Case Study Title: Automated Reality Data Capture and Analysis

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Since entering the Irish market in 2006, our service and sector offer has grown considerably to cover aviation, data centres, technology, and commercial offices. Today, we're an established top 10 construction contractor in the country and our consultancy team has been instrumental in delivering a series of major projects and programmes across the breadth of the infrastructure industry.

With Irish infrastructure schemes receiving significant investment as part of Project Ireland 2040, there is a healthy long-term pipeline of major projects and programmes in the country. Add to this, overseas investment in exciting sectors like offshore wind-farming and data centres, and it's clear that Ireland is set for a construction and infrastructure boom over the next two decades.

To support Ireland in rising to the challenge and building the property and infrastructure it needs, Mace is using its unique blend of global construction knowhow and consultancy expertise to offer a different perspective through project and programme management, PMO, cost and commercial services.

Meanwhile, our construction business offers a complete set of delivery and procurement solutions across a host of sectors, including commercial, data centres, aviation, and technology. In recent years, we've seen success in delivering the next generation of hyperscale data centres for leading tech giants. Applying advanced offsite and digital solutions, our team has driven service excellence in the sector, delivering best in class projects, recognised as such by the industry.

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Overview & Background to the Lean Initiative

Background

The current method of capturing and analysing point cloud data from construction sites is a manual and time-consuming process. The time it takes from the moment data is captured to the moment it is analysed is lengthy, resulting in a protracted process of establishing a digital twin and poor turnaround time in QA/QC installation verification.

Lean Initiative:

We have introduced an automated process of capturing data on site, underpinned by technology, which utilises:

- 'Spot' the Dog robot by Boston Dynamics with a Trimble XR7 laser scanner to capture reality point cloud data via automated route selection.
- Trimble FieldLink which processes and streamlines point cloud data.
- CloudEngine that allows to carry out automatic installation accuracy analysis between point cloud and BIM model.

The combination of the above listed elements allows us to capture larger quantities of high-quality laser scan data, process the information and analyse the findings in a faster, more effective manner. This also allows us to use that data to improve efficiency onsite and enables the utilisation of new technologies such as automated progress and commercial reporting.

Figure 1: Spot the Dog Robot by Boston Dynamics

Lean Initiative Undertaken – Lean Thinking, Tools, Techniques

In January 2022, we began a trial at our hyperscale data centre project in Clonee, Co. Meath to test the capabilities of the Spot the Dog robot by Boston Dynamics with a Trimble XR7 laser scanner and previously mentioned software. To make sure we conducted the trail in an effective manner, we introduced lean techniques to bring added value to our investigative efforts.

Step 1: System Tree Assessment

To truly understand the benefits of the automated robotic alternative approach to capturing laser scans, we first needed to understand the main components of work activities that made up the process of capturing laser scan information from the field and how this information was used by our teams.

1. The initial component of work was the physical scanning of the construction environment by an engineer. In our example, this was work undertaken by an external engineering company. This was an activity completed in an ad-hoc manner during the project, to ensure we gathered enough laser scan information to form a digital twin as-built model of the building we were constructing. An as-built model was a specification requirement and was essential to the handover process to the client at the end of the project. This process included the completion of individual scans in a grid format of each individual room of the building.

2. The next stage was the combining of these scans into one overall laser model i.e. "Registering" the laser scan models into one combined file.

3. This is followed by sharing the information with our BIM team. Due to the file size and the fact that actions 1 and 2 are completed by an external company, this can take several hours.

4. The laser scan file is reviewed by our BIM team who compare the laser scan information against the live construction model. This was a manual process taking multiple hours of work, where clashes and/or deviations of constructed elements were identified against the BIM model.

5. This information was then shared with the trade contractors and our construction management team, so that appropriate actions could be completed such as:
   • Deviations or wrongly installed elements in the field could be noted as defective and mitigation measures could be completed;
   or
   • The laser scan information could be used to inform the construction model and an as-built model can begin to be generated.

Step 2: Value stream Assessment

We then used value stream analysis to gain a full understanding of this original manual process used to record and analysis laser scan data. The following graphics provide an illustrative view of the before and after results of our initial desktop findings after we introduced time. The potential benefits of an automated process were evident and informed how we should complete our trial.

