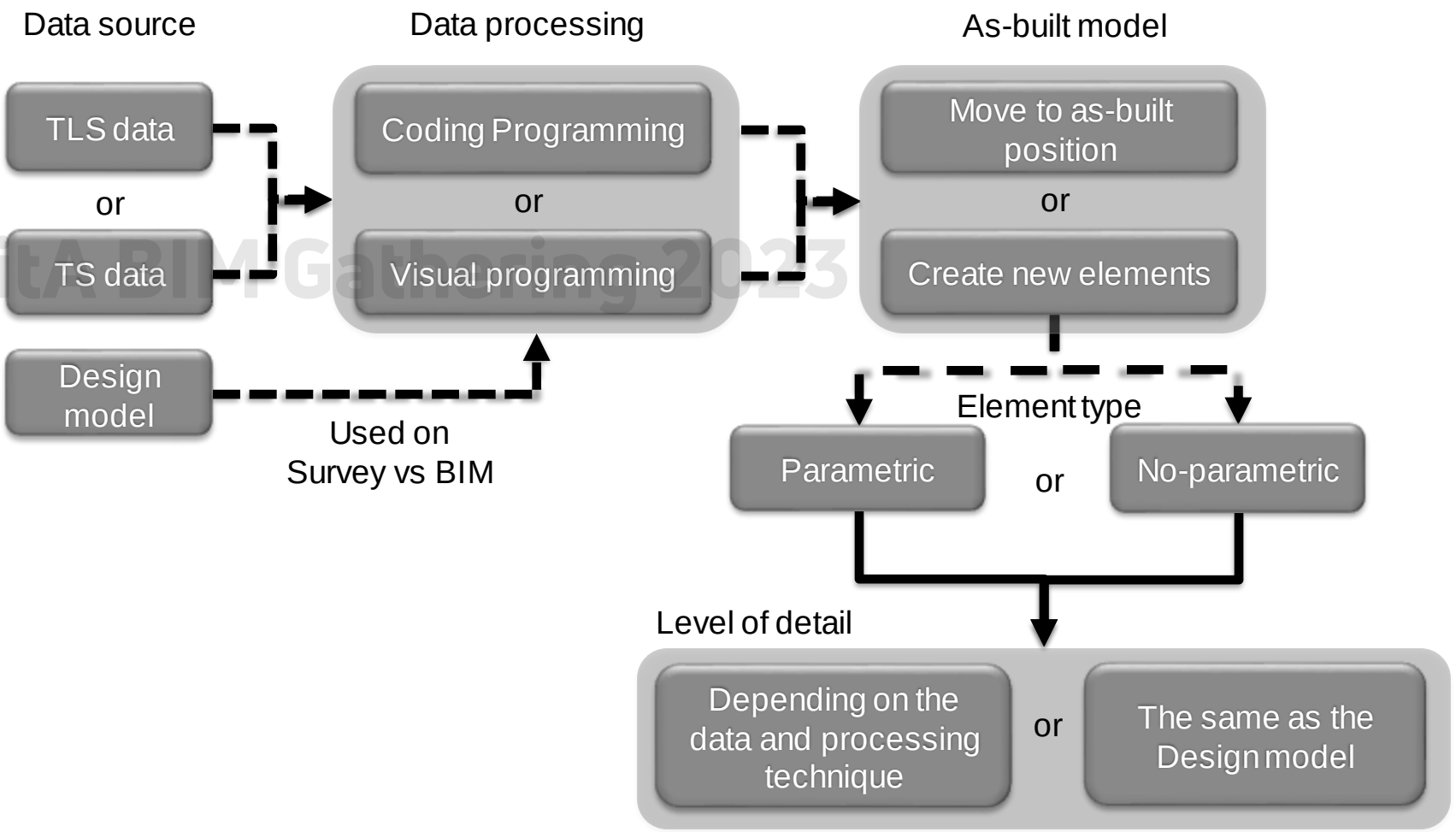
LITERATURE SUMMARY

The literature highlights modeling new elements methods instead of updating design to as-built models. These don't fit the construction update process due to varying LOD and data techniques. Additionally, most workflows prefer Coding Programming Languages over the more accessible Visual Programming.

