Terrestrial LiDAR applications within the rail sector

In recent years the introduction of terrestrial **LiDAR** has provided surveyors with a method of data capture giving significant advantages within the rail industry. IAN ANDERSON explains further, and describes a project being carried out for Network Rail at Folkestone Warren

Terrestrial LiDAR or Terrestrial Laser Scanning (TLS) provides a 3D pointcloud of the surveyed environment which can be both internal or external, to which colour can be applied and from which vectorisation can take place, generating conventional 2D or 3D CAD outputs. Figure 1 shows a 3D pointcloud displayed with greyscale intensity and in Figure 2 the pointcloud has been coloured using high resolution digital photography.

TLS provides the following benefits:

- Rapid data capture, typically between 50,000 and 500,000 points per second
- Non-contact measurement of each point is based on the reflectance of the laser from the surface being surveyed
- Measurement range is typically from 1m to 500m, although long range systems are available that measure over a number of kilometres
- Comprehensive data capture provides for many potential applications from a single site visit. Data can be held as an archived as-built record, from which subsequent data extraction can be undertaken as required
- Pointclouds from a number of different scan positions can be combined into a single pointcloud which can be geo-referenced to the required coordinate system.

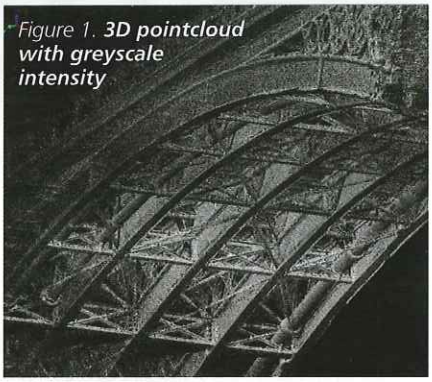

Figure 1. ***3D pointcloud with greyscale intensity***

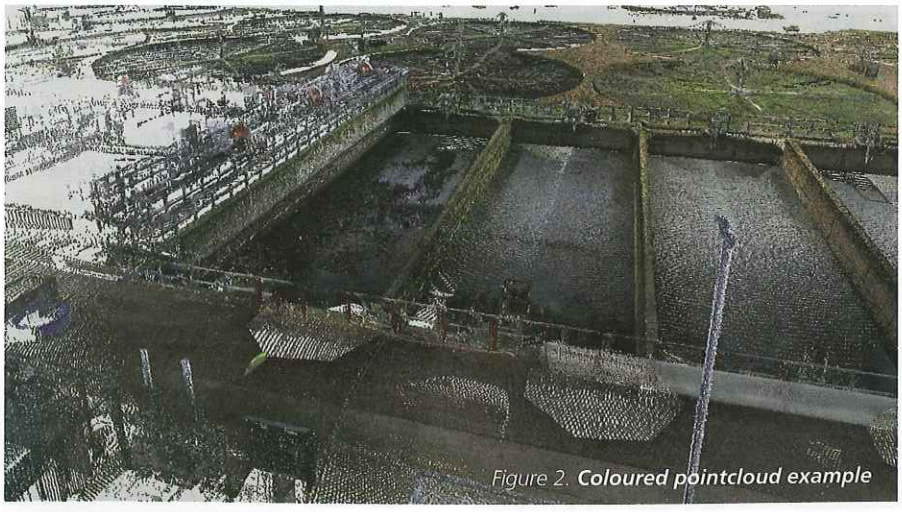

Figure 2. ***Coloured pointcloud example***

Examples of applications of TLS within the rail industry are numerous, and this method of data capture has been used in a range of topographical and as-built surveys. Station surveys provide an example, where the required deliverable was topographical plans of the station layout and infrastructure and elevation drawings of the building façades. The pointcloud provided comprehensive data for the extraction of the required deliverables and formed a data archive, from which additional information can be extracted if required. The speed of data capture ensured that the survey time within the station was reduced, minimising any potential disruption to both station staff and the public. Additionally, the requirement to include in the plans and drawings track infrastructure and general track layout was all extracted from the pointcloud, without the need for surveyors to access the red zone, and therefore negate the need for track possessions and associated costs and other health & safety implications of working within the red zone environment.

Further application areas that have benefited from the use of TLS include:

- Tunnels – deformation and topographical surveys
- Internal building surveys
- Building deformation
- Landslide/embankment monitoring

Figure 3. **Folkestone Warren looking eastwards**

Figure 6. **Cliff-top scanning**

The final example of TLS techniques relates to the monitoring survey at Folkestone Warren, Kent. The work is being carried out by Halcrow under commission from Network Rail. The landslide area is approximately three kilometres in length and the Dover/Folkestone rail runs across the landslide. Figure 3 shows the Folkestone Warren area.

The Folkestone Warren area has been subject to long-term monitoring, with a series of survey points installed along the sea defences and to the south of the railway line along the vehicle access track. These survey points have been coordinated and precision-levelled to show horizontal and vertical movements at their locations. Figure 4 shows a typical trackside monitoring point.

