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2023 TECHNICAL AWARDS ENTRY FORM

Extended Entry Deadline: Thursday 6th April 2023

Please tick which categories you are entering (entries may be submitted in multiple categories using the same entry form)

Landbased Pipeline Project Award	☐
Landbased Pipeline Technology Award	☐
Utility Pipeline Project Award	☐
Utility Pipeline Technology Award	☑
Subsea Pipeline Project Award	☐
Subsea Pipeline Technology Award	☐
iICE Award	☐

1. **Brief title of entry:** **AUSMOS: Improving GPR Data Collection**
2. **Company name:** **ULC Technologies**
3. **Signed:** **Nathan King**
4. **Date:** **06/04/23**
5. **Company contact name:** **David McLeod**
6. **Telephone:** **07531 535942**
7. **Email:** **david.mcleod@spx.com**

8. **Precis of your entry (50 words):** ULC Technologies, in collaboration with SGN and Transport for London have developed the next generation of GPR technology. The Automated Utility Service Mark-Out System (AUSMOS) is a semi-autonomous robotic platform that collects denser GPR data and marks-out below-ground infrastructure to reduce the risk for accidental damage to buried assets.

9. Summary of entry:

Ground penetrating radar (GPR) can penetrate the ground and measure both the electrical properties of the subsurface as well as other physical characteristics such as stone/rock composition. It can also be used for a variety of applications including identifying the location of buried objects and mapping underground utilities. However, GPR is still not used as widely as it should be today in the industry due to the GPR processing method being very time-consuming and technically challenging because of the precise adjustments that must be made in order to collect accurate results. Errors from human or machine sources must be manually identified and corrected before detailed analysis can begin. In addition, due to its complexities, GPR data processing and interpretation has traditionally taken place offsite. This process can introduce significant delays to projects.

Using learnings from the below ground sensor capabilities of the Robotic Roadworks and Excavation System (RRES), ULC Technologies developed the Automated Utility Service Mark-Out System (AUSMOS) in collaboration with SGN and Transport for London. AUSMOS (Figure 1) is a semi-autonomous robotic platform that detects and marks-out below-ground infrastructure utilising a sensor suite comprised of ground penetrating radar and electromagnetic sensors. This robotic platform automates underground mapping enabling denser GPR data collection and more powerful post-processing techniques that results in easier to interpret data, reducing the risk for accidental damage to buried assets. AUSMOS can provide a variety of benefits when collecting and mapping underground assets compared to traditional methods, including same day data collection, processing and road mark out; higher density and higher resolution data; no human bias/error in data collection; accurate localization in GPS denied environment; fully autonomous and simple deployment.

<u>AUSMOS Pilot - Clapham Hill, London UK:</u> ULC's operatives deployed AUSMOS on two adjacent sites at Clapham Hill, London, where it successfully completed an operation from scanning through interpretation and mark-out. This autonomous mapping took place in a semi-congested region as traffic continued flowing with minimal disruption to local residents. While abiding by regional traffic management guidelines, AUSMOS mapped out a 25m^2 region within a few hours. This mapping process took place in an urban environment in southwest London where GPS signal can be sporadic. As AUSMOS' localization is GPS agnostic, its results were not impacted. At Clapham, ULC identified two sites for mapping (Figure 2) and for these scans, ULC's team requested the utility maps from the respective owners and was used for qualitative analysis (Figure 3).

At each respective site, ULC's team deployed AUSMOS using its ground penetrating radar and electromagnetic sensors. During these tests, all processing was done onsite by ULC's team of two, without evaluation by a subject matter expert. This interpretation was performed through AUSMOS's user interface where both 3D and 2D results are shown (Figure 4). Following processing, indications of assets were marked-out by the operators using the robot (Figure 5). Following mark-out ULC's team captured drone images that could be used for qualitative analysis of the results. The analysis was focused on three main areas of interest: agreement with existing utility drawings; AUSMOS' mark-outs in correspondence to the existing pit on site; the correspondence of mark-outs in adjacent areas and their localization relative to each other.