Aspect	Methodology	Reference Paper	Total
Data Source	TLS	[13] [15] [4] [3] [6] [9] [5] [2] [16]	9
	TS	[10]	1
Data Processing	Coding Programming Languages (CPL)	[13] [15] [4] [3] [9] [2] [16]	7
	Visual Programming (VP)	[6] [5] [10]	3
Element type	Non-Parametric	[16] [13] [15]	3
	Parametric	[4] [3] [6] [9] [5] [2] [10]	7
As-built model	Model new elements	[4] [3] [6] [9] [5] [2] [10]	7
	Point cloud points classification	[16] [13] [15]	3
	Move elements to as-built position	____	0

EXISTING WORFLOWS

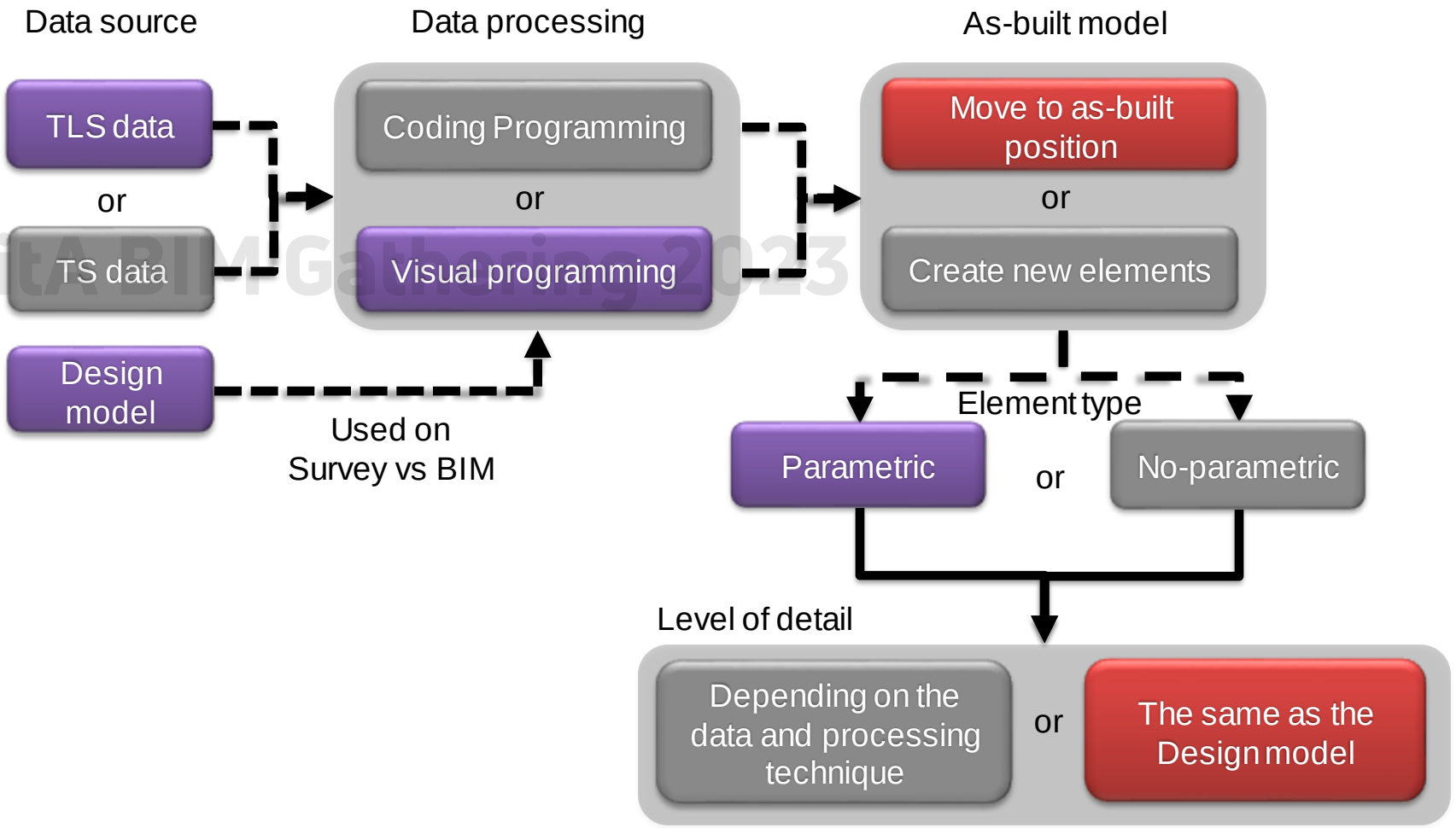
The literature details workflows for as-built model data collection. Selection is based on information use, LOD, and alignment with BEP and EIR tools and guidelines. The processes fall into three stages: data source, data processing, and as-built model.