However, as with any point monitoring, the areas between these points have no survey information and, if the structure as a whole is to be analysed, assumptions are then made as to the probable movements between survey points. This approach can apply to any structure, building, landslide or road surface as examples.

Figure 5. **Vehicle-mounted scanner for 'Stop & Go' data capture**

The use of survey markers for monitoring is related to the technologies that were available to the surveyor and the areas of the site that could be safely accessed. These survey points provide an excellent historic record of the site's behaviour and, as such, the proposal for the monitoring of Folkestone Warren was to continue with the established survey points but complement these with a Terrestrial Laser Scanning survey of the sea defences, the railway line and the cliff areas. The scan data would provide extensive coverage of the cliff areas, from which subsequent scan data sets could be used to provide surface comparison outputs, together with cross-section analysis.

The pointcloud would then be used as a method of both analysing and managing the site. So as an example, if the analysis of the pointclouds detects an area of deformation

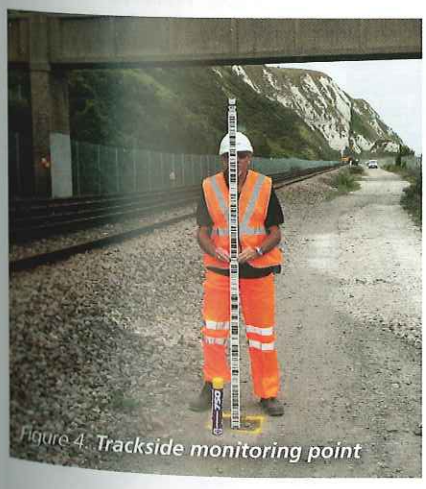

Figure 4. **Trackside monitoring point**

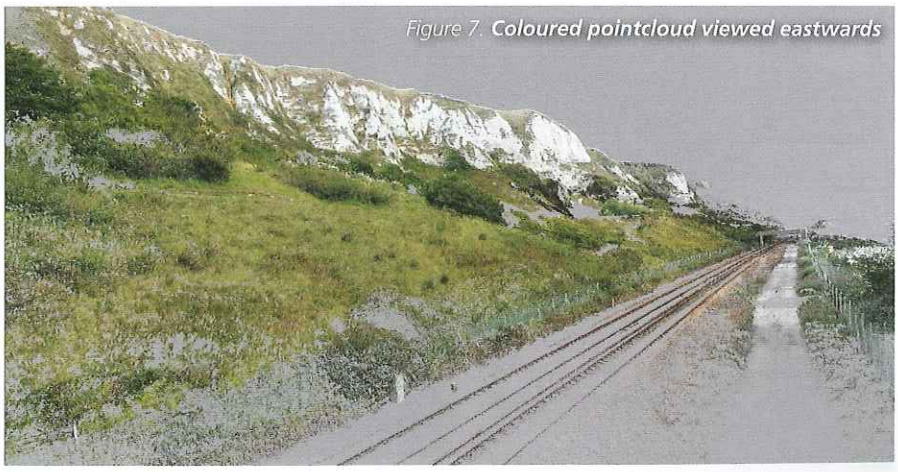

Figure 7. **Coloured pointcloud viewed eastwards**

between existing monitoring points, then an informed decision can be made if additional monitoring points are to be added, or another form of monitoring used.

To ensure scan data coverage of Folkestone Warren site, a Riegl VZ-400 scanner was chosen. This provides a data capture rate up to 125,000 points/second and has a measurement range up to 500m, ensuring that data would be collected on the high cliffs along the northern boundary of the site. This system also incorporates a high resolution digital SLR camera, providing the imagery from which the pointcloud can be coloured.

Approximately one hundred scan positions are used to provide data coverage of the site and for the sea defences and trackside scanning, the system is mounted on a vehicle, and driven to each scan position where the vehicle is parked for the duration of each scan, approximately ten minutes. This 'Stop & Go' methodology of data capture improves site productivity, reducing site time. Figure 5 shows the scanner system mounted on the survey vehicle. For the cliff-top scans the system was tripod mounted at ten vantage points.

The individual scans are combined together into a single pointcloud using a combination of known target coordinates and cloud-to-cloud registration methods. The pointcloud is then coloured from the captured photography.

The Folkestone Warren monitoring survey is now delivered via a web portal, providing users with site mapping, all historic and current point monitoring data with any detected movements displayed as vector arrows for horizontal movement and graphical outputs for both vertical and horizontal displacements. In addition, the website displays site photography, and survey reports and related documentation. The pointcloud data is displayed via video fly-through files and the scan data analysis as surface comparison displays and cross-sections.

