Introducing the Vogel R3D

Tom Wren, Technical Manager for Rail at Plowman Craven, describes an innovation which seems certain to transform high precision surveying.

With more than 20,000 miles of track and 40,000 structures requiring continual inspection, monitoring, renewal and maintenance, everybody working in the industry understands that Network Rail's need for accurate survey data is vital to the efficient running of our rail infrastructure. In an ideal world, it would be done with nobody on the tracks, without track closures and in as short a time as possible to minimise passenger disruption. Sadly, the current way of working couldn't be more different.

Traditional survey and inspection methods require track possessions to enable surveyors to manually measure and observe the entire track and the surrounding rail infrastructure using Total Stations, laser scanners or track-mounted measuring devices (TMD). It is hugely time consuming, sometimes taking months to complete a straightforward topographical survey because of gaps between possession access, and with surveys usually at the front of any project, these delays can bring the entire undertaking grinding to a halt. The costs of these possessions and the resulting delays can be enormous. As a survey company, there are also huge risks involved that need to be mitigated, with surveyors working at night in hazardous conditions, often alongside multiple companies carrying out maintenance works.

There had to be a Better Way

If there was a defining moment, it came late one weekend a few years ago after our rail team had driven up the M6 to Manchester for a few hours on a stretch of track. It was freezing cold, pitch dark and we had to jostle our way through to try and take some measurements. On the way back, there was a weary consensus: there just had to be a better way of doing this. Surely we could figure out a way to apply all our knowledge and harness new drone technology to remotely capture essential data without accessing the tracks?

But flying is the easy bit and aerial surveys using drones are nothing new. The real challenge is in the quality of data produced. Network Rail design engineers require Band 1 accuracy, which is +/-5mm for the rail positions. Existing drone surveys were giving an accuracy of 60mm, with 30mm being very much a best-case scenario. That was a massive gap to bridge.

Luckily, we like a Challenge...

So, we assembled a crack team that brought together skills from around the business. That meant Marta Wren providing photogrammetry and data processing expertise, James Dunthorne specialising in the UAV platform and sensors and myself looking after the ground survey and rail survey elements. With strong support and significant financial backing from the Board, the team set to work trying to achieve our very clear objectives:

- Remove the need to access tracks for surveys or inspections
- Reduce exposure to hazards associated with on-track working
- Shorten project programmes, particularly early phases when data is required
- Reduce costs associated with possessions and line blocks
- Reduce costs by reducing the number of shifts onsite and safety personnel
- Provide high-accuracy data that meets sub-5mm accuracy requirement
- Provide added value to current surveys by delivering high-resolution photography and point cloud data.

How to do it

So, how did we achieve our objectives? Firstly, we determined that photogrammetry was the only way to succeed. Current aerial lidar systems could not provide the accuracy or data quality required for rail surveys, but the rapid advancement of photogrammetry software has enabled the production of 3D point clouds from raw photography.

Armed with this knowledge, we kept testing, exploring the merits of the best equipment available, assessing possible hardware and software combinations, devising the workflows, processes and algorithms that would bring everything together. With additional input from surveyors, UAV experts and technical specialists from across the business, creating Vogel R3D became a truly collaborative effort.

Throughout the process we were in dialogue with Network Rail, and in particular Chief Surveyor, Chris Preston, who was hugely supportive of the project. This was vital. It is one thing to create a system that you think could work, it's another for it to be verified by Network Rail, and another thing still for it to be permitted to fly over a live railway, for that, you need to convince the Track Technology Board, as well as the Air Operations team. Without Network Rail approval we would have nothing, so having them on board was crucial to the success of the project.

The Two Fitted Perfectly

Having spent eighteen months developing Vogel R3D, we first trialled the system on a stretch of a heritage railway in Northamptonshire in September 2016. We measured the tracks twice using the industry-standard Amberg GRP1000 to establish a benchmark and then put the Vogel R3D to work. Once we processed the point cloud, we took a slice through the rails, dropped in the Amberg measurements and took a deep breath. The two fitted perfectly.