TLS = Terrestrial Laser Scanning
TS = Total Station

PROPOSED WORFLOW

TLS, Design Model and Visual Programming, moving elements to as-built position turning the Design model into the as-built model.



TLS = Terrestrial Laser Scanning
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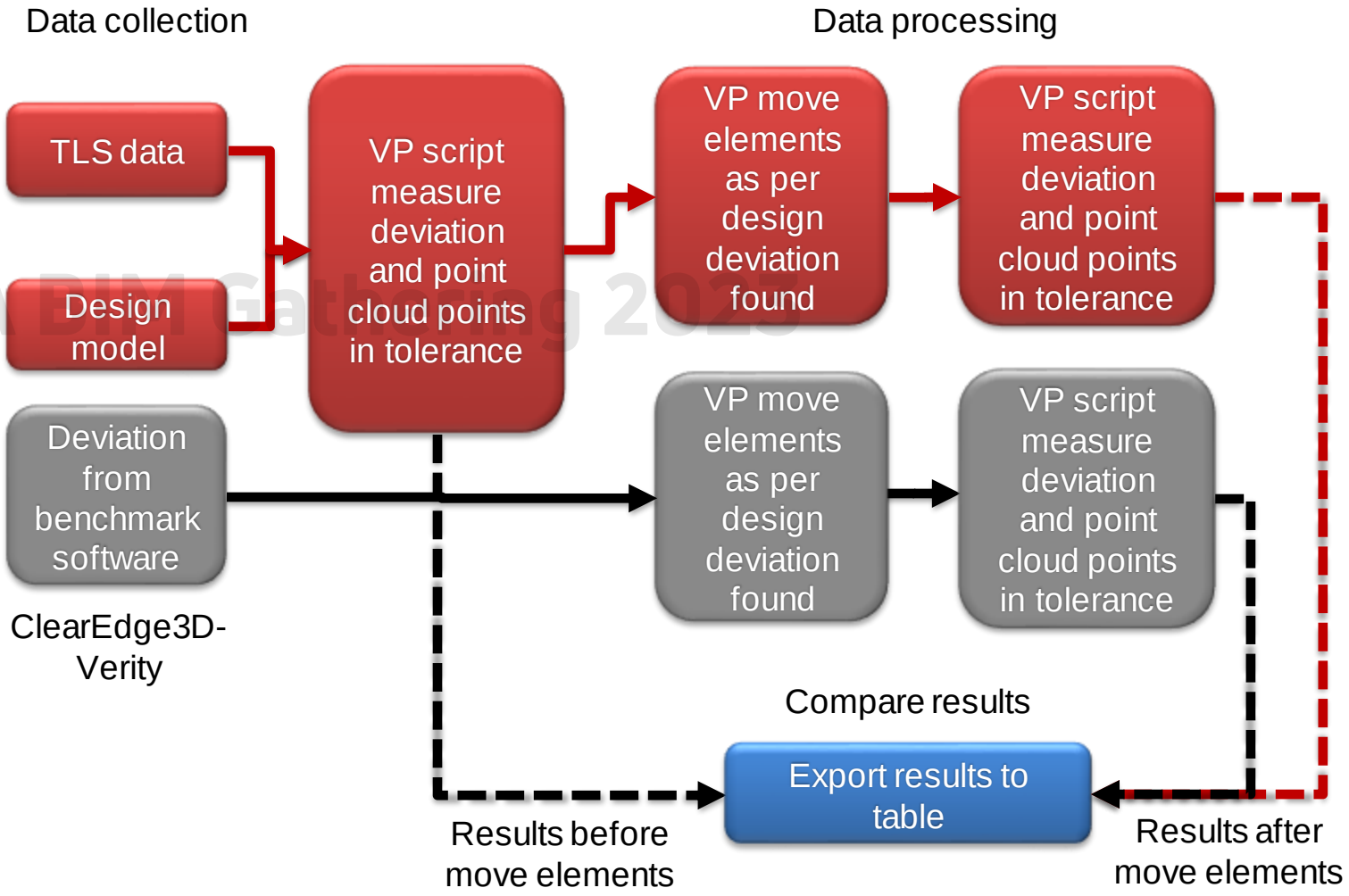
ACTION PLAN

To evaluate the solution's accuracy, we'll count point-cloud points within design tolerance before and after adjusting the design element to its as-built position. This will be compared using deviations from both the proposed solution and the benchmark software. The plan encompasses four phases: data collection, processing, comparison, and result analysis.

