On-Site Design and the Implementation of Laser Scanners and Virtual Reality

Carlos René Vides Caballero

Introduction

Field data accuracy, crew safety and overall project engineering value may be increased by integrating laser scanning and virtual reality to typical on-site design practices. This integration can in turn be streamlined to reduce time and costs of plan production. The nature of the laser scan provides automated and accurate measurements guaranteeing minimized data loss between the field and the office when compared to standard surveying methods. Additionally, virtual reality provides designers with a versatile and natural interaction with the site.

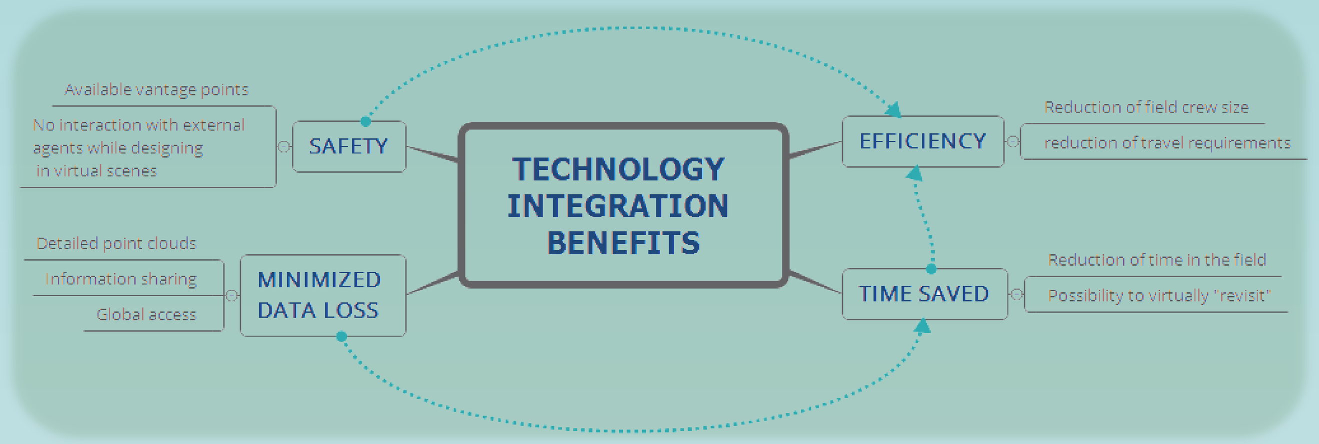

FIGURE 1 – Integration Benefits

Process

The selected on-site design process consists of:

- Field data collection: gathering and sketching measurements of existing features and taking photographs
- Field design: identifying issues, potential conflicts, taking relevant notes and sketching the proposed solution
- Transferring sketches and notes to digital media to produce existing conditions diagrams
- Modifying and finalizing proposed design

The proposed process after integration of technologies consists of:

- Field data collection: scanning the location including a 360-degree photograph
- Converting scan into a virtual scene
- Design: virtually identifying potential issues and conflicts and corroborate measurements within the scan
- Produce existing condition diagrams from the scanned point clouds
- Modifying and finalizing proposed design

Case Studies

Case Studies were conducted at five different locations, three in Texas and two in Portugal. Figure 2 shows the three scan locations along Fredericksburg Road near the intersection of Mockingbird Lane in San Antonio, Texas. Figure 2 also shows the two scan locations taken at the Faculdade da Engenharia da Universidade do Porto (FEUP). Virtual reality scenes were produced out of the scan conducted at these locations.