We presented the findings to Network Rail and they were very excited – so much so that they funded a second, more complex test at a live site with crossings and switches. This was a really strong affirmation, not only of the fact that we had come up with something that worked, but it was exactly what they were after. The second trial took place at Grange Sidings near Stoke-on-Trent in February 2017 – in the presence of many Network Rail representatives. This was the ultimate test for Vogel R3D and there was inevitably a great deal of pressure to produce the goods. Two years of hard work had essentially come down to a single session - if it succeeded, we would have cracked it. Thankfully, despite the complexity of the site, the Vogel R3D delivered. We'd conquered our Everest, producing sub-5mm accurate data from a UAV.

How Did We Do It?

In terms of hardware, we are using an Aerialtronics Altura Zenith ATX8 industrial UAV paired with a 100-megapixel Phase One IXU1000 camera. The flying height varies between 25m – 40m depending on the necessity to avoid aerial obstructions. This gives us a GSD of 1-2mm. The UAV platform has many built-in safety features, such as redundant power, motor and communications systems, which were essential in gaining permission to overfly the operational railway.

Data processing is handled by a mixture of off-the-shelf software combined with bespoke algorithms to enhance the pixel matching between overlapping photos and improve the accuracy of aerial triangulation. Ground Control Points placed at the side of the track are measured by conventional ground survey and tie the photogrammetry to the project survey grid. Automatic extraction algorithms are then used to identify the height of the crown of the rail and the plan position of the running edge from the point cloud data. Topographic surveys or 3D BIM models can then be created from the data.

To verify the accuracy of the data, independent checks were undertaken during the testing and proving for Network Rail. Independent Ground Truth Points (GTPs) were placed at approximately 10m intervals throughout the site and surveyed with a total station. These GTPs were identified in the photogrammetric software but not used for the processing of the image alignment results. The calculated coordinates of the GTPs were then compared to the measured coordinates, with differences of 1.5mm in plan and 3mm in height found.

Verification of the rail alignments was undertaken by comparing with an Amberg GRP1000 track survey. Differences of 2- 3mm in plan and height were found between the two methods.

Ringing Endorsement

The proof of concept is certainly in the pudding. Network Rail's Chief Surveyor, Chris Preston, has validated the Vogel R3D as able to produce Band 1 accuracy surveys (+/-5mm), adding: "The application of the Vogel R3D is a real game-changer for Network Rail and helps us to satisfy many of our survey requirements in a safe manner without the implications or potential programme delays associated with multiple possessions."

Going Live

Just as pleasing is that it has now been proven on a live job for Network Rail at Salfords Sidings, on one of the busiest stretches of the UK network, through which the Gatwick Express and Thameslink routes run. The purpose of the survey was to enable design work for a S&C (switches and crossing) replacement. The traditional way of doing this would have needed two months (minimum) to secure a possession before approximately 13 days manual surveying on site to deliver a topographical survey. Using Vogel R3D we needed two days of surveying set-up, two days of flying and two weeks of processing to deliver a topographic survey and much more – without a single possession. So that's time saved, money saved, no track closures and no safety staff in attendance. More and bigger jobs are in process and planning. As these are completed the real value of Vogel R3D will undoubtedly become apparent.

Complete Visual Record

The exciting thing about the new system is the potential for enhanced deliverables, thanks to the capture of more and better data. Where traditional 'manual' surveys can only provide raw data of the specific points being measured, the fact that both high-resolution imagery and high-accuracy data of the entire site are being captured ensures a complete visual record with measurement data behind it. The benefit of this to operators is significant.

Site visualisations, condition surveys and asset inspections can easily be conducted, enabling stakeholders to 'walk' the site from anywhere in the world using a tablet or computer using a widely available software package such as Leica's TruView. No more trudging around a site with a clipboard! Better still, users can 'interrogate' the imagery, pull up exact measurements on screen and share with interested parties. For train operators and maintainers with extremely limited information on the physical characteristics of their routes, being able to access such usable and verified survey data could be hugely beneficial.

And that's saying nothing of the raw photography itself. It's so detailed that it's possible to read the markings on the sleepers, identify specific rail clips, examine crossing noses and clearly view flash butt welds – simple things that are highly problematic for surveyors working on the tracks at night.

The challenge now is to apply the Vogel R3D technology to other industries which require survey-grade remote UAV data capture. With so many potential applications and benefits, the use of drones really is changing the face of rail and infrastructure surveying.

This article was published in Geomatics World November/December 2017

https://www.gim-international.com/content/article/introducing-the-vogel-r3d