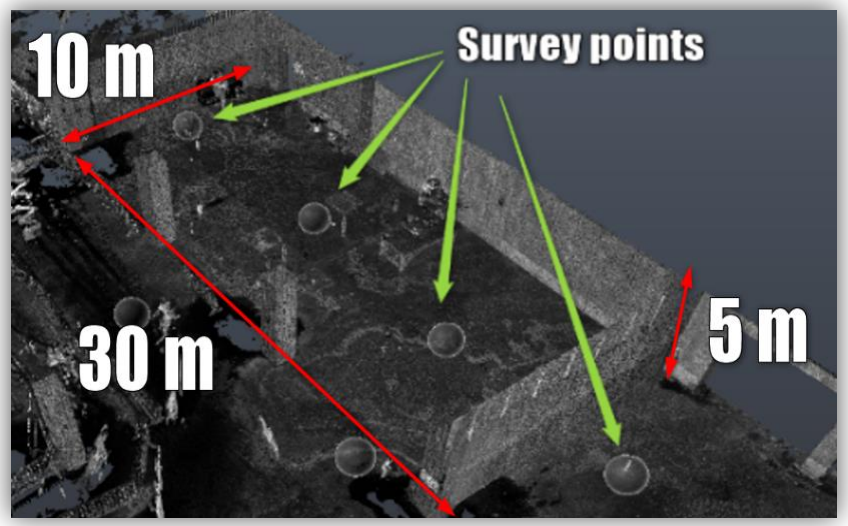


DATA SOURCE

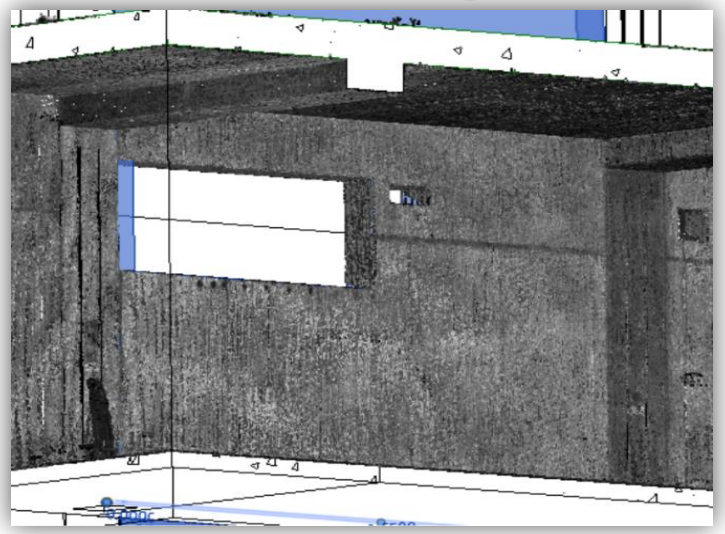
A 10m x 30m x 5m area. One floor with 16 parts, 7 walls, 8 columns, and 2 beams. This region was laser-scanned four times. Using a Leica P40 TLS, capable of scanning up to 1 million points per second at ranges up to 270m.

DATA PROCESSING

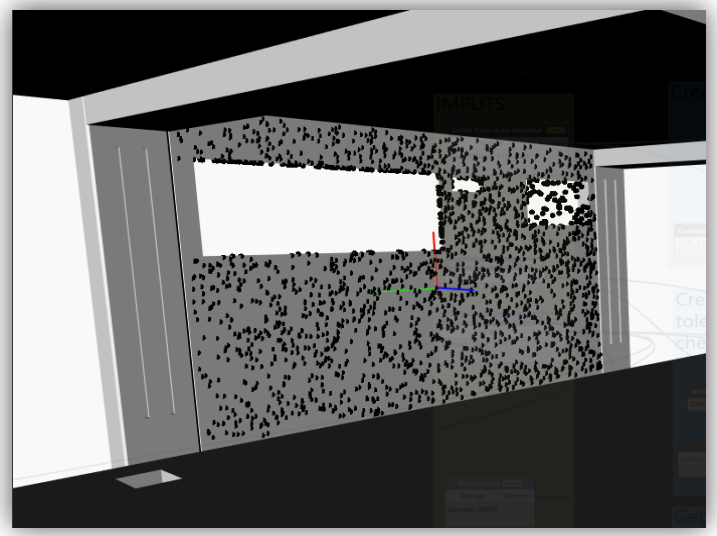
Dynamo version 2.1. Computer i7 11th Gen Intel(R) Core (TM) - 2.80GHz processor and 16.0 GB RAM.