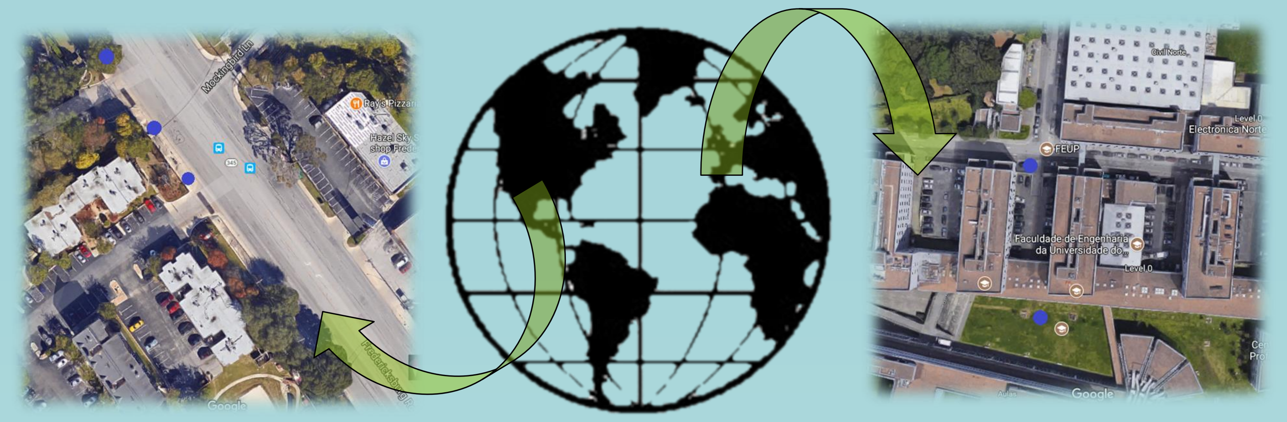

FIGURE 2 – Location Maps (Source: google images)

Original Process Execution Results

The implementation of the selected process presented no unusual setbacks. Figures 3 through 6 illustrate the results.

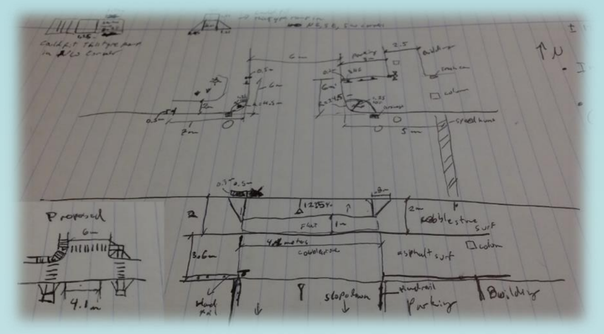

FIGURE 3 – Porto Intersection Sketch

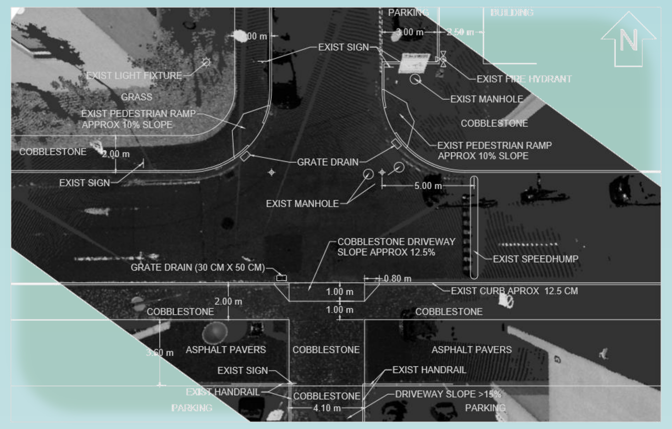

FIGURE 4 – Porto Intersection Existing Diagram

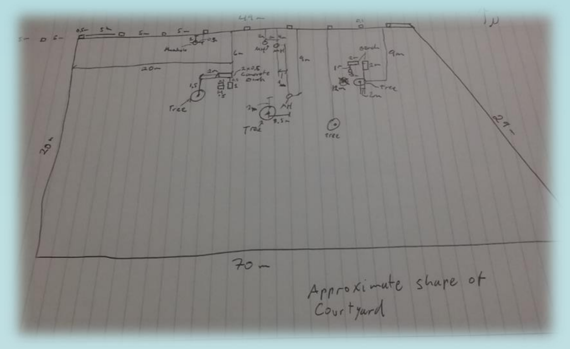

FIGURE 5 – Porto Courtyard Sketch

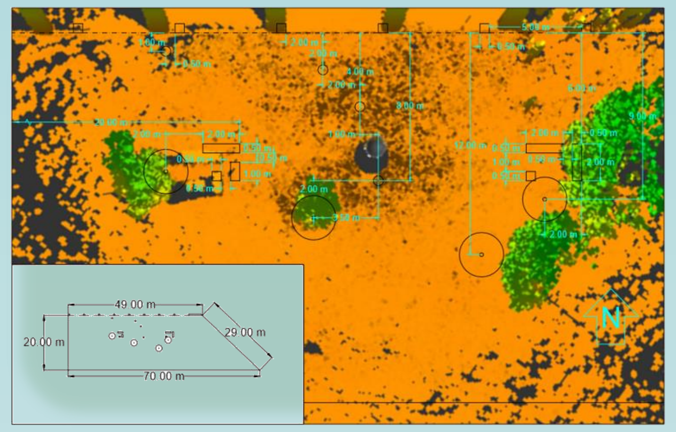

FIGURE 6 – Porto Courtyard Existing Diagram

Proposed Process Execution Results

After struggling with software and file format incompatibilities, mesh generation was finally accomplished. Figure 7 shows the user interface after virtual scenes were generated for the case studies.

