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Emerging inspection techniques for proactive railway drainage management

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Abstract

This paper examines the potential for emerging technologies to more effectively identify and inspect railway drainage assets. More effective inspection would enable targeted maintenance. This would help to reduce track flooding impacts and water related damage to other assets (such as earthworks) whilst minimising the risks and costs associated with work that currently requires trackside access. A horizon scan identified emerging technologies, while a visioning workshop and interviews with rail drainage engineers helped to explore their potential. Physical tests examined the suitability of some of the identified mid-term solutions (Manhole Zoom Camera, SewerBatt™, and Thermal Imagery) in a controlled laboratory environment and subsequently in real track drainage. Results show that SewerBatt™ can identify the position of features to ± 0.3 m, while empirical relationships are proposed to estimate the dimensions of these features via the Manhole Zoom Camera. Aerial thermal images showed variable data making the detection of buried pipes uncertain. However, they do demonstrate a capability to identify catchpits in a buried drainage pipe.

Keywords: railway drainage; horizon scan; inspection; proactive maintenance.

1 Introduction

This paper describes work carried out to identify and assess existing and emerging inspection technologies that may have the potential to provide improved methods for the identification and inspection of assets in railway drainage systems. This work was carried out to address the need to reduce track flooding impacts and water related damage to other assets (such as earthworks) which is often caused by the poor condition drainage assets.

Blockages in drainage systems present difficult issues and often occur in locations of low flow velocities, as well as in pipes with small diameters [1]. Traditional CCTV surveying techniques have high costs to monitor pipelines and they require significant time investment for in-pipe inspection [2]. To address this, SewerBattTM was developed to complement existing methods and allows for rapid surveys of long lengths of combined sewage and drainage pipe networks, demonstrating cost savings of up to 82 % compared with CCTV technology [8]. An acoustic signal is used to identify potential blockages and other defects within the pipe and their longitudinal position [3]. Manhole Zoom Cameras (MZC) also offer the potential to visualise defects within pipe systems. Phlihal et al. [4] suggested that the combination of these two technologies may improve the inspection of sewage and drainage networks compared with traditional and more expensive CCTV based methods.

Thermal cameras have been used previously for a range of purposes such as the identification of buried assets or leakage problems in buried pipes [5, 6]. This technology is based on the detection of temperature differences between different objects and materials (water and soil) in order to identify features that cannot be observed by the human eye; even buried infrastructure [7]. Anglian Water has been the first company in the U.K. water sector to use this technology to identify leakage problems in buried trunk mains. They used drones with thermal cameras in a rural area. Results show that this technique is able to identify leakage problems in buried pipes in the countryside. Moreover, the technique can identify areas with different soil temperatures and correlate those areas with the presence of water, and thus with leak problems [8]. These previous studies indicated that aerial thermal images may have the potential to locate trackside drainage pipes buried in ballast.

2 Methods

A Horizon Scan was conducted to identify emerging inspection technologies available in other industrial sectors that may provide more rapid and safer inspection methods. A visioning workshop and interviews with rail drainage engineers helped to identify and rank the key needs to improve asset inspection to support better proactive management of railway drainage assets. Potential technologies and approaches were scored based on the potential reduction of time for operators working at trackside, the current development stage of the technology and the time needed for it to be fully implemented in a rail environment. From this, three technologies were considered in more detail.

In the laboratory, a range of objects were introduced into a 150 mm diameter and 30.3 m long PVC pipe at different locations and the combination of SewerBatt™ and MZC was used to estimate the percentage blockage provided by each object (75%, 50% and 25% of the pipe section). Aerial thermal images of a ballast-buried PVC half-perforated drainage pipe with a diameter of 300 mm and a total length of 4.75 m were recorded in a laboratory environment to assess the feasibility of using drone-carried infra-red imaging to identify buried drainage assets. The pipe was buried in an enclosure 1.3 m wide and 6 m long. The pipe was connected to two 600 mm diameter manholes and buried in 0.2 m of ballast. Heated water was introduced into the buried drainage pipe and into the bottom of the ballast layer to create a temperature difference to test the suitability of infra-red camera technology to identify under-track drainage assets.

The suitability of the combined SewerBatt™ and MZC method was further demonstrated in a field environment using track drainage assets at the Tuxford Rail Innovation and Development Centre. This combined inspection approach was applied to the four different culverts and buried rail drainage pipes with diameters between 225 – 450 mm and lengths between 9.40 – 20.55 m. A drone-mounted thermal camera was also used to record images of the same trackside area at seven different spatial locations.

3 Results

The three technologies identified during the horizon scan are illustrated in figure 1.