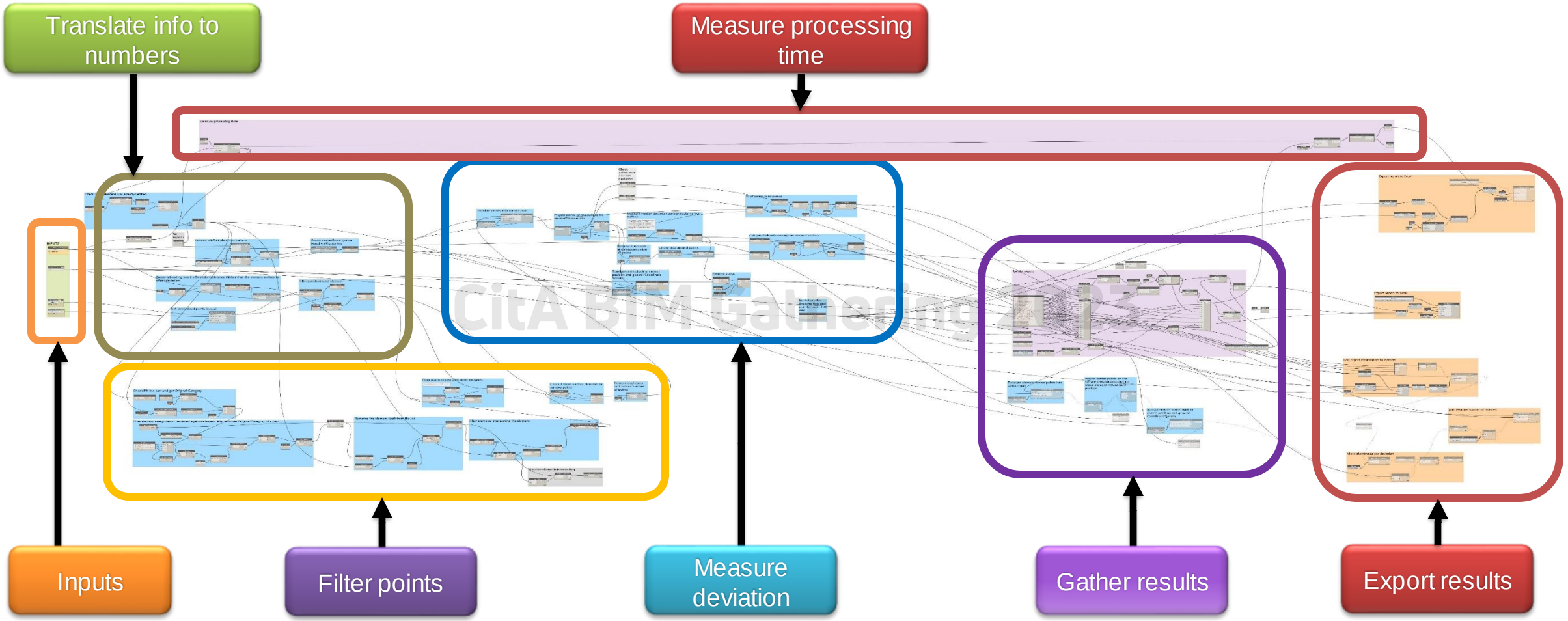
Point cloud



Design model + Point cloud



Dynamo visualization


Translate info to numbers
Measure processing time
Inputs
Filter points
Measure deviation
Gather results
Export results