Firstly, results were evaluated in the context of the available utility drawings. Site 1 identified three potential assets, but these mark outs do not include that of the exposed 24" pipe. This was expected because the robot did not capture data on the walkway at site 1, and as a result, did not cross over the asset in question. However, since site 2 crossed over the region, this pipe became visible in the second scan area. Of the assets captured in site two, one asset should be expected to be the 24" cast iron gas main, and the others may include the water/trunk mains. In addition, it's worth noting that data acquisition was performed in a single antenna orientation for both tests. Where traditional GPR systems map utilities using grid scanning techniques, AUSMOS' post-processing is more agnostic to the antenna orientation during data collection. This post-processing allows for its system to capture and reconstruct data in more generalized orientations more effectively than traditional GPR processing algorithms.

The second area of interest was related to the mark-outs correspondence to existing infrastructure, in this case the pit. To evaluate the relative accuracy of the mark-outs, the drone images were used to project the potential path of the 24" gas main. These results were then qualitatively compared to markings made by AUSMOS which showed strong correspondence. This comparison (Figure 6) and shows the accuracy of the localization of the robot in urban environments. The final evaluation includes the that of comparison between both independently mapped regions. In this case, the focus is paid to do potential assets that appear in adjacent regions reflect mark outs that are in agreement. This test seeks to understand the robot's repeatability of measurement. To make this assessment, the drone image is used to draw projected mark-outs from site 1 into site 2. The results show that these mark outs agree with each other highlighting the repeatability of the processes (Figure 7).

Ancillary Entry Information

(Entry restricted to normal type face and font size on this form plus no more than 3 pages of A4 drawings or photographs)

Figure 1: AUSMOS scan and mark-out

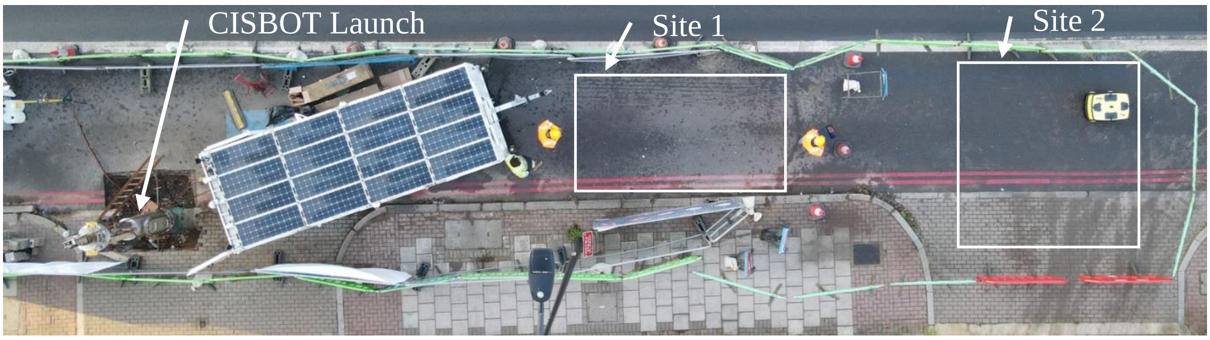

Figure 2: Two adjacent mapping sites for AUSMOS at Clapham Hill, London.