FIGURE 7 – Natural User Interaction with Virtual Scenes

Following the initial interaction with the scenes, measurements took place inside the scans, as shown on Figure 8.

FIGURE 8 – Point Cloud Measurement Examples

Based on virtual interactions and point cloud measurements it was possible to create accurate designs and field conditions exhibits, as shown on Figure 9.

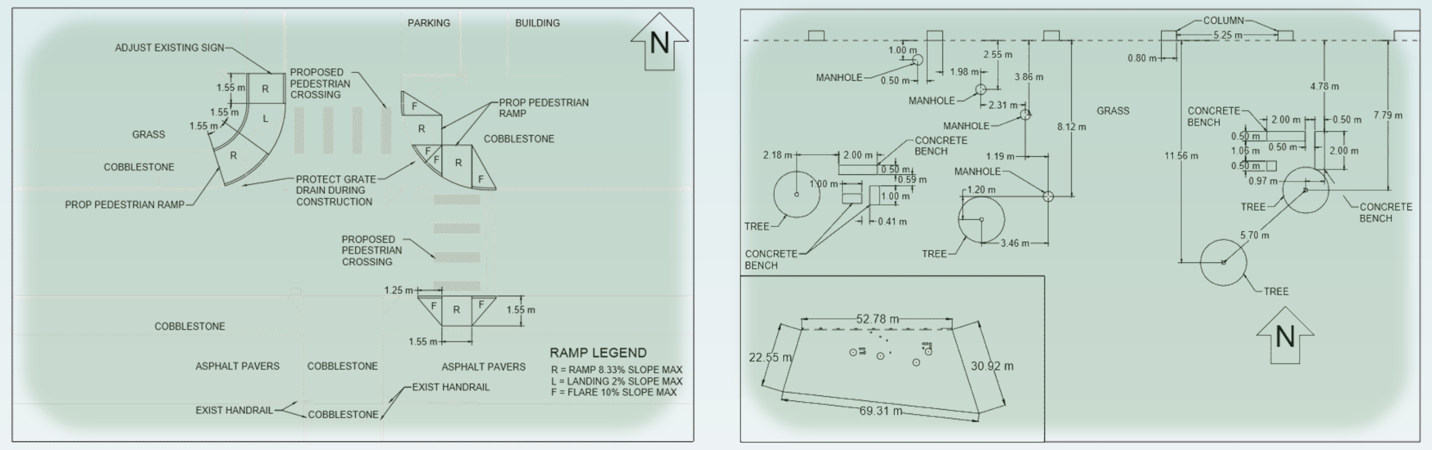

FIGURE 9 – Final CAD Exhibits (not to scale)

Discussion & Comparison

Comparative Analysis Table

Criterion \ Location & Process	ORIGINAL PROCESS Loc 1	ORIGINAL PROCESS Loc 2	ORIGINAL PROCESS Average	PROPOSED PROCESS Loc 1	PROPOSED PROCESS Loc 2	PROPOSED PROCESS Average
Time Spent in the field	90 min	150 min	120 min	20 min	20 min	20 min
Drafting Time required	45 min	60 min	53 min	30 min	45 min	38 min
Clarity of Field Data	3/5	2/5	2.5/5	4/5	4/5	4/5
Field Data Accuracy	3/5	1/5	2/5	5/5	5/5	5/5
Data Handling	4/5	4/5	4/5	2/5	2/5	2/5
User Interface	2/5	2/5	2/5	4/5	4/5	4/5
Reproducibility of Results	4/5	1/5	2.5/5	4/5	4/5	4/5

In the comparison table above we can see that the proposed process outperforms the existing method in most categories. Reductions in data collection and design times could be immediately exploited in the industry. The accuracy and minimization of data loss also provides tremendous benefits to designers. However, the time and equipment required to generate a traversable virtual reality interface relevant to the design process should not be ignored. While this study provides proof of concept, there is still a technological gap in point cloud to mesh surface conversion, as the models are not aesthetic enough for all audiences.

Conclusions

Currently the proposed method would produce similar overall positive results and benefits if the virtual reality portion of the process were removed and the laser scans were implemented on a large scale. A natural user interface would not be possible for non-engineers or designers, but staff executing this method is expected to be proficient with point cloud manipulation. The accuracy that laser scanners bring to design opens many capabilities for future application, including a full replacement of current surveying methods. Further research in the field of point cloud to mesh conversion processes is recommended to close the existing technological gaps encountered in this project.

Escuela Técnica Superior de Ingenieros de Caminos, Canales Y Puertos.
UNIVERSIDAD DE CANTABRIA