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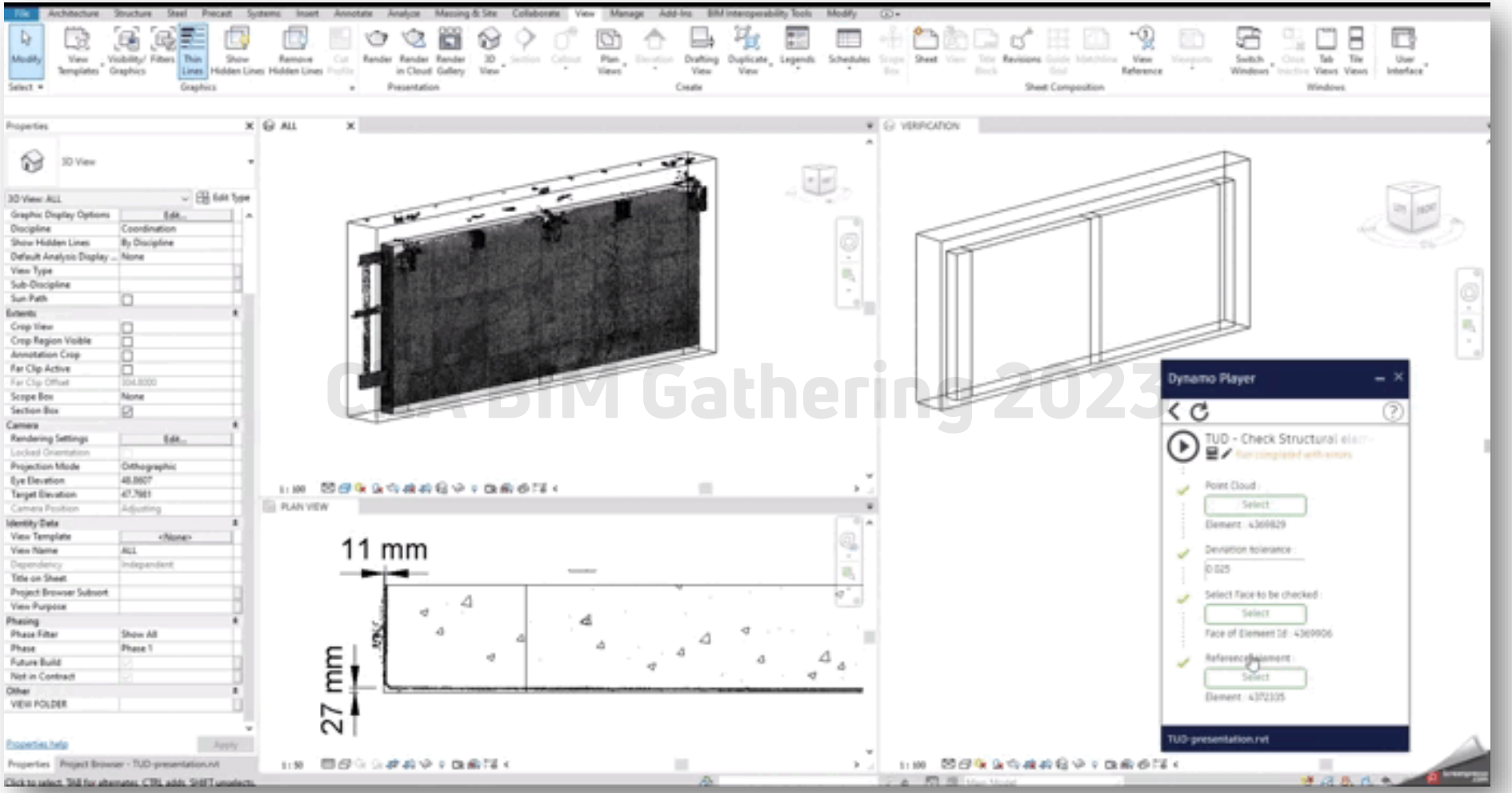
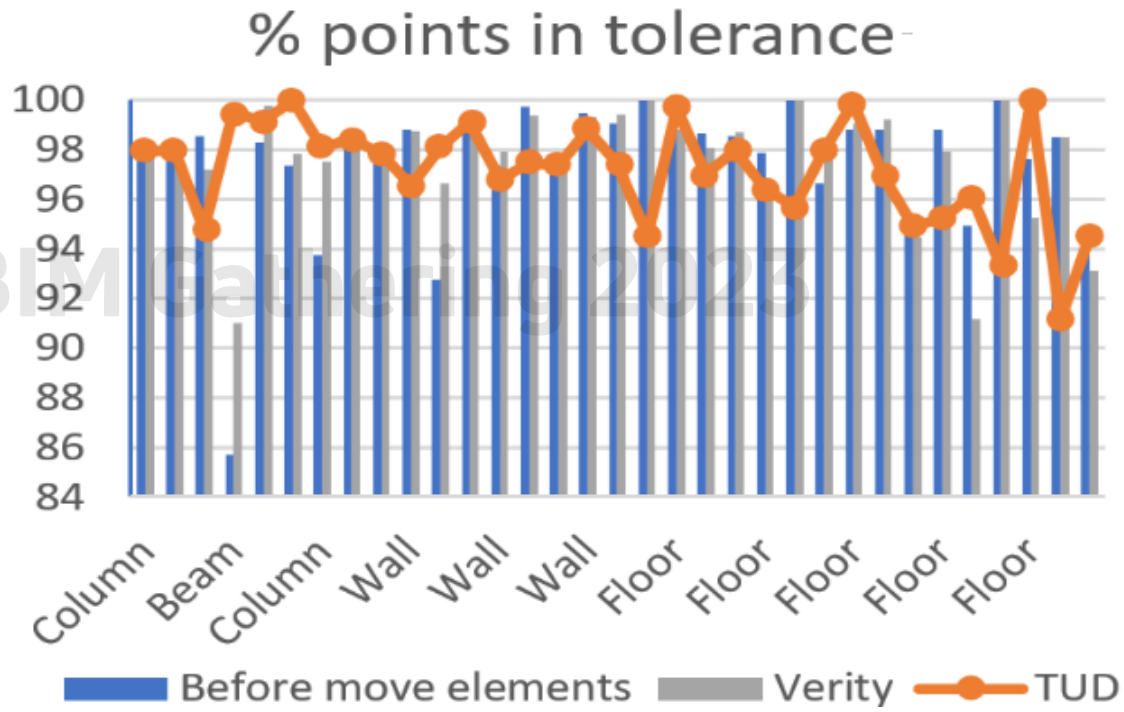
Experiment



