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3D GPS Based Earthmoving

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The Need

Construction design includes using a construction planning or survey software to create an elevation design to which the machine operators should work. This design may be a simple production dozing such as a dual sloped plan for field drainage or a much more complex design such as super-elevated curves.

Designs are developed using a survey of the site and the identification of various natural and man-made structures. Traditionally, these designs are transferred to the field by placing survey stakes at key locations.

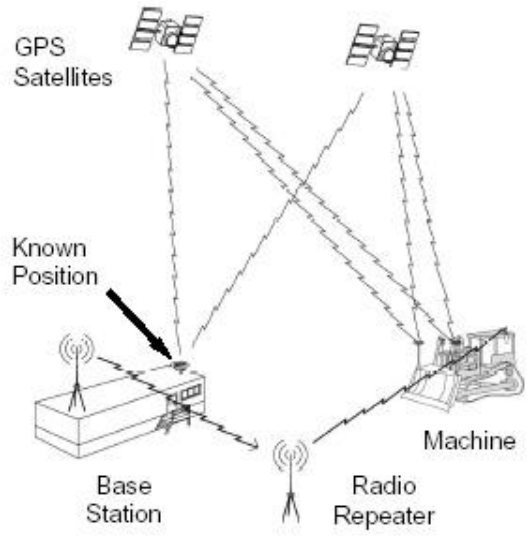

Figure 1 Typical Site Vision System

The number of stakes that must be used depends on the complexity of the design. It is impossible to supply enough survey stakes to convey the same resolution that was in the original design. Field foremen and paper plans usually supplement the survey information. As the job progresses, additional surveys may be required to convey information on the next phase, to make changes to the current work, and to document completed work against plan. This conventional process is time-consuming and it contains numerous opportunities for error.

The Technology

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GPS is a set of satellites run by the US Department of Defense, which broadcast radio signals that contain precise time and other information. A GPS receiver on the ground receives signals from several satellites and computes its exact location in three dimensions. Position accuracy of GPS systems for grade control applications is better than 20 to 30 mm (0.1ft).

Recent advances in GPS receiver design, computer processing power, real-time data processing algorithms and availability of rugged touch screen computers have enabled GPS based machine guidance system or grade control system.

Site design in the form of plans or a digital terrain model, which is developed based on GPS data, is downloaded to the on-board computer which then works out where the machine is and how much cutting or filling is needed at that point by referring to the site gird. The computer makes the decision based on GPS data of the blade. The information is transmitted to the operator via the monitor or the light bars.

The system is composed of the followings:

GPS receiver - The GPS receiver on the machine computes the exact position of the GPS antennas many times per seconds. On a new construction site, one receiver is set up on a permanent base mounting with the antenna, and another receiver is placed in the machine with its antenna(s) mounted on top of the cab or blade.

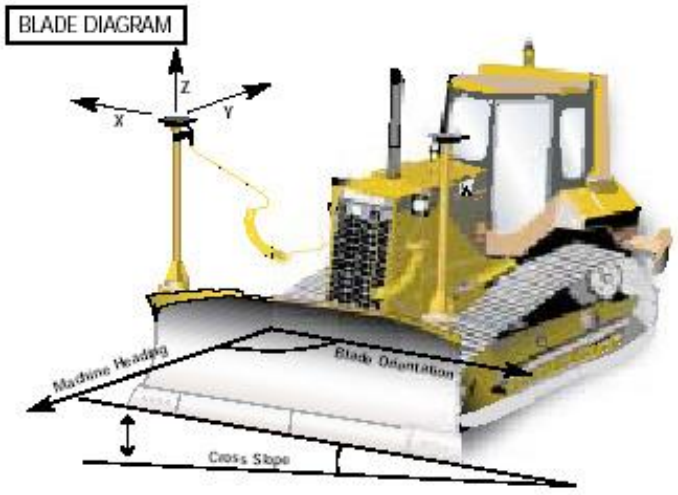

FIGURE 2 GPS INSTALLATION

Computer - The computer takes the GPS antenna(s) coordinates and translates them to ground position based on antenna(s) mounting heights. It then displays cut cut or fill amounts, as well as the position of the equipment in plan view, section view, profile view or text.

Radios - Communications between the base and machine is performed by a high speed communications radio network.

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BENEFITS

The benefits from applying these products are:

- Fast and accurate decision and control due to real time information of position and grade displayed in the cab.

FIGURE 3 DISPLAY MOUNTED WITHIN THE CABIN

- Reduction of surveying and grade checking costs and increase of machine utilization. The operator and the machine aren't waiting for surveyors to stake, or re-stake the job.
- Faster job cycle. Operators know where the grade is, as well as the locations of design elements, and are able to move more dirt each day. They can work regardless of wind, dust or darkness, finishing jobs faster.
- Reduction of the rework caused by the lack of correct information in the field.
- Lower operating cost. Better machine utilization and fewer hours per volume of dir moved.

STATUS

There are a couple of systems available:

- SiteVision GPS from Trimble Navigation Ltd.
- Dozer2000 from Leica Geosystems Inc.

These companies performed some projects successfully including Clearwater Resort and golf course development (Christchurch, New Zealand, Trimble) and San Miguel Lignite Mine mining operations (San Antonio, Texas, Leica).

BARRIERS

GPS is still only used regularly on big projects and bulk earthworks because of the limitation of accuracy.

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System preparation, education and understanding on the procedure that is different with traditional method. e.g. site coordinate calibration, system setup and configuration, and design data handling, etc.

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Reviewers

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