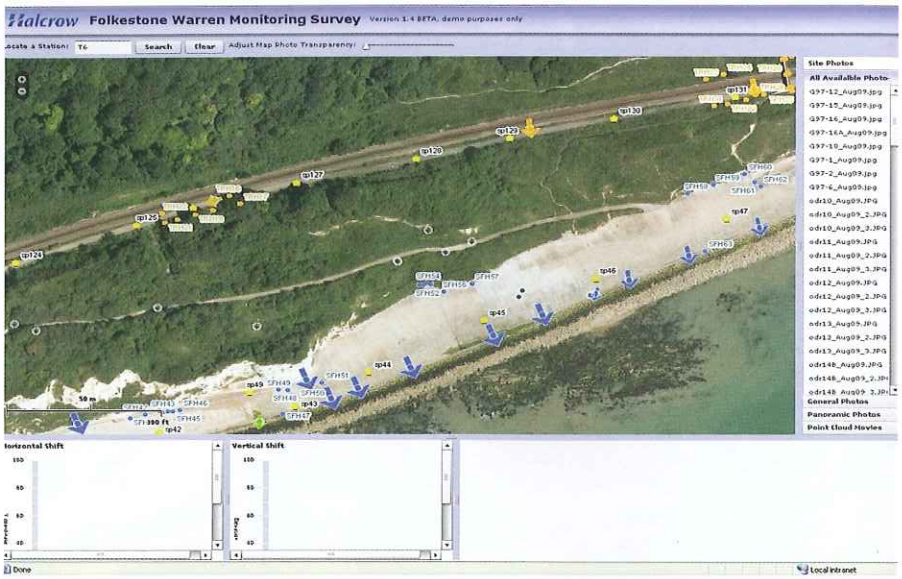

Figure 8. ***Website showing aerial photography with monitoring point locations***

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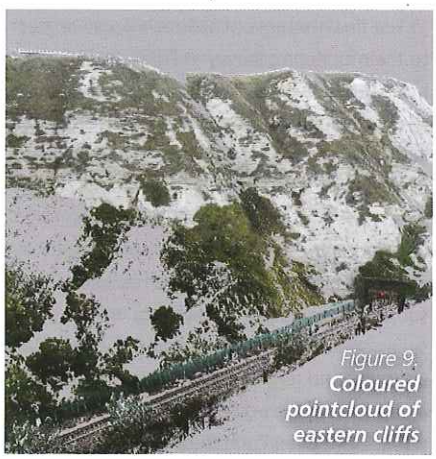

Figure 9. ***Coloured pointcloud of eastern cliffs***

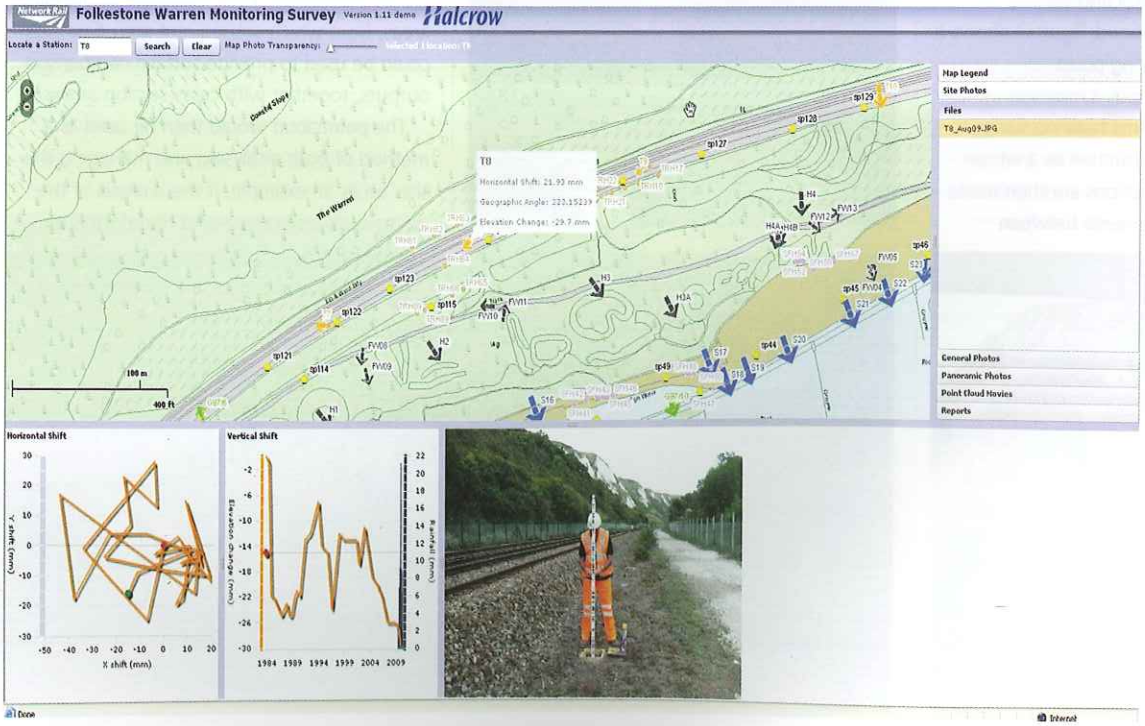

Figure 10. ***Website display of monitoring points, horizontal and vertical displacement graphs and site photography***