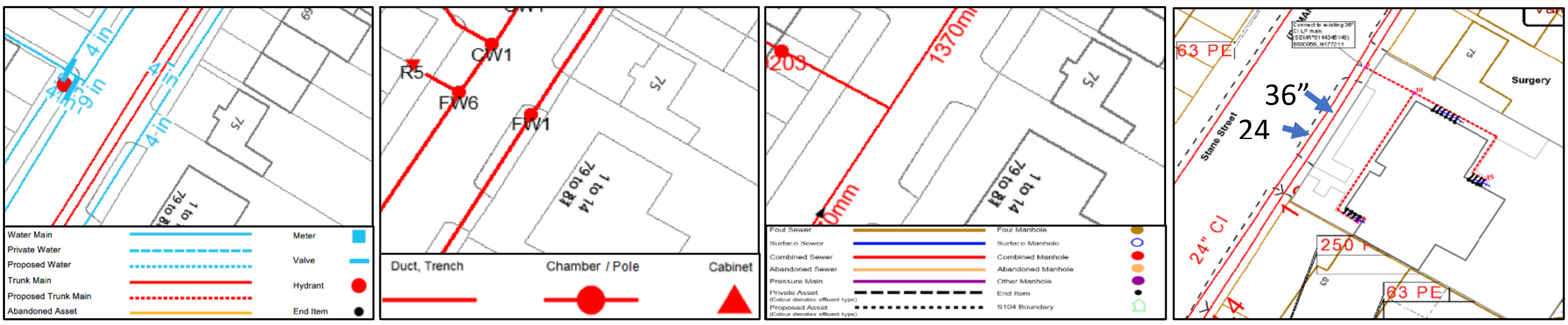

Figure 3: Utility survey of region of interest.

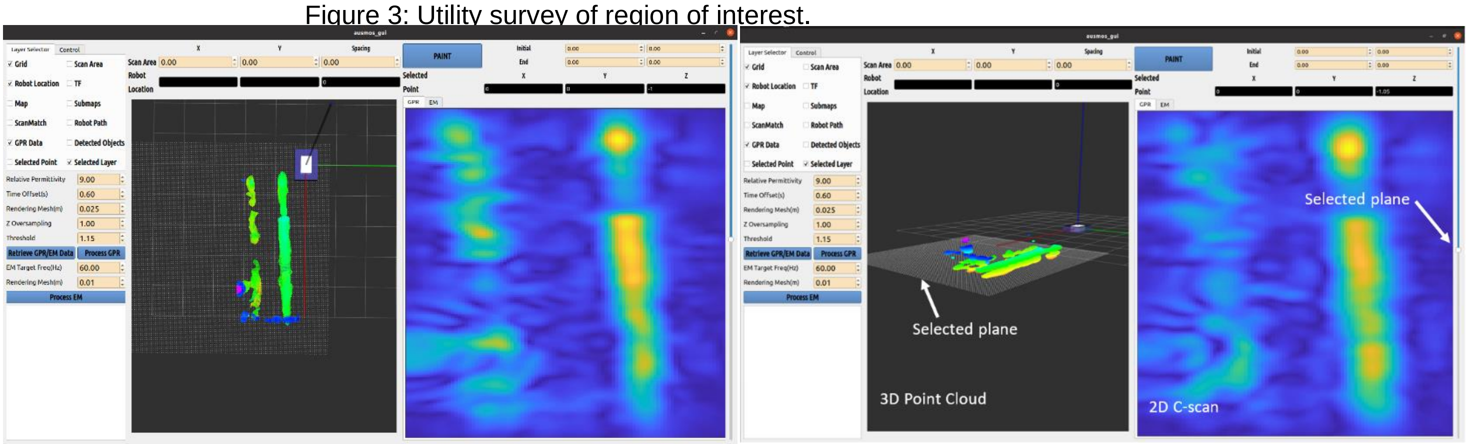

Figure 4: Site 1 ground penetrating radar outputs used by the operator to facilitate ground mark-out. The corresponding C-scan may be found at: https://youtu.be/ZMVVwMgDI1o.

