

INSIDE AN ICON

COVERING AN ENTIRE CITY BLOCK, BERGEN'S BT BUILDING IS A 150-YEAR-OLD LANDMARK. SO WHEN ITS OWNERS DECIDED TO RESTORE ITS INTERIOR, IT HAD TO BE MAPPED WITH SUB-MILLIMETRE ACCURACY. **MARY JO WAGNER** FINDS OUT HOW

The proposed design of the BT building's new front entrance and vision for some of the interior infrastructure.
© Geomatikk Survey





The BT building present day. At 2,560 square metres, the 150-year-old building covers an entire city block. © UiB.

For the past two years, Svein Ivar Vestbø, a survey engineer with Norway's Geomatikk Survey, has been scanning and producing 3D point clouds of relatively small structures – residential houses or low-rise commercial units – for architecture firms and other organisations.

That all changed in December 2018 with a restoration project that would scale the company's scanning and surveying expertise to never-before heights and depths. The reconstruction target was the 150-year-old 'BT building', the former home of Bergen's Tidende (BT), Norway's daily regional newspaper, located in Bergen's city centre.

Measuring 2,560 square metres and covering an entire city block, the building presently accommodates the University of Bergen's (UiB) social science centre, photo archives and various UiB offices. In a move to meet UiB's needs for a more functional working environment, the university decided it was time to completely rebuild the interior of this structure.

Capturing such a massive building would not only be a significant challenge in scanning and data processing, but adding to the complexity were two additional aspects: the building has wall-to-wall windows, and surveying and scanning accuracy requirements ranged from 0.5mm to 2mm respectively.

"The scope of this work was intense," says Vestbø. "The architect needed a 3D model of the building's façade at a precision of 2mm, which would require a huge number of scans. And it has more than 500 windows and other glassed features. That means the scanner would shoot through windows and collect millions of extraneous data points inside the building, which would add complexity to the data processing. Also, our measurements of the heights of the multiple floors inside the building needed to be within 0.5mm, which is incredibly tight."

Such a tall order required precise, efficient scanning and surveying technology, robust data-processing software, and an innovative data-integration approach. Vestbø and his team leveraged these three



The SX10 atop the UiB building, with a clear view of Bergen. Fortunately, not a snowflake fell during the scanning of the building. © Geomatikk Survey

skill sets and delivered the 3D data depth and breadth needed to help modernise and transform the historic building.

Setting up for scanning

The architecture firm, Artec, awarded Geomatikk Survey the BT contract in mid-December 2018. The project had three phases: company surveyors would first need to scan the building's façade, roof, courtyards and backyards; they would then measure and calculate its varying floor heights; finally, they would scan the existing walls and spaces after the interior was demolished.

A boxy structure, the BT building measures 26m high, 64m long and 40m wide, and contains 10 floors. In overall footprint, that equates to about two Olympic-sized swimming pools.

Five days after winning the project, Vestbø was in the field to begin phase one.

With the risk of inclement weather, Vestbø chose to capture the roof first. Viewed from above, the building resembles a thick W; the flat roof has two long rectangular ends running vertically, a wide horizontal strip across the length of the building and an elevated rectangular block in the middle. Dotted around the surfaces are various utility structures and a cluster of picnic tables and benches.

Using a Trimble R10 GNSS receiver, he established site control by setting three temporary fixed points on the roof. He observed each point for about one minute, waited 15 minutes, and then repeated the process two more times. Tying into Norway's CPOS GNSS measurement correction service, he obtained an initial overall accuracy between 8mm and 14mm in plane view and 2-3 cm accuracy in the vertical. The R10 data was saved using Trimble Access field software on a Trimble TSC3 data controller.

Vestbø occupied each temporary fixed point with the total station mode of the

Trimble SX10 scanning total station and measured those points. He then moved the instrument to two other roof locations to establish a set of new benchmarks for a tighter control network. Integrating the R10 and SX10 measurements created an average accuracy of 3mm in horizontal, vertical and elevation.

Focused on the façade

Per the project's specifications, Geomatikk Survey needed to scan the BT building's façade, roof, courtyards and backyard features, and produce a point cloud with an overall accuracy of 2mm. In addition, the architect required a second point cloud that would include the building's surroundings including trees and buildings across the street.

To capture the entire building and meet that precision, Vestbø established seven georeferenced scan locations, including roof corners, street-level building corners and the back of the building, and set up an additional 45 scan stations; those non-registered scans would be tied into the georeferenced scans in post processing.

