

Rhodes Communications, Inc.
Press Release for Magazines

Steering by Satellite: New Technology Automates Dozer Control for Mining Sites

Imagine this...

You are a dozer operator working on a land reclamation site. On top of your vehicle is an antenna receiving signals from orbiting satellites that measure your position in three dimensions within centimeters. In front of you is a large computer screen that shows a picture of your machine as it moves across the site and displays exact cut and fill values to match a precomputed design surface.

And it's all done without survey grade stakes.



Something out of science fiction? Not any more. It's a reality now. Thanks to new developments in precise satellite navigation technology and machine guidance software.

In this article, we will describe a new machine guidance technology that will revolutionize earthmoving, providing a way to save on survey costs, bypass staking, bring a site to grade faster and verify grade independently.

The Traditional Method

Current methods for guiding earthmoving machines require surveyors to set grade stakes to provide a visual guide for machine operators to move earth to the desired design level. The grade stakes are placed in strategic locations around the site and indicate the level of cut and fill required at that location. Machine operators use their expertise and experience to interpolate the grade between stakes.

On-site surveyors are required to stake and re-stake, checking on the resulting surface to calculate the volumes of earth moved and deviations from the desired design surface. Moreover, the grade stakes are often knocked down by the machines during the course of daily work, making it necessary for surveyors to replace them.

The procedure is labor-intensive, and requires the surveyors and machine operators to work closely together to produce the final result.

Technology to the Rescue

For several years, it has been recognized that the Global Positioning System (GPS) – a U.S. military satellite navigation and positioning system that is also available for non-military use – offered interesting possibilities for machine automation. Recent advances in GPS receiver design, computer processing power and ruggedized touch-screen computers have combined to enable the development of a completely new approach to machine guidance, in the form of a new system recently introduced to the market by Leica Geosystems, in cooperation with Carlson Software.

Satellites and Computers

Leica's Dozer 2000 is a revolutionary vehicle positioning and guidance system specifically designed to enhance the productivity of earthmoving equipment. The Dozer 2000 system uses signals from GPS satellites, corrected for local errors by signals from a nearby base station, to determine the exact position of the vehicle in real time. A large touch-screen display in the cab clearly shows the position of the vehicle in relation to the desired design surface, giving easy-to-follow steering and cut and fill directions.

The Dozer 2000 system uses a technique called differential GPS (DGPS) to achieve the highest levels of accuracy and reliability. At the construction site, a differential GPS reference station is established at a fixed location to monitor the signals from all of the GPS satellites and calculate corrections to compensate for errors in the satellites' navigation messages. Correction data is then transmitted

to any number of earthmoving machines equipped with the Leica DGPS receivers. The range of the transmitters is about 10 km.

Each bulldozer is equipped with a Leica GPS receiver, a ruggedized computer loaded with the Dozer 2000 software and a radio receiver. The GPS antenna is mounted on top of the cab, where it has a clear “view” of the orbiting satellites, and the touchscreen computer is placed in the cab. Power for the GPS receiver and computer are taken from the vehicle’s battery.

The system has been field tested at mining sites in Texas and North Dakota with excellent results.

Ease of Operation

To start working, the operator simply turns on the computer. The system takes about three minutes to initialize, after which the Leica GPS receiver starts measuring the vehicle’s position 10 times every second. The Dozer 2000 software displays cut and fill values along with views of the vehicle moving across the site.

The start screen of the Dozer 2000 is very easy to use. Large on-screen icons illustrate the major options:

- Grade
- Navigate
- Slope
- Monitor
- Project
- Transfer
- Options
- Exit



The icon pictures make it easy to select the desired option. Grading is represented by a dozer. Exit is a doorway. Align is a North arrow. To select an option, the operator simply taps the appropriate icon on screen with a finger.

Once the system has been set up initially, all the operator has to do is turn on the computer and touch the dozer icon for a typical day’s work.



The main grading screen has three options:

- Plan and section view
- Plan and profile view
- All three views

Touching the “View” icon will switch from one view arrangement to the next. In all cases, cut and fill amounts are shown at the top of the screen in large numerals. The display can be configured to any number of decimal places, depending on the precision required. Plan views can be scaled up or down with the Plan + and Plan – buttons. As grading work proceeds, the dozer moves across the plan view, which always faces due north. The operator can reference his position against any plan view feature, such as building pads, edge of pavements, ponds, streams and utilities.

At any time, the operator can choose the cut/fill color screen. This screen conveniently displays cut values in red and fill values in blue, with colors darkening as deviation from the desired surface increases. At a glance, the operator can see where fill material needs to be placed, or where the larger cut areas are. When the colors disappear, the site has been graded to within the precalculated tolerances. That tolerance (for example, $\pm 5\text{cm}$) can be entered by the operator, the foreman or other staff person, and remains permanently stored.

