Photo: GEOconnexion

London Bridge: a station reborn

Monika Zibolyte recounts how construction giant Costain exploited the latest innovation in photogrammetry to document as-built conditions for a key element in the £6.5 billion Thameslink rail project

As part of its vision to improve the safety, reliability, and efficiency of rail travel within London and beyond, Network Rail undertook responsibility for the government-sponsored £6.5 billion Thameslink project. The latter was initiated in 2009 with an expected completion of January 2018, when new spacious trains will travel through central London at peak times every two-to-three minutes.

The massive railway improvement scheme includes platform lengthening, station renovations, new railway infrastructure and additional rolling stock. It involves collaborative efforts by train operating companies, architects, engineering and design firms, and construction organisations, all managed by Network Rail.

At the heart of the Thameslink initiative is the redevelopment of London Bridge station, Britain's largest and fourth busiest rail terminal handling over 56 million passengers annually. Plans for the station involve reconstructing its concourse ... a move that will unify the station for the first time and give passengers access to all platforms. Now well on the way to completion, the project also involves new retail outlets and station facilities for the new street-level concourse that will be the largest in the country, exceeding the size of the pitch at the iconic Wembley Stadium.

To manage the project, Network Rail awarded the Costain Group - one of Britain's leading providers of engineering solutions - a £400 million contract to deliver detailed design and reconstruction plans. "Our focus is to design and deliver a world-class London Bridge Station that enhances the capital's infrastructure and improves the journeys of the hundreds of thousands of passengers who pass through the station every day," commented Andrew Wyllie, Chief Executive of Costain.

The reconstruction challenge

The sheer size of reconstructing the station to add 15 new platforms presented numerous demands. These ranged from reconfiguring the rail tracks and installing new signaling, to demolishing existing platforms and removing the existing roof - all while keeping the station operational. To minimise disruption to passengers, it was decided to tackle the project in nine phases, for which Costain and the project team needed reliable data on the near 200-year old site.

Originally constructed between 1836 and 1839, the station housed a considerable number of masonry arches that required surveying to determine the optimal approach for designing and constructing the new concourse. To obtain this information, Costain needed cost-efficient survey techniques that could generate an accurate 3D representation of these structures in order to assess the potential of the subsurface for reconstruction and to help stakeholders make informed decisions against a tight deadline.

Photogrammetry vs Laser Scanning

Laser scanners have long been the preferred method of accurately capturing digital data with which to survey and document site conditions. They have the ability to capture point clouds with a density akin to 3D pictures. Points in the scan are given 3D coordinates and this virtual georeferenced representation can be shared among the design team.

Costain has invested in this technology to successfully deliver numerous projects. However, given the age of the structures at London Bridge Station and the limitations of laser scanning (a process that would take months to complete), Costain's graduate

The St. Thomas Street entrance to London Bridge Station (left) is one of several that provide access to the new concourse (right) which is now nearing completion. Photos: GEOconnexion

ContextCapture provided an accurate 3D representation of surface and sub-surface structures and assets as an aid to planning. Images: Costain Group
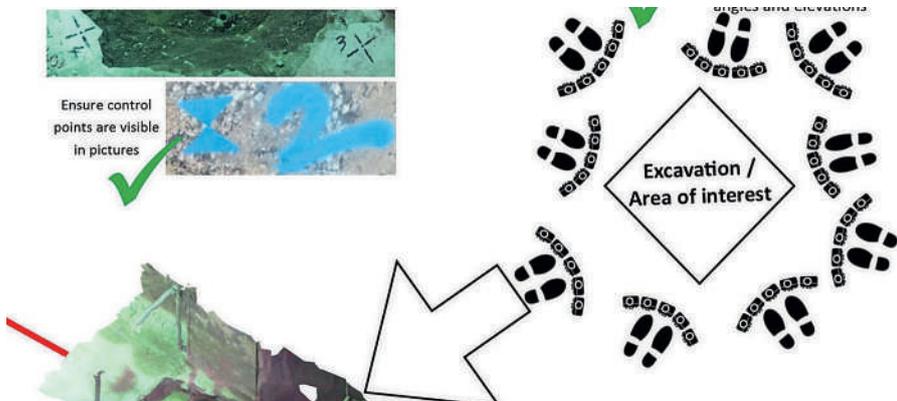
The initial data capture process can be implemented by anyone with five minutes training Image: Costain Group

surveyor, Richard Bath, experimented with photogrammetry to ensure each brick in the existing structures would match perfectly with the proposed new façade.

Using a simple camera to capture the old surface area delivered a denser survey than the scanner and also provided colour, enabling designers to quickly identify the bricks from the mortar joints. Furthermore, photogrammetry was less disruptive to onsite workers, given the speed and size of a small digital camera, or even just a smartphone, to survey the site. The workers were able to move out of the area while Bath recorded a video or snapped a few photos and, within minutes, return to their assigned task.