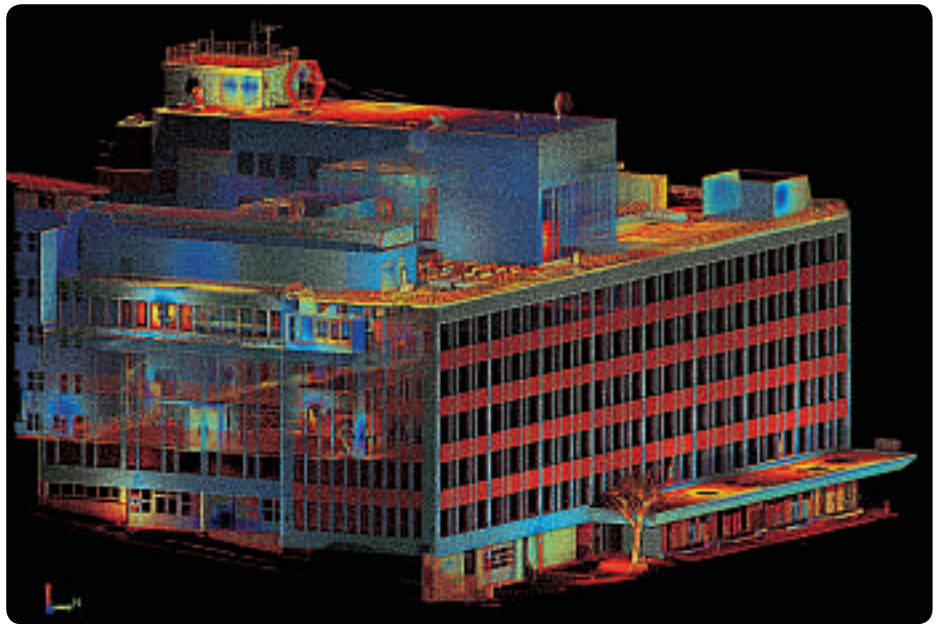
Setting the SX10 on the roof positions, Vestbø first scanned all of the roof's features including picnic tables and benches, utilities, raised structures, air vents, and fencing along the external edges. From that vantage point, he also had clear sight to scan the courtyards and backyard features, including a glassed-roof atrium, 30 m below. He then moved to the street, and methodically moved around the BT structure, setting up and levelling the SX10 and capturing a full dome scan of every detail of the façade, as well as the courtyards and backyards.

At scanning distances ranging from 2m to 30m, each scan took 12 minutes to complete. Vestbø then spent another three minutes using the scanning total station's built-in camera to take a series of photos. After 13 hours of scanning, Vestbø had collected 260 million data points with a 40-60% overlap.

SURVEYING



The SX10 scans all of the roof's features including picnic tables and benches, utilities, air vents and fencing along the external edges. © Geomatikk Survey



The colorised 2mm point cloud of the BT building. © Geomatikk Survey

"The scanner is surprisingly quick and quite precise," says Vestbø. "And with so many overlapping points, it makes it much easier to process the data and create an accurate point cloud. It also automatically registers the data, so you don't have to georeference the point cloud during post-processing, which is a huge time saver."

Tying it all together

Back in the office, Vestbø used the drag-and-drop capability of Trimble Business Center (TBC) software to integrate the GNSS and scanning data and colorise the scan. He then used the seven georeferenced scans to spatially anchor the 45 unregistered scans. He manually delineated a window of referenced points and the software automatically georeferenced each scan one by one to create a spatially accurate 3D point cloud – a process that took about two minutes per scan.

"Previously, post-processing scanning data could be quite time-consuming because you had to georeference each scan first," says Vestbø. "With the scanning total station, the point cloud is almost ready when you're done scanning. It's a simple, automated process to tie in any unregistered scans and it's much more efficient."

Automation also played a key role in cleaning up the 3D dataset. Scanning through 550 windows and two different glass roofs created millions of extraneous points inside the building that Vestbø needed to clean and clear.

Using TBC's limit box tool, Vestbø could remove exterior walls to expose the interior data points, and after setting certain parameters and boundaries, the software automatically removed 80 million points of additional data captured inside the building. He ensured the remaining 180 million data points were clean and then finalised the

2mm point cloud of the building's façade.

For the secondary point cloud, Vestbø also applied the same cleaning tools to remove superfluous features such as parked cars and people walking around the building.

Three days after completing the phase one scanning fieldwork, Vestbø delivered the precise 3D model of the BT building façade and the secondary point cloud to the architect.

Levelling the floors

In late January 2019, Vestbø and a colleague returned to the site for phase two of the project: measuring and calculating the height of each of the 10 floors in the building. Because of the age of the building, the floors were not constructed with uniform heights. Some floors have slopes, or dips or raised sections with a step – one floor may have all three – which has created not only varying floor heights between floors but along the same floor, the height could vary up to 50cm. The Geomatikk Survey team needed to accurately survey and calculate the elevation levels of each floor to within 0.5mm.

The crew first established a set of benchmarks for survey control. Vestbø placed a prism on the inside of a window on each floor. Setting up on the street, he used the Direct Reflex technology of the SX10's total station functionality to shoot and record the position of each prism.

Once inside, they used a digital levelling instrument to collect the height data. Because they weren't allowed to draw on the floor, they used tape to mark measuring points. Using the established benchmark point as the starting point, they methodically moved along each floor, collecting measurements from the existing walls, doors and openings, and recording, on average, 20 height measurements for each floor.

To add value to those accurate height data points, Vestbø took 2D DWG files of the building that he acquired from UiB and used TBC to integrate them into the finished 2mm point cloud. Using the georeferenced point cloud, he georeferenced each DWG drawing and then scaled and rotated each drawing so it fit precisely into the point cloud. Through this innovative exercise, they were able to annotate the point cloud showing the correct coordinate and elevation of each height point on every one of the 10 floors in the building.

Two days after completing the levelling fieldwork, they provided the architect with an updated point cloud layered with the DWG floor drawings and the calculated heights on each floor.

"Scanning not only captures all the unique details of the building incredibly quickly, it provides so much data depth and feature definition that it's like you're standing in front of the building or inside it from your own computer," says Vestbø. "A 3D model like that will enable the architects to better evaluate and visualise the structure and incorporate that precise view into their own design model and workflow."

After the BT building's interior is demolished for phase three of the project, Vestbø will return to the site with the SX10 scanning total station to capture the remaining external walls from the inside. Although he can't anticipate challenges he may face, he is certain that the scanning details will play a pivotal role in transforming such a historic icon. That's a story he's happy to help write.

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