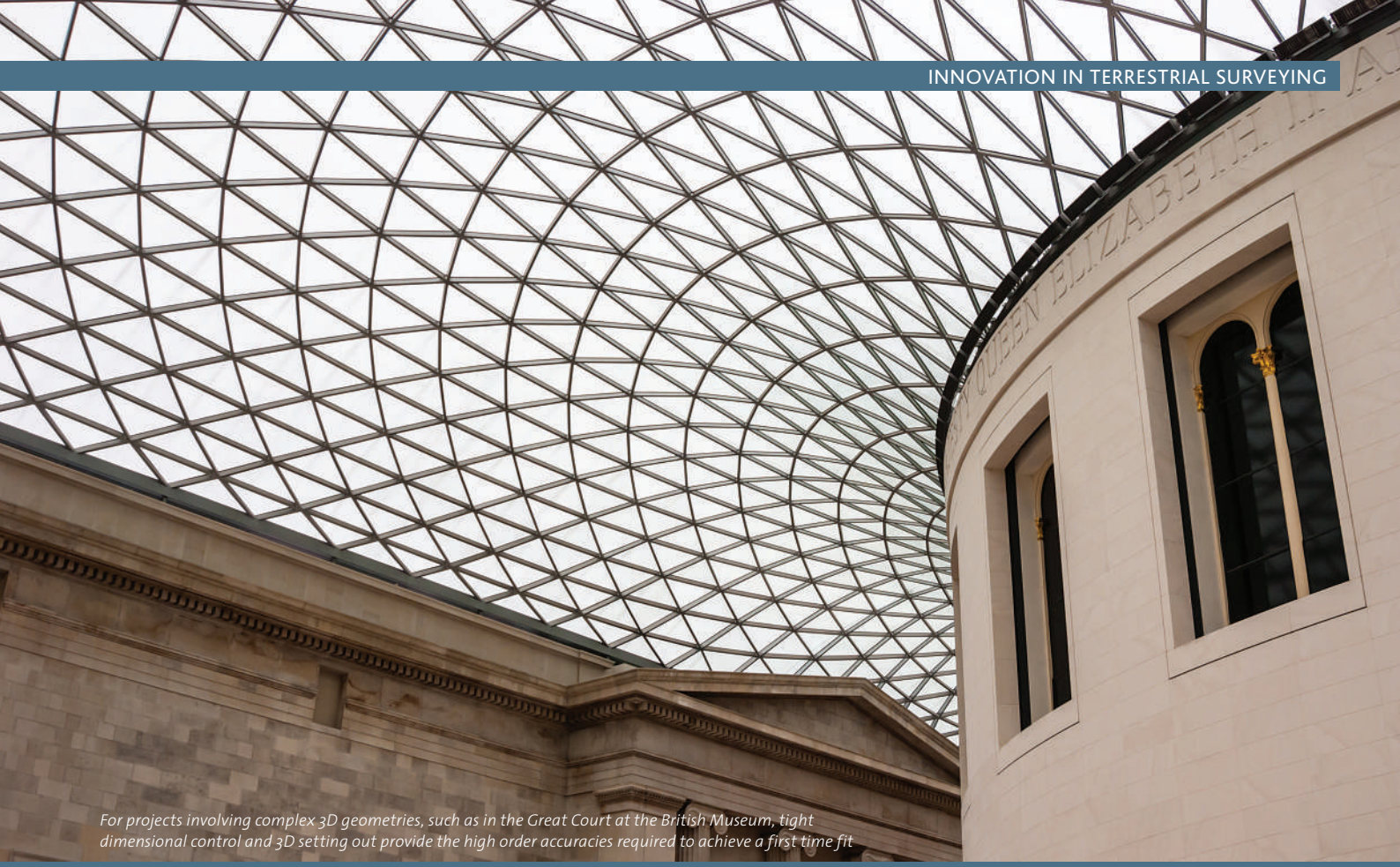


For projects involving complex 3D geometries, such as in the Great Court at the British Museum, tight dimensional control and 3D setting out provide the high order accuracies required to achieve a first time fit

Into the next dimension

Laser scanning heralded a step change for surveying, design and construction professionals. Where complex geometries are involved or a precision fit is required, dimensional control - which also involves traditional survey techniques - is often more appropriate. Peter Field reflects on what constitutes true dimensional control and, above all, the importance of ensuring survey results are 'fit for purpose'.