When the ramp or slope feature is selected, the operator touches a start grade icon, moves forward and touches an end grade icon. This establishes an alignment and a slope. A new slope can be entered if desired. Cross slopes are entered next, and the width of the ramp feature is entered. The ramp then displays on the screen, and cuts and fills are shown as the grading work is conducted. In this way, linear single-slope features can be created without any office consultation whenever necessary. Sloping grades can also be verified in the field.

The system also includes an option for a tilt sensor to calculate grades accurately at the base of the track or blade when slopes are steeper than 10%.

During the working operation, data is automatically logged on a PCMCIA card in the vehicle's computer. This data can be downloaded from the card to the office computer at the completion of each day's work. The site manager can therefore have information available to monitor progress of work and the final elevation of the graded surface.

Applications

The Dozer 2000 is ideal for earthmoving sites in large open locations where the visibility of the satellites is not blocked or attenuated by overhanging foliage or structures. Mining companies are currently using the system for land reclamation projects after open pit mining operations. The system has proven itself able to meet the demanding requirements of the U.S. Department of the Environment mandating that the earth removed for strip mining be replaced to an accuracy of 30 cm.

The Dozer 2000 enables bulldozer operators to complete this task in a highly efficient manner without the need for survey stakes. The land can be modeled and replaced exactly as it was before the mining operation commenced.

In heavy construction applications, the Dozer 2000 can be used for rough cut grading or preparing a site for stone or seeding. The system can assist the operator to complete these tasks to less than 5 cm in vertical. Construction companies have used the Dozer 2000 system to prepare sites for shopping malls, highways, building construction and even golf courses.

Site Inspection

The Dozer 2000 system can also be mounted on inspection vehicles for mining or construction sites, for checking grades and navigating to specific locations. Station, offset and cut/fill amounts are displayed continuously and saved for record keeping. This saved information can be



downloaded and compared with engineering design files to provide a very quick and accurate method of calculating deviations from the design surface.

Empowering the Operator

The Leica Dozer 2000 brings many productivity benefits to earthmoving, in terms of cost savings and increased productivity. Most importantly, it empowers the machine operator to optimize the use of the equipment, by providing an easy-to-use tool that lets him do the job faster and better. The equipment operator is no longer dependent on surveyors and other support team members, but works independently to complete the job.

Experience has shown that there is little or no need for grade staking with the Dozer 2000. It is quite possible to bring an entire job site to within a few centimeters of the desired surface without a single stake being placed.

In other words... survey costs are down, and job efficiency is up.

The ease of operation of the Dozer 2000 has facilitated its acceptance by machine operators, who now have the information necessary to optimize their equipment. The machine operator can make decisions as to how the earth can be moved around the site in the most efficient way, knowing exactly his vehicle's position relative to the final design surface. Even the grade checking can be done by the dozer operator himself, by driving over the completed work and recording the results.

The Dozer 2000 also enables the operator to complete a number of important design tasks in the field. For instance, he can automatically and quickly design ramps between bench levels on site, by measuring the elevation of each bench level. The system automatically calculates the ramp placement and position at a predetermined location. The operator can also use the Dozer 2000 to log the position of any feature on site. For instance, he could log existing utilities on a construction site or the edge of ore bodies on a mining site.

Office Savings

In addition to increased productivity for earthmoving operators, the Dozer 2000 system can also provide significant savings in computation time in the office. The Leica Site Manager makes the data flow between the office and

the field transparent. Design files that are calculated in the office can be automatically uploaded into the vehicle's computer and displayed directly to the machine operator.

As the work on site proceeds, the Dozer 2000 logs the position of the machine and saves the final grade to the PCMCIA card. The grade is stored as a grid file and can be compared to the grid file for any previous day or to the grid file made at the start of the job. Quantities between grids can be calculated to determine grading progress on a daily basis or at any interval.

This process enables critical information to be available to the site manager, who can compare the actual surface with the original design file and easily monitor the progress of the work and volumes of earth that have been moved. The calculations are completed quickly, easily and automatically at the conclusion of each workday.

The ability to log data directly in the field and compare this information to a design surface makes the Dozer 2000 system a useful inspection tool. The system can be mounted on a inspection vehicle and driven over a completed site. At the completion of this inspection survey, the logged data can be downloaded and compared with the original design file. The inspector can then create a spreadsheet of information that highlights the deviations of the actual surface to the design surface.

Conclusion

Advances in precise satellite navigation technology, combined with new software for machine automation, have made it possible for operators to perform many earthmoving jobs without the need for grade stakes. Initial installations of the Leica Dozer 2000 system at mining and construction sites have revealed significant savings and enhanced productivity. Most importantly, the system has been embraced enthusiastically by dozer operators, who have been impressed by the system's ease of operation.