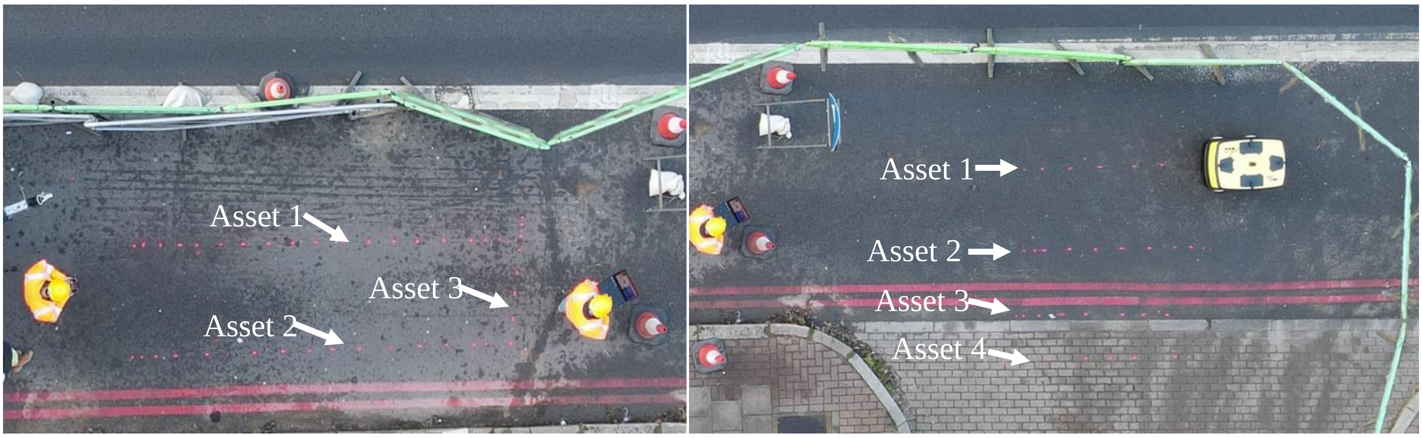

Figure 5: Same-day mark-out performed by AUSMOS at Clapham

Figure 6: Projection of paint marks to exposed pit and correspondence to AUSMOS mark-out. The white line shows the projected path of the 24” gas main into site 2. The yellow lines highlight the actual line marked out by AUSMOS.

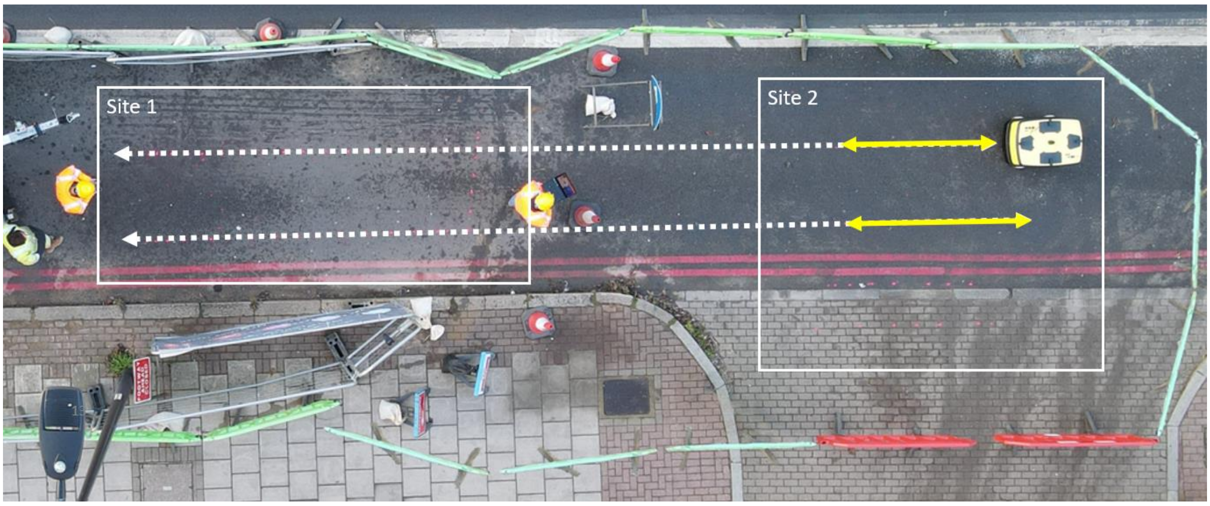

Figure 7: Comparison of paint marks in two adjacent regions that were scanned and marked out independently of each other. The white arrow shows the projection of mark-outs from site 1 into site 2. The yellow arrows highlight the paint markers placed at site 2.