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Machine control technology taking over grading

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- Allen Zeyher

An automatic machine control system probably won't turn an earthmover into the killdozer of horror movie fame, but it might make the equipment seem as though it has a mind of its own. Guided by sonics, lasers, radio signals or Global Positioning System (GPS) satellites, roadbed preparation machines are increasingly taking their instructions from a computer.

"Today, if you're building a road, using 3-D machine guidance and machine control technology will take anywhere between 15 and 30% out of the cost of your earthmoving and preparation phases," Mark Nichols told Roads & Bridges. "It eliminates the need to go out and put stakes in the ground, so you can significantly reduce your survey costs associated with the project."

Nichols is the general manager of a brand new joint venture between Caterpillar Inc., Peoria, Ill., and Trimble Navigation Ltd., Dayton, Ohio, aimed at developing new and better machine control technologies tailored to fit Cat construction equipment. Before the joint venture was announced on March 15, Nichols was the division vice president for machine control and fleet management at Trimble's Engineering and Construction Division. The joint venture is called Caterpillar Trimble Control Technologies LLC and is based in Dayton.

Until now automatic machine control systems have been aftermarket products that could be attached in about a day. Now the goal is to have the ability to ship the motor grader, dozer, scraper or excavator with the positioning and machine control system installed.

The operator in a motor grader equipped with a machine control system can sit in the cab and look at the jobsite on a graphic display. The contours of the site plan have already been programmed into the machine's computer directly from the engineering drawings. The display tells the operator exactly where he is on the jobsite, how his blade is oriented and where dirt needs to be cut or filled.

The latest generation of machine control technologies has been around for only about three years. They use either a robotic total station or a GPS receiver to calculate the position and orientation of the machine in three dimensions. With the computer linked to the hydraulic valves on the machine, the system can change the orientation of the blade as the operator drives to get a flat surface or a crown on a roadbed or to cut a side slope or a complicated superelevation or vertical curve.

"With one of these systems on board, the operator can tell anywhere on the site how much fill material is needed," commented Nichols, "so he can direct the driver of a truck, for example, more closely to where the material needs to be dumped, and therefore he has less distance to travel to push and spread that material. That increases his efficiency again."

The improved productivity can lead to a quick return on investment and better profitability.

"You've got companies now that before would have a hard time investing \$20,000 into a motor grader system, now are investing into a three-dimensional system at \$100,000 and realizing the payback much quicker and are purchasing second and third systems much sooner," Murray Lodge, national sales manager for equipment automation at Topcon Positioning Systems Inc., Pleasanton, Calif., told Road & Bridges.

Topcon has its own joint venture with Sauer-Danfoss Inc., Ames, Iowa, announced Feb. 2, 2001. Tim

Kramer was with Sauer-Danfoss and became the general manager of the joint venture company, called TSD Integrated Controls. In the announcement, Kramer said the combination of his company's strong position with equipment manufacturers and Topcon's innovative positioning technology would "provide a standardized solution to the task of adding automated positioning and machine management control systems to off-highway equipment."

Sauer-Danfoss makes engineered hydraulic systems and components for use primarily in applications of off-highway mobile equipment.

"By forming a joint venture with them," said Lodge, "we're actually able to go into the equipment manufacturers themselves now and provide the full solution so that we can actually install a system at the factory."

In the first year of the joint venture, TSD Integrated Controls has partnered with more OEMs than all the other laser and machine control companies combined, according to Ray O'Connor, executive vice president of Topcon. The companies include Case Equipment, Caterpillar Paving Products, Cedarapids, CMI, Dynapac, Gomaco, Guntert & Zimmerman, Miller Formless, Power Curbers, Roadtec and Voegle America.

Different technologies for different folks

The operator can use the positioning system as a guide and manually do bulk earthwork, then switch to automatic machine control to do finish grading. With a robotic total station sitting on the site tracking the machine, the 3-D positioning system can achieve an accuracy of 0.03 ft. Using GPS, the machine can reach an accuracy of 0.1 ft.

Setting up a rotating laser at the jobsite and equipping the earthmoving machine with a receiver can get about the same accuracy as a total station, but only on a two-dimensional plane. The laser cannot track the machine up a vertical curve.

Sonic positioning systems have been around for about 15 years and need a reference to follow, such as a curb or string line, to establish an elevation.

The advantage of the total station is its control and precision. The disadvantage is that it requires one total station for every machine to be controlled on the jobsite. With a laser grade system, one laser can provide 2-D grade information to many machines. GPS can provide 3-D information to many machines on the jobsite, but it is not quite as accurate as a total station, which receives a signal from the earthmover, calculates its position and transmits the information back to the machine.

Innovation can thrive in tough times

Contractors are climbing on the electronic bandwagon—or at least the electronic earthmover—and increasing productivity and decreasing job times.