3D laser scanning and CAD modelling are well established survey techniques that are today used in projects of all types and sizes. As a long-established survey company operating internationally, Warner Surveys was an early adopter of laser-scanning and has since pioneered many bespoke applications and methodologies, using the technology to overcome previously insurmountable challenges.

A huge leap forward for surveying, laser scanning enabled the remote capture and dissemination of large amounts of data, where previously each data point had to be measured individually and frequently, physically. The technology is now used extensively for the accurate mapping of large scale development projects and complex buildings, including, for example, in heavily congested or inaccessible areas with complicated assets, as well as in potentially hostile environments such as refineries and industrial plants.

Collaborative working

Being able to call on a comprehensive database offers benefits for collaborative working, where many different influencers require input into the design process. The interoperability of modern 3D models generated by a variety of software packages is a major contributor to the BIM workflow approach ... one that is increasingly seen as desirable within the construction industry and is now a prerequisite for Government contracts. Drawing together a range of disciplines through collaborative work-sharing, these latest technologies enable performance to be optimised at every stage, from delivery of design concepts to on-site construction and beyond.

Also key to the Government's BIM requirements is access to accurate legacy data for buildings and structures. The availability of a comprehensive database that goes beyond original design specifications to provide 'as built' information is vital during the building lifecycle. Assigning intelligence to data provides a tool for asset management and a valuable guide for future extensions and alterations. This is particularly important for clash detection and prevention, e.g., installing pipes or other new elements within an already congested site or structure.

Laser scanning or dimensional control?

Laser scan surveys are often requested when the required tolerances actually necessitate dimensional control techniques with more traditional instrumentation. So how do you decide what you need? The following may help:

Laser scanning is a rapid and reliable method for surveying often

From top: CAD model of an existing "As Built" power station; Elevation Section through CAD model; Section through laser scan point cloud; Complete registered and georeferenced laser scan point cloud

inaccessible, complex or congested areas.

Survey control is the essential, traditional survey activity, providing auditable accuracy to so many survey operations, including laser scanning.

Dimensional Control has become the name given to high accuracy survey techniques that are used to achieve a good fit up between new, basic pieces of plant.

Critical Interface Surveying raises the bar for dimensional control and relates to the use of high accuracy techniques and instrumentation to achieve first time fit ups between new and old complex pieces of plant or structures.

Data accuracy

Although laser scanning is 'fit for purpose' for many design and construction applications, it has inherent limits on accuracy, with terminal accuracy subject to and dependent upon a number of variables. Good quality survey control, range, reflectivity of the surface, type of scanner, temperature variations, stability of the survey subject, and even the symmetry of a survey subject can all have an impact on results.

In the real world, most survey subjects are exposed to a significant temperature change that, alone, can make a difference of several millimetres in the data registered. Additionally, the 'noise' produced within a point cloud from a flat surface can range from as little as two to 10 millimetres or more depending on the quality of instrumentation and the surface being scanned. Interpolation of this 'noise' can lead to further distortion in the data. Where the objects being scanned are vibrating or subject to other influences that cause movement, this will also affect the results.

For this reason, claims that laser scanning can provide accuracy to within +/- 2 mm should be approached with caution. Using the highest possible specification, a terrestrial laser scanner in a stable, controlled environment at relatively short range (10 to 20 m) and with high order survey control (+/- 1 mm) may possiby produce data to that kind of auditable accuracy. If the data is not auditable, then accuracy claims should be dramatically downgraded, with +/- 5 mm being more realistic.