ACCURACY

Of the 33 elements, TUD improved the tolerance points in 13 instances (39.39%), while using the deviation from the benchmark software showed improvement 15 times (45.45%).

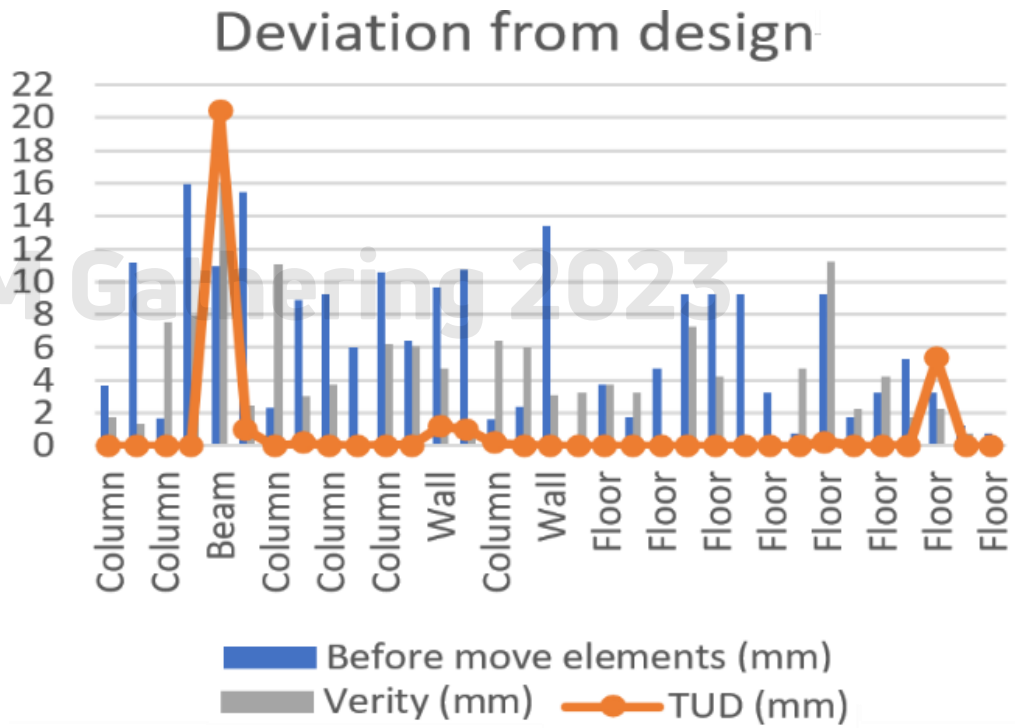
Both results were under 50%, suggesting the accuracy parameter might be irrelevant or inaccurately measured or was not measured correctly.