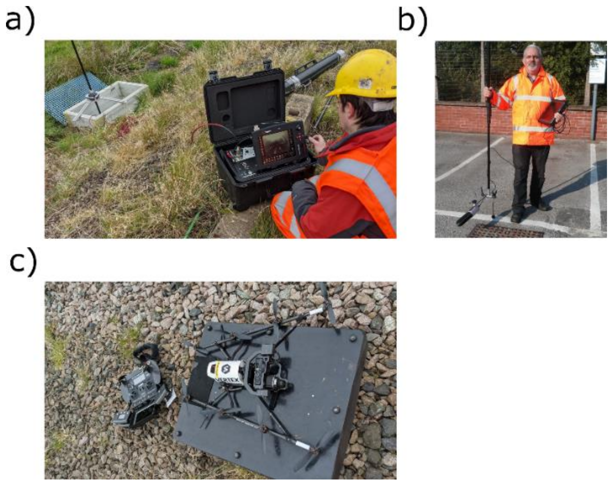

Figure 1 (a) MZC in operation at RIDC Tuxford, (b) SewerBattTM in operation and (c) Ascending Technologies Falcon 8 Drone with FLIR Tau 2 640 IR camera deployed at RIDC Tuxford.

Laboratory tests show that SewerBatt™ can locate blockages and large silt depositions in PVC pipes accurate to ± 0.3 m. Empirical relationships were developed to estimate the dimensions of these in-pipe features from MZC images based on zoom configuration and longitudinal distance of the object (Figure 2). These relationships show a mean relative error of ±12.5 % with respect to the real object dimensions. Field experiments showed that the combination of the SewerBatt™ and the MZC technologies could improve the inspection of culverts and pipes, providing detailed information about their internal conditions. The total weight of the MZC is 6.4 kg and the operational time is 15 min to install the system plus approximately 1 min per image recorded. SewerBatt™ has a total weight of 5 kg and can collect data in approximately 1 min. Both systems require fewer personnel and are more rapid than a traditional CCTV system.

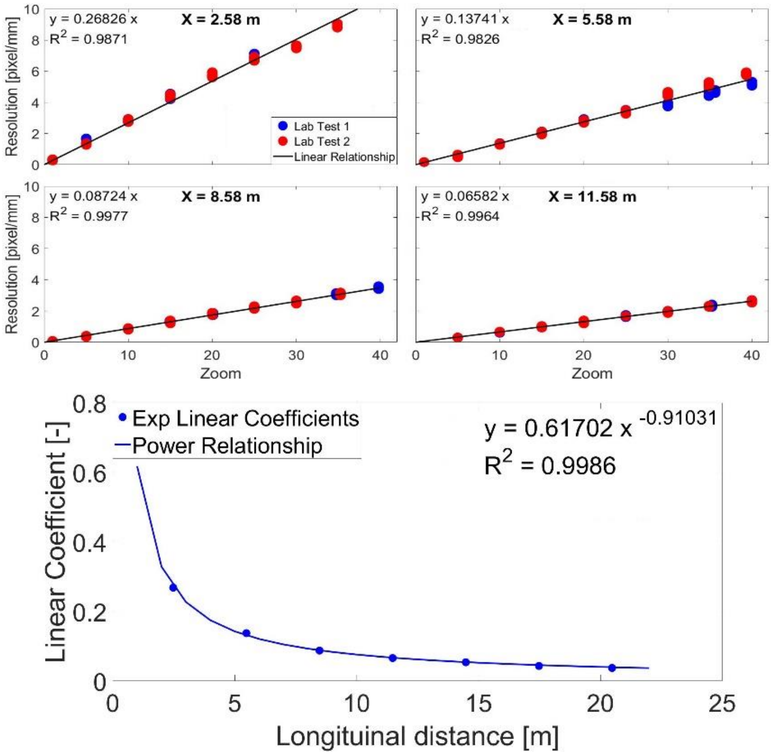

Figure 2. Empirical relationships between zoom configuration, longitudinal distance and recorded object resolution using MZC.

Thermal images from the laboratory show variability depending upon ballast condition. For sand-free ballast, an increase of temperature was recorded when higher water temperature was created inside the pipe. However, the increase was seen over a wide ballast area, rather than just over the pipe. When sand was present, heat transmission was constrained, suggesting the method may be unreliable in real environments. The infra-red images were able to identify when the ballast contained significant amounts of water, especially when water level was less than 0.2 m from the ballast surface, which may be useful in identifying wet beds. In the field tests, thermal images did not detect buried pipes but did show catchpit locations, which could aid in locating drainage systems. Thermal images also identified regions close to the track covered with vegetation and surface water bodies such as outlets.

4 Conclusions and Contributions

This study has explored a number of technologies to support the enhanced inspection and detection of buried drainage assets in a railway environment. Results show that acoustic based SewerBatt™ can identify the position of features within drainage pipes to a resolution of ± 0.3 m, while empirical relationships are proposed to estimate the dimensions of these features via simultaneous measurements from the MZC. Both techniques can be deployed and used more rapidly than traditional CCTV based inspection systems. Aerial thermal images show variability depending upon the condition of the overlying ballast, making accurate detection of buried drainage pipes difficult. However, this work did show the ability to identify the location of catchpits using drone derived image data in a buried drainage pipeline in a railway environment. It is suggested that Network Rail (or other rail operators) begin to test solutions such as MZC and thermal drone cameras at route level to fully assess opportunities for improved asset management based on higher capability inspection and detection technologies. It is understood that at least one Network Rail route has already begun to explore the MZC technology.

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