On the surface

Moreover, the concept that modelled surfaces are more accurate than the basic cloud data is only true in certain circumstances. Surfaces are often irregular, the geometry of old basic primitive shapes can become corrupted, and even the lack of perpendicularity between (for example) walls and floors can result in some software squaring-off or smoothing out such irregularities. This may result in a very good looking model but fails to accurately represent what actually exists on site; so in this context, the accuracy of the model can actually be dictated by the "quality" of the structure being surveyed. While a number of software companies are actively involved in investigating how these limitations can be overcome, a commercially viable solution is still some way off.

Another option available to data users is to bypass the automated software corrections and more complex 'as built' geometries by interrogating the underlying databases directly.

Frequently overlooked in the delivery of 3D models, the point cloud database captured during laser scanning is, in itself, a valuable resource for designers and contractors. Containing high quality, auditable data that can be interpreted factually, such databases offer the flexibility with which to interrogate and view point clouds and to produce 2D plans and elevations directly. In doing so, it can prompt the need for additional deliverables from the original survey team, e.g., in the form of sections, or facilitate drill down into specific areas at minimal extra cost.

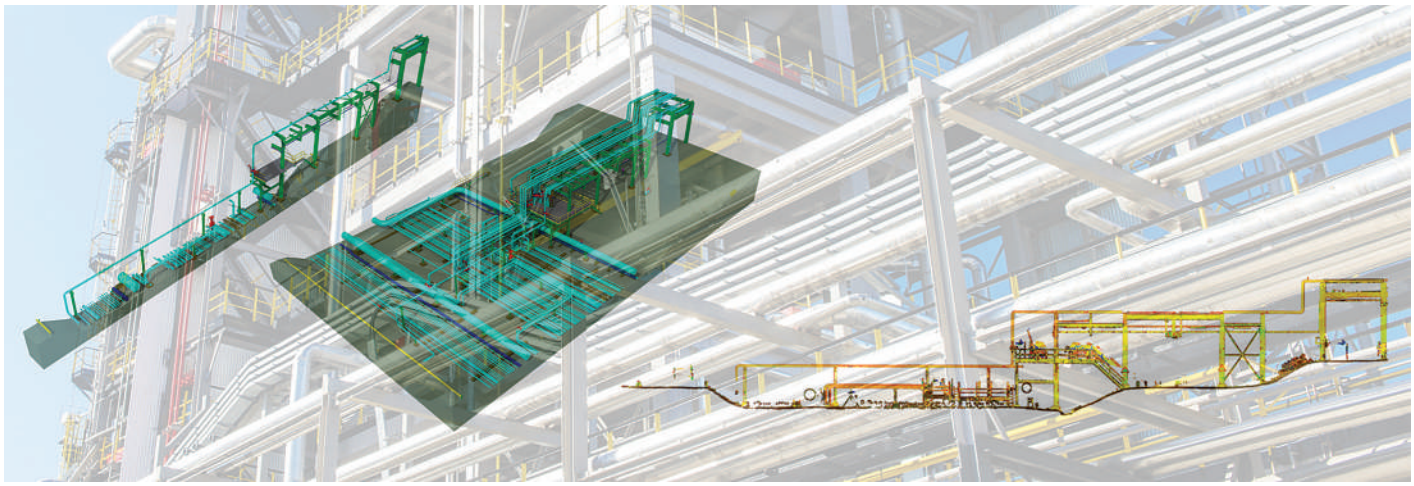
In addition, opening up wider access to raw data within project teams can facilitate greater interoperability, although this may be hampered by the availability of the necessary software in some cases. Often however there is no substitute for a full CAD model.

Dimensional control – raising the bar

A more inclusive and wide-ranging approach, the critical interface surveying provided by companies like Warner Surveys calls for a different order of complexity and accuracy in dimensional control. For example, ensuring complex cone to cone connections between new and old plant are achieved on a first time lift and fit or high value reactor/regenerator heads and internal components are replaced in a single lift. The same complex geometry setting out experience has been successfully applied by Warner Surveys to some of London's latest generation architectural structures including City Hall, the British Museum Great Court Roof and, most recently, the new Tate Modern.