MOVE ELEMENTS TO AS-BUILT POSITION

In the total of 33 elements, TUD reduced the as-built element distance from the median point-cloud plan 31 times (93.94%).

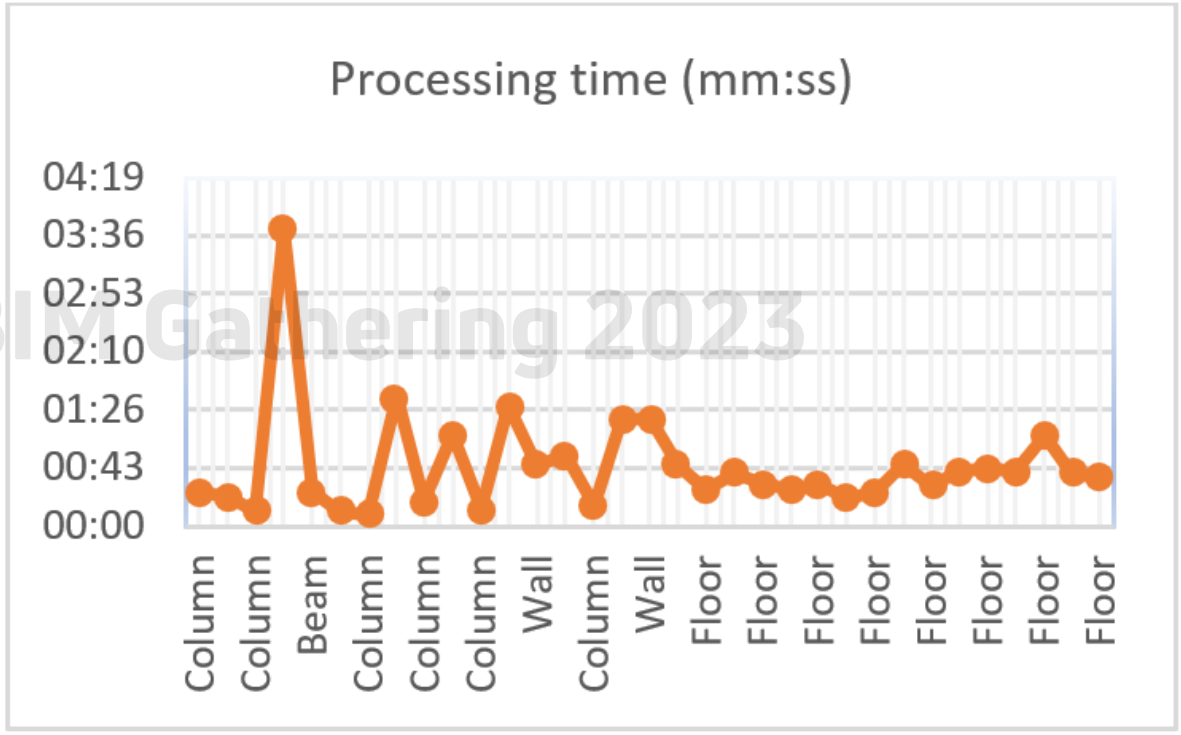
While moving the elements using the deviation from the benchmark software, reduced the distance 21 times (63.64%).



PROCESSING TIME

The reference software's processing time was unavailable.

The proposed script averaged under 1 minute, significantly faster than manual analysis and adjustments of the point cloud.



CONCLUSION

Design deviation was measured by the distance between the design and the median point-cloud plan. TUD succussed 93.94% of 33 elements, while the benchmark hit 63.64%. With under a minute per element, TUD's method is quick. Though 0.48% less accurate than the reference, its promise suggests room for improvement.

Aspect	Benchmark software	TUD script
Improve accuracy	15 out of 33 (45.45%)	13 (39.39%)
Move elements to as-built position	21 out of 33 (63.64%)	31 (93.94%)
Processing time	Not available	> 1 minute

FURTHER STUDY

The study assessed design deviations based on perpendicular distances in point-cloud data. Future research could explore deviations in x, y, z axes, and element rotation, possibly integrating deep learning in BIM. Such advancements can refine accuracy and introduce innovative methods in construction data management.

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“You can’t improve what you don’t measure.”

Attributed to Peter Drucker

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THANK YOU