Lodge said the technologically less sophisticated side of Topcon's business had gone through a little bit of a slowdown recently, but the machine control business was actually up from last year: "Contractors realize they've got to figure out a way to be more productive if they're going to be competitive. And machine control does that for them."

In fact, Lodge commented that automatic machine control was being written into the specifications for some federal and state highway construction jobs, because the agencies want tighter tolerances on grades and faster job completion times.

Nichols echoed the same thought: "What you see with an emerging technology, particularly one that has a very fast return on investment and a very distinct advantage in reducing the cost of doing earthmoving, what you see is even in times when there is an economic slowdown, that doesn't necessarily mean that

this type of technology slows down. In fact, it can continue to grow and often grows faster, because the astute contractor understands that by having this technology he can win business in a tougher economic environment because he can bid at a lower price and still make money by utilizing this class of technology.”

The following are descriptions of a few of the grade control products applicable to roadbed prep.

3-D grading

The BladePro 3D machine control system from Trimble combines its TerraModel software with position information and the BladePro dual control system to deliver an automated fine grading solution.

The system uses either a GPS receiver or a robotic total station to measure X, Y and Z coordinates and compares the current position to the preloaded digital terrain model of the project. The system automatically moves the blade to the correct cut or fill position, elevation and slope by directly controlling the machine’s hydraulic system.

BladePro 3D is available for dozers, graders, motor scrapers and carry-all scrapers (Circle 943).

Trimble announced the extension of its SiteVision GPS guidance and control product to excavators on March 19 at ConExpo-Con/Agg 2002. The system provides for accurate digging by programming the site design into a computer in the excavator’s cab and using GPS technology to calculate the position of the machine in 3-D on the site.

Advanced 3-D GPS

Topcon’s GPS+ incorporates the company’s Paradigm technology, which uses both GPS and GLONASS satellites to maintain signal lock even under adverse conditions. The result is higher accuracy and faster automatic performance, according to the company. Plus, in-band interference rejection and advanced multipath reduction cleans up the information received.

The operator can monitor the GPS+ (Circle 942) on a touch screen in the cab. The System Five Control Box displays real-time design elevation and design slope, as well as real-time equipment location, distance to finish grade and actual cross slope. It works for GPS+, LPS (Topcon’s total station 3-D machine control system), laser, sonic and cross-slope applications.

Topcon’s 3-D GPS system uses a digital terrain model to show the operator the equipment location on the jobsite, design elevation, design slope, actual blade slope and distance to finish grade.

Other Topcon products automatically control pavers, dozers or excavators. With 3D-GPS Automatic Grade Control, multiple machines can be operated from one base station and make rough grading directly from site plans.

EZ does it

The EZ-Blade Motorgrader System from AGL Construction Lasers & Machine Control Systems, Jacksonville, Ark., features an on-board grade and slope sensing system that provides uniform grade control over the entire job with minimal staking. The system can follow a curb, existing pavement, a string line or a laser reference.

EZ-Blade enables finish grading in one or two passes, according to AGL, instead of three or four and allows finish grading in second or third gear. It has a slope sensor that feeds precise information to the cab and a rotation sensor to ensure proper slope when the blade angle is changed.

EZ-Blade (Circle 938) also features a laser receiver that allows the operator to set the reference point

wherever the laser beam happens to hit the receiver, rather than needing to align the on-grade area of the receiver with the beam. The receiver will send information to move the blade up or down from that reference point.

Pro control

The Pro Control System is the latest in machine control from Laser Alignment, a Grand Rapids, Mich., division of Leica Geosystems. Laser Alignment makes a variety of construction lasers, pipe lasers and machine control solutions.

The Pro Control System (Circle 939) is a proportional machine control system for dozers, scrapers, graders and skid loaders. It can function for manual control, fully automatic control using dual power masts, tilt control and 3-D GPS.

Like a laser shot

Laser Reference Inc., Campbell, Calif., makes a variety of construction lasers for grade checking, form setting, transferring elevations, land leveling, setting drop ceilings and other applications.

The L1-AS Servo Leveled Slope Laser, for instance, is designed for grading and pipeline contractors (Circle 940). It can shoot slopes of 0-9% in increments of 0.01% with an accuracy of 3/32 in. at 100 ft. It has an operating range of 1,000 ft. All the user has to do is set the unit on a tripod, dial in the desired slope and push the power button. The unit will level itself.

Level yourself

The PLP-5H/PLP-50 Automatic Self-Leveling Laser (Circle 941) is one of a line of lasers suitable for roadbed prep from Pentax Corp., Englewood, Colo. The waterproof laser will level itself in seconds simply by turning it on. It uses an internal electronic leveling mechanism. The PLP-5H delivers an accuracy of ± 10 in. with a measuring radius of 1.65-660 ft. The PLP-50 delivers an accuracy of ± 12 in., with a measuring radius of 1.65-330 ft. The diode laser beam can rotate at 300 or 600 rpm.

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