In the quest for greater consistency and faster construction, prefabricated assemblies manufactured under factory conditions and transported to construction sites are becoming a regular feature of many new construction projects, from housing and hotels to complex and architecturally-demanding designs and infrastructures.

Offering greater programme certainty and lower labour costs, this approach also creates less waste. However, the in-situ work to abut prefabricated assemblies requires absolute accuracy if civils interface problems are to be avoided.



From left: section through CAD model; wide sectional view through CAD model; Section through laser scan point cloud

In such cases, and as a total solutions provider, Warner Surveys applies high order Total Station survey control, combining laser scanning with proven methodologies such as conventional survey control, dimensional control and critical interface fit ups. It is also active in integrating traditional survey techniques with UAV and vehicle-mounted scanners. It is the combination of Laser Scanning, conventional survey control, dimensional control and Critical Interface surveying that can provide the overall data base for design, BIM and clash prevention applications along with 1mm accuracy dimensional control techniques for specific "corridors of interest" or tie in points. Such an approach has been adopted by the company's survey teams in Korea, Italy and Kazakhstan following the award of Tengizchevroil 's Future Growth Project-Wellhead Pressure Management Project (see boxout on this page)

Horses for courses

Land surveyors have a duty of care to ensure the services they provide are 'fit for purpose' and delivered to the required accuracy. Equally however, designers and construction professionals need to be clear about what a project demands. Ultimately, good survey control techniques must lie behind and support the laser scan, however high its quality. Only in this way will there be auditable proof that there is no degradation in the laser scan due to other outside influences.

Peter Field, FICE, is Managing Director of Warner Surveys (www.warnersurveys.com). Established in 1979 and based in Reading, Berkshire, the company offers a comprehensive array of services, providing an end-to-end solution for all survey requirements

Surveying the future at Tengizchevroil

Warner Surveys was appointed by Tengizchevroil (TCO) in 2013 as part of a team providing front-end engineering design (FEED), engineering, procurement and construction management activities for further development of the Tengiz oilfied in Western Kazakhstan ... one of the world's deepest developed super giant oilfields (more at www.tengizchevroil.com/fgp). The FEED aspect of TCO's Future Growth Project-Wellhead Pressure Management Project (FGP-WPMP) has been completed and detailed engineering is now underway.

Warner Surveys has been appointed to oversee all technical aspects throughout with the aim of ensuring first time fit on site – a process now referred to as Single Weld Hook Up (SWHU).

While laser scanning models are being used for clash detection and prevention, process plant design and asset management, the technology will only be deployed during engineering and construction for final clearance checks prior to shipping through dimensionally-restricted inland waterway systems.

The extent of the project and the off-site fabrication of modules require the application of high-end dimensional control techniques throughout to ensure final correct positioning as per design, working within very tight tolerances of less than +/- 2 millimetres. Warner Surveys will be involved in the full life cycle of every module, from fabrication and transportation to on-site positioning and the final hook up.

Working closely with fabrication teams from its local office in Kazakhstan, Warner Surveys is responsible for the establishment of Standard Operating Procedures and validating the accuracy of the fabrication process through to sign-off. Constant monitoring and reporting allows any occurrences outside of accepted tolerances to be checked back with designs and the necessary amendments made before shipping to site.

As part of this brief, Warner Surveys is involved with marking the cut lines for pipe connections. On-site, the company will continue to manage the civils interface by setting out demarcation lines and match marks. These will allow cranes and other module transportation systems to manoeuvre and lower modules into place on the concrete foundations and achieve the delicate fit required. The result is a perfect Single Weld Hook Up, minimising construction timescales and avoiding costly on-site reworking.

One of the global energy industry's largest major capital projects, the FGP-WPMP is planned to boost TCO's crude oil production capacity by approximately 12 million tonnes per year, raising its total annual production to around 39 million tonnes