Industry Standard Workflow

Figure 2: Industry Standard durations

The analysis of our existing process without the robot dog, showed that there could be as much as a 10-day turnaround for the entire process as follows:

- The initial "Capture" phase would be a 2-day period of laser scanning across multiple locations on site.
- This would be followed by 1-day to process and register ("Alignment and Registration") all the individual scans into one zoned laser scan.
- The next stage is the transfer of this information to our internal teams ("Data Transfer.")
- The fourth phase ("Analysis") is the deviation and progress analysis of the construction works onsite by comparing the laser scan against the live construction BIM model. This is a manually intensive review, where clash observations are recorded by our teams individually.
- Lastly, the final phase ("Action") included multiple activities, depending on the findings of the analysis phase.

Robotic Automated Workflow (Near-Term)

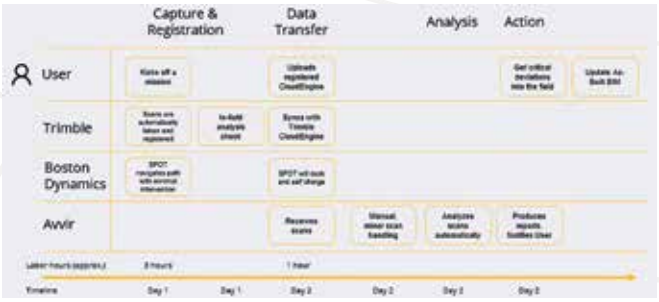

Figure 3: Improvement on Standard Duration

Our near-term view of the benefits of the robotic automated approach showed that we could vastly improve on the turnaround time for processing the reality capture data, which has significant benefits when it comes to identifying and mitigating QA/QC issues in the field. A two-day turnaround, in comparison to 10 days provides opportunity for much earlier identification and rectification of defective work, avoiding expensive reworks later during the construction phase.

Robotic Automated Workflow (Future)

And finally, the long-term goal would be to get immediate feedback between gathering information in the field and comparing it against

the Construction model via view analysis in the field.

Figure 4: Proposed improved duration.

Lean Initiative Improvements & Impact

The outcomes of our trail showcased that the 'Spot' the Dog robotic solution, combined with Trimble hardware and software is a viable option that can be used in the construction environment. We have reviewed and proven its use as follows:

Security

- We developed new security protocols to protect the use of the robotics during its operation. The preferred operation period is overnight, as this ensured the risk of conflict with live construction works was eliminated. It also ensured that the natural interest of construction personnel was avoided, which meant the laser scans themselves were not impacted.
- A dual approach to GPS tracking for both internal and external movement was implemented.
- We also developed a unique doghouse solution, which provided security for the hardware in the field while not in operation, but it also doubled up as a useful method to transport the hardware to different location across large sites.

Logistics

- The doghouse solution was a custom design developed by our team, to provide multiple benefits such as a safe transport solution of the hardware, stable base location for onsite positioning, secure storage, and a work platform for the onsite engineer.

Legal

- We took the time during the trial to ensure the legal aspect of operating the robot was fully reviewed and the correct insurance protocol was put in place.
- GDPR was also taken into consideration and a modification of our Data Protection protocol was completed to ensure legal compliance.

Site Utility

- While 'Spot' can operate independently on its own private Wi-Fi network, we investigated what onsite utility connections would benefit the future use of the hardware in the field such as 5G connectivity and hard-line fibre/Cat6 connection at charging dock locations.

Figure 5: Logistic storage and Operator Interface

Data

- One of the main outcomes is that the potential quantity of laser scans that can now be completed will generate a huge increase in the amount of online storage required to reality capture data. We reviewed this with our internal IT team and identified a preferred approach, utilising the Trimble CloudEngine licence as cloud storage to manage this information during the project.

One of the main successes of the trial came in July last year, when we achieved a 10hr, 100 scan mission in fully autonomous mode. It was a world first for the operation of the Spot the Dog robot, completing all 100 laser scans in fully autonomous mode. This also included the first time globally that auto charging was utilised on a laser scan mission. This was completed coordination with the Boston Dynamics and Trimble teams, a partnership we continue to foster.

Summary and Lessons Learned

Through the continued testing of the robotics in the field, we were able to identify the optimal scans of scan mission we undertook. This ensured that the laser scan model generated for each mission was manageable in file size for our BIM team when it comes to the automated review of the data against the BIM model in CloudEngine.

As a result of our trail, we have now progressed the robotic laser scanning platform into operation. We developed our user guidance

manual and ensured that this laser scanning solution is now used on all our projects moving forward into the future.

We continue to foster the relationship with Trimble and Boston Dynamics and have begun the process of working with them to enable the robotic dog to be used for complete Geo Technical surveys, photographic assessments, laser scanning, heat mapping etc. The roadmap of development for this robotic solution is bright and we look forward to advancing its use to improve its return on investment.