

Spotlight On Heavy Equipment

A FLEXIBLE UPGRADE

Machine Grading Control Systems Have Something in Common with Project Delivery Systems Such as CM at Risk: Flexibility and Cost Control

by Don Talend

The most commonly cited benefits of Global Navigation Satellite System (GNSS)-enabled machine control are grading and excavation productivity and the cost savings that result from a reduction in manual tasks such as excavation depth verification using conventional surveying methods. The use of this technology on recent underground utility work for a state vehicle maintenance facility outside of Phoenix, AZ, demonstrates that it has something in common with the Construction Management at Risk (CM at Risk) project delivery method, in which cost control is a major priority.

In early 2009, Haydon Building Corp., constructed a 24,000-square-foot, \$9.9 million Arizona Department of Emergency and Military Affairs (DEMA) field maintenance shop in Florence, AZ, located about sixty miles southeast of Phoenix. It was one of the first projects in which Haydon used GNSS to control an excavator digging excavations for underground potable water pipe, sewer force main, gravity sewer and storm drain pipe servicing the new facility, which is equipped with work bays and a lube bay for DEMA vehicles, as well as administrative areas. All told, Haydon installed 3,535 linear feet of 10-inch PVC pipe for potable water, 2,000 linear feet



Haydon Building Corp. installed pipe for potable water, sewer force main, gravity sewer and storm drain at a field maintenance shop in Florence, AZ.

of 4-inch high-density polyethylene (HDPE) sewer force main, 500 linear feet of 8-inch PVC gravity sewer and 100 linear feet of 12-inch HDPE storm drain. All but the potable pipe was new and not tied into an existing system.

Under the CM at Risk method, the construction manager serves as part of a team with the owner for the design and construction phases of a project. During the construction phase, the construction manager's role converts to the legal equivalent of a

general contractor once a Guaranteed Maximum Price is established for the construction work. The construction manager is responsible for ensuring that the project stays on schedule and conforms to the contract details and, therefore, takes on more of the risk that other project stakeholders otherwise would assume. Benefits of this approach include flexibility, quality control and cost control; rather than managing multiple contracts, the construction manager can bid and subcontract a portion of the work at

any time and sign the construction contracts, even when the design of an unrelated portion is not complete.

In the spirit of construction cost control, Haydon has also incorporated GNSS grade-control technology into its day-to-day operations over the past several years and purchased two X63 systems from Topcon Positioning Systems in 2008. The company may purchase several more systems in the future, as the technology becomes an even bigger part of day-to-day operations, according to Jeff Fields, Haydon's GPS manager.

GNSS Impacts Dirtmoving

A GNSS machine-control system uses a rugged antenna mounted to a shock-absorbing, vibration-damping pole and a receiver box mounted in a secure location on the machine. Satellites send positioning data to another antenna/receiver combination at a stationary base station. Positioning data is also sent to the machine. The stationary base and machine work together to provide real-time kinetic (RTK) position information, revealing the machine's three-dimensional location on the site. Software compares the machine's position to the design grade at a given location. The design grade information was built from site plans.

The data files are loaded into a machine-mounted control box via a USB flash drive. The control box updates positioning data and sends signals to the hydraulic valves. The blade is automatically positioned for elevation and slope. Other sensors inform the control box of certain machine conditions; for example, dozers are



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equipped with a slope (tilt) sensor on the blade to measure the cross-slope of the cutting edge. “Indicate systems” provide in-cab visual guidance for machine operators, who manually control the machine to cut or fill to the desired grade.

During the past several years, these systems have evolved in terms of flexibility and reliability. An alternative to a base station—one that Haydon uses—is subscribing to a network that provides positioning corrections using cellular technology. The contractor does not have to set up a separate base station on each jobsite.

“With a base station, you’re setting on a known point on that job and on that known point, that base station transmits to the machine or

rover corrections of where it is,” said Todd Hermsen, Haydon’s Topcon sales representative at Branco Machinery in Gilbert, AZ. “When you move to a cellular communication with a network, the machine is actually dialing up to that network via cellular communication and receiving its corrections.” He added that Branco’s TAZNet (Topcon Arizona Network), which went online in mid-2007, reaches the Phoenix and Tucson metropolitan areas. “What it allows [Haydon] to do is take their base and rovers that they may already have and instead of tying up that base station on that job, give them the flexibility of taking that base station and converting it to a rover. So someone like Jeff is able to take it out and use it for his survey work and not

have to have that base station on the job at all times.” Once Branco installs cables and sensors on the machine and activates the modem, the contractor accesses the network via a wireless telecommunications service provider.

GNSS has become even more reliable and accurate in recent years by adding compatibility with the Russian GLONASS satellite constellation as well as the U.S. Global Positioning System constellation. This dual-constellation capability roughly doubles the number of signals available to the GNSS antenna/receivers and provides a high degree of positioning accuracy.

Like CM at Risk project delivery, this equipment can provide flexibility to the grading or excavation portions of a project. “Things change so quickly and if we have our 3-D model set up and we want to pull off one section of the job and go to the next, we don’t have to get the surveyors to come out and restake it,” says Fields. “This technology gives us the ability to do that. That’s one of the big reasons we decided to go with the 3-D system.” Fields, who has a surveying background, learned conventional surveying skills while working for his grandfather starting at age fourteen and eventually surveying in several Midwestern and Western states over the years. He now uses the GNSS equipment to verify takeoff estimates and collect location data used to build digital site models. Fields is also able to troubleshoot the system, often with just a call to the dealer.

Excavating with Precision

In early March 2009, with crews staking curb work for a winding entry road and masons constructed brick walls on the new maintenance facility, Fields walked over the buried pipe



that had been installed three months earlier. Haydon had used a relatively new method of exposing the existing communications and water utilities, which would all be kept in service, before locating them with the X63. A vacuum excavator was used for subsurface utility engineering, a nondestructive method of locating buried underground utilities that also improves worker safety. The excavator located utilities by forming clean-cut, targeted potholes above the utilities without adversely affecting the surrounding soil stability.

After locating the utilities, Haydon had Dirt Pro, LLC of Higley, AZ, build 3-D site models and loaded the models into the X63 system control box via a flash drive. A Caterpillar 330 CL excavator was equipped with Topcon’s X63 grade-control system, which is specifically designed for excavators. The system consists of four temperature-compensated 360-degree CAN-based tilt sensors that measure angles from the cab, boom, stick and bucket; a GX-60 color touch screen control box; two GPS+ antennae and a GPS+ receiver.

While digging trenches, the excavator operator ensured the proper digging depth by viewing on the GX-60 the machine’s exact position on the site, in addition to the bucket’s constant position. The system eliminated the need for a grade checker to continuously monitor excavation depth. The depth for the potable water pipe and sewer force main was about four feet and the width about two feet. The depth for the gravity sewer was about eight feet and the trench width about three feet.

“Basically, [the system] eliminates the need for a guy manually checking grade, whether he’s shooting it with an eye level or just simply putting a tape down or even a grade stake,” said Manny Tarazon, pipe superintendent for Haydon’s Heavy Civil Division. “You can also check the elevation on your pipe—if you put that bucket right on top of that pipe, you can actually take a shot. We were sloping the sides of the trenches, too, so the system even helped us to make sure we had our proper slope.”

Most importantly, several contractors have reported that machine-control systems can double productivity, i.e., reduce dirt-moving time by half. In addition to the sheer increases in grading and excavation efficiency, the systems eliminate the need for conventional staking and, in some cases, verification of grading and depth by a licensed surveyor. Some contractors have reported that the improved productivity can translate to savings up to the five-figure range on some projects. ■

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