Using Bentley Systems' ContextCapture software allowed Costain to process the captured images into accurate 3D mesh models. This facilitated decision making and provided documentation of existing conditions, not just for use in the London Bridge reconstruction, but also throughout the lifecycle of the infrastructure for maintenance and future projects.

Simplified Workflow

Another advantage of photogrammetry is that it accelerated workflows. While laser scanning requires highly skilled, well-trained technicians to obtain a virtual 3D representation, photogrammetry requires only a camera to snap a few photos and,

by using ContextCapture, to automatically generate a 3D reality model.

Costain followed a basic four-step workflow process: 1. Mark ground control points (GCPs) of the area of interest and ensure these are clearly visible in the photos; 2. Take pictures from varying angles and elevations surrounding the area; 3. Survey the GCPs (at least three are needed to scale and geo-reference the model), and 4. Process photos and GCPs together using ContextCapture to produce the final model in a range of deliverables.

The first two steps can be implemented by anyone with five minutes training on determining the best method to mark GCPs and take the photos to ensure optimal deliverables. The final step uses Bentley's reality capture software and is completely automated, aside from the limited user time required for uploading the pictures and identifying the GCPs. While the overall processing time varies according to number of photos and GCPs, the entire workflow, from taking the photos, surveying the GCPs, and processing, can be completed in under an hour.

Achieving optimal results

In comparing the accuracy of photogrammetry to that of laser scanning on the project, Bath observed there was a difference of a few millimeters for many uses on site, such as excavations. And, while the accuracy of the final 3D reality mesh predominantly relies on the comprehensiveness of the photos acquired, it is not imperative to invest in an expensive camera. The entire process, from initial photography through to the 3D model, is automated; and for the London

Bridge reconstruction, this yielded sufficiently accurate results to optimise costs and other project deliverables.

Photogrammetry saved time for data collection and eliminated the bottleneck associated with sharing a scanner among two dozen surveyors. Furthermore, using a camera is much less expensive than the cost of a laser scanner. Photogrammetry and ContextCapture provided a safe, reliable non-contact survey technique that streamlined workflows and improved efficiency. Using Bentley software for the London Bridge Station reconstruction saved time and costs while reducing the chance of misinterpretation. It bodes well for a railway project that promises to transform travel throughout London and the UK, expanding through-station passenger capacity to 90 million people annually.

Said Bath, "ContextCapture is providing Bentley users like Costain a software environment that is progressing the use of reality 3D capture on a construction site. With just a smartphone, the entire workforce has the potential to document visually rich 3D construction progress with a minimal amount of training. ContextCapture is changing data capture on site.".

Monika Zibolyte is an Application Engineer with the Reality Modeling division of Bentley Systems (http://www.yppartnership.org.uk)
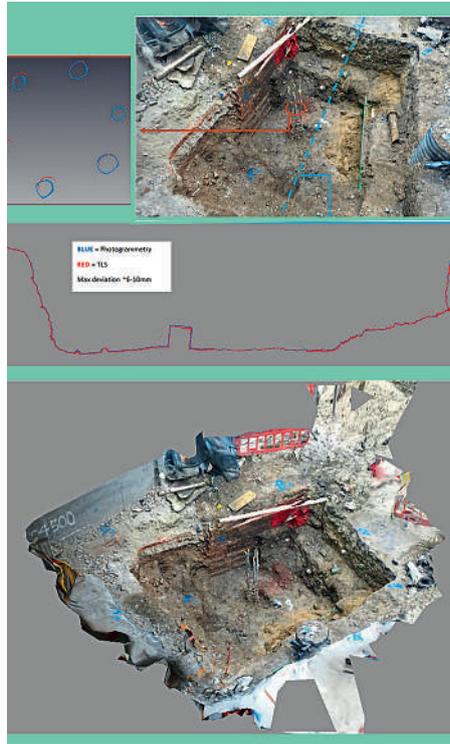
Upper image: Horizontal cut of rebars make an accurate comparison between photogrammetry and terrestrial laser scanning (TLS): blue circles represent photogrammetry, and red circles represent TLS; maximum deviation is ~6-10 millimeters. Lower image: ContextCapture automatically processed images into accurate 3D mesh models to document the as-built conditions at London Bridge Station prior to redevelopment. Images: Costain Group

Rail tracks lead into London Bridge Station which lies immediately adjacent to the iconic 309m-high Shard, one Europe's tallest skyscrapers. Photo: Network Rail
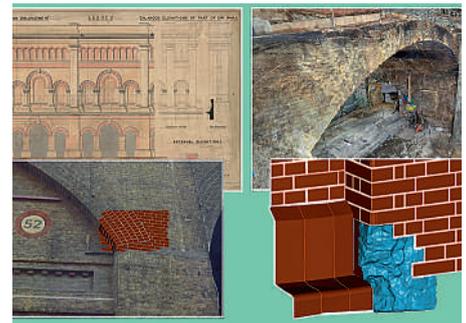
A considerable number of original masonry arches required surveying prior to the design and construction of the new concourse. Photogrammetry was used to ensure that each brick matched perfectly with the proposed new façade. Images: Costain Group