Machines in control

Machine control software is taking a big leap forward into site management and measurement

It might be thought the availability of 3D design information models would stimulate the take-up of "pegless" construction sites. Machines follow an internal computer model displayed to the driver on a screen showing where to cut instead of requiring on-site strings and marker stakes, so digital 3D design data should make the process easier.

But machine control has been evolving on a separate path. Though design models remain important, the software on site continues to develop its own possibilities, with electronic positioning of machines and their movements now evolving into detailed management of equipment fleets on-site, and measurement of the work carried out.

New software, taking advantage of modern high capacity data storage, database analysis and fast communications, is opening up a wealth of possibilities to monitor quantities, machine performance, fuel use, costs and billing. Design updates and changes are increasingly possible 'on the fly'.

That may do more to push forward the pegless site than designers 3D output.

However, pegless sites for roads and highways are still few and far between. "It has perhaps moved beyond the 'early adopters' into the mainstream though by no means yet a majority of contractors use it," said John Fraser at Hexagon Machine Control Group which recently bought Leica's machine control division and owns other associated companies.

Use varies, from substantial in Scandinavia and Australia, especially on big projects, to fairly limited in parts of North America. Types of machine fitted also differ, with perhaps 10% of excavators fitted, bulldozers around 25%, graders between 70-90% and nearly all concrete pavers, estimated Achiel Sturm, construction business unit manager at Topcon Europe.

"The machines which are doing finer work have the potential to save more in materials and fuel usage, which is why graders and pavers are at the top," Sturm said.

"Full take up will be some years yet however," added Alan Sharp, the site positioning systems manager at Trimble, one of the three big players in the sector. Manufacturer Caterpillar also fits its AccuGrade-branded GPS systems to its machines in the factory and offers an array of products, developed in partnership with Trimble.

Direct transfer of electronic models is also slowed up because legal disputes still resolve around paper drawings, particularly in the US. Software for machine control very often still works off CAD drawing therefore, though all three suppliers have capacities to import road design package information, sometimes directly from models like Bentley MX or Inroads, and often through Land XML, DWG and other common file formats. Increasingly, closer links are being forged; Trimble is currently working with Autodesk to link directly to Civil 3D, "...which means accessing a deeper level of information," said Sharpe.

That will help more complex site management possibilities now opening up. Initially machines were controlled quite simply, by a laser level or basic GPS which required only a simple design input for the immediate task, prepared by the surveyors from the designs and survey data and working to a single level.

The use of sophisticated GPS technology on construction equipment is now widespread, boosting accuracy, reducing construction time and cutting costs

"What you might call 2D control may still be all that is needed or wanted for many tasks," said Fraser at Hexagon. It is of course cheaper and simpler to understand for the operators and recognising that, Leica produces a "snap-on" control panel, Powersnap, to allow two machines to share 3D and 2D control, switching to either as needed.

But more and more machines are working to a full 3D model in the onboard computer, which allows them to grade and level more complex cross slopes and curved shapes, either under driver control or by direct hydraulic connections controlling the machine blades.

Now office preparation software used by the surveyors creates the specific models for each machine, in a format for the control systems they have onboard to position themselves. Mostly they do that by satellite signals from GPS or the Russian Glonass, and in future the European Galileo, said Sharp. "Satellite control is the major focus for Topcon", he said.

Wireless linked total station control is sometimes chosen because it works better in tunnels or places without a signal and is very accurate but it is complex to set up. To overcome the inherent 20mm vertical limit of GPS accuracy it is more usual now to use a laser level as a supplement to the satellite signal.

Even as 3D becomes the norm, the contractor's software needs are specific, paying attention to 'real world' on site, emphasised Sharp. Trimble software can take into account such factors as compaction shrinkage in producing levels for example, and produce models for the various grade and subgrade levels not present in the original, or 'densifying' the information by interpolating between points and cross section intervals.

All three of the suppliers have office preparation suites which have evolved from surveying software: Trimble has its Trimble Business Centre in a special heavy construction edition; Hexagon uses uses the GeoConstructon suite from Swedish company SBG, which it now owns; and Topcon has long produced surveying suites which prepare models for the machines, with outputs to the machine control software. Currently this is 3D Office.

While these suites evolve in capacities, so does the software for control on the machines. New levels of accuracy in GPS positioning are a feature of Topcon's development 3D-MC^2 which recently launched its software for bulldozer control which works with more complex algorithms tied to GPS and an inertial system. It increases by a factor of ten, the frequency at which machine position is calculated.

"That means the corrections against the design model are smaller, maybe one millimetre instead of 10mm," said Sturm. "In the older system the hydraulics could not respond quickly enough to big corrections causing unevenness except at slow speed. Now dozers can give a smooth result at up to 14km/hr meaning less machines to finish a job." Results are so good from a dozer that "perhaps you can even cut out the grader stage," he suggested.

But the biggest software developments in future are likely from communications and data collection as well as control. A feature of machine automation has been the need to alter machine tasks to cope with design changes or corrections which are frequent on many sites.

That has been done with card inputs or discs, usually driven out to the machine for the operator to insert into the onboard computer. But sites are increasingly provided with communications systems, either as in America and Australia using wireless links, or via mobile phone type connections in Europe where frequency restriction make wireless less useful. The links allow base station corrections to be sent over for GPS to give centimetre accuracies. But they open up many more possibilities.

By tying into a special website it is possible to synchronise machines and field surveyors to the central office design files remotely. Trimble Connected Community already allows this, both for machines to update and for surveyors to send in information, which on a large project can save a huge amount of time and cost.

Topcon is currently testing beta versions of a communication system SiteLink that goes a step further, allowing instant communication and update rather then one-off synchronisation at a particular moment. It works from a dedicated server at the construction site main office. It will be launched next year.

Hexagon/Leica has a Smartnet system for corrections which is being extended with a package called Visual Mobility and ViewServe which again allows machine updating from a local server established at the site. It is just being rolled out in some countries said Fraser.

But the possibilities are much greater. Because machines are constantly calculating where they are, relative to the design model and the real world, there is a huge amount of data available every second, which currently is discarded as the machine re-calculates. By storing and analysing it on the server, a multitude of new management options become available. "The door is just opening," said Sturm.

One simple option is just to track machines positions for site fleet management, or distributing daily tasks. It also becomes possible to calculate how much material they have moved, how much fuel, how much maintenance downtime.

Trimble is building much of this type of functionality into its Business Centre heavy construction edition (TBC-HCE). TBC has evolved from merging several software packages for surveying, take-off and estimating and engineering design and now integrating new functions. "We are about four years into it and have a couple more to go," said Sharp, though of course the current versions already have significant capacity.

Topcon is promising an initial launch of a complete new system too, in time for Bauma next year. It has been working with German civil engineering design and site costing specialist software house RIB whose products are widely used in Europe. "They have software for 3D design and quantities, and also for estimating," said Sturm. "But the missing element is data on what has been done on site and that is where we come in."

By storing machine data it will be possible to control construction and also produce more or less instant invoicing and bills as quantities roll in. ■

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