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Today's Topics...

Engineering Automation

Survey Automation Design Automation **Construction Automation**

Construction Automation – Ron Singh

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Today's Topics...

Engineering Automation

Survey Automation Design Automation **Construction Automation**

Site Monitoring Surveying Material Certification

Inspection Machine Automation Positioning

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Major Components of Construction Automation

- Inspection Tools
- Enhanced use of GPS
- Material Delivery and Certification
- Remote Construction Site Monitoring
- Connected Site
- Machine Automation
- Post Construction Surveys

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Moving On...

Engineering Automation

Survey Automation Design Automation Construction Automation

Machine Control and Guidance Systems

Site Monitoring Surveying Material Certification

Inspection Machine Automation Positioning

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For The Purpose of This Presentation...

A Machine Guidance system will be considered to be one that uses automation to provide the equipment operator a visual indicator of the position of the cutting edge (blade, bucket, screed, etc) relative to the design surface being constructed.

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For The Purpose Of This Presentation...

A Machine Control system will be one where the cutting edge of the equipment is fully controlled by automation.


The system is connected to and controls the hydraulics while the operator simply drives the equipment and manages the automation.

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3 Components of Machine Control


1. The Design and Resulting Data
2. The Machine w/Computer, Sensors, Hydraulic Control, and Radio
3. The Positioning System – GPS, TPS, Laser, or combination



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Structured Data Exchange




Detour To XML

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Guidance Systems

- Provides the interface between engineering design and the machine operator




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Types of Guidance Systems

- Stakes
- String Lines
- Sonic Sensors
- Lasers
- GPS
- Total Stations
- GPS w/Lasers




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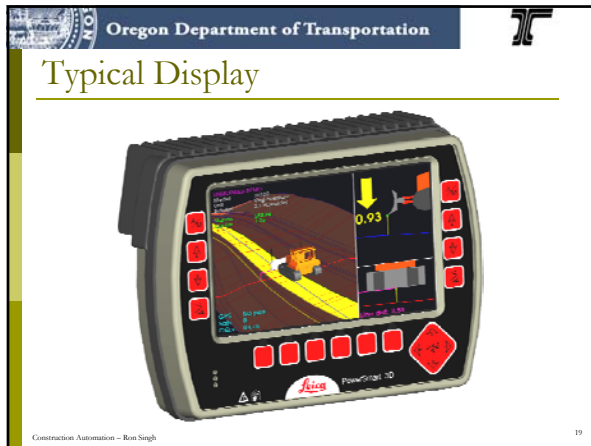
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Guidance By GPS

- GPS based machine guidance
- GPS provides near exact position of vehicle in “real time”
- Cab mounted display indicates position of machine relative to design anywhere on the surface
- Equipment operator controls cutting edge

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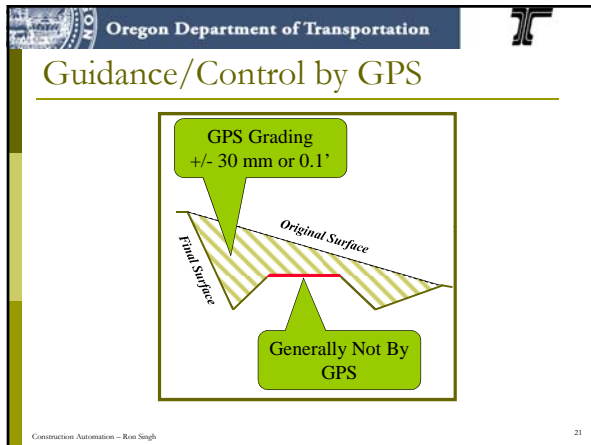


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Control By GPS

- ❑ GPS provides near exact position of vehicle in “real time”
- ❑ Position of the cutting edge is computed
- ❑ The hydraulics moves the cutting edge accordingly to match the design surface

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Guidance/Control by GPS

Advantages

- ❑ No line of sight required from reference to rover
- ❑ High enough accuracy for most applications (except where elevation is critical)
- ❑ One base - many rovers
- ❑ Works in all weather conditions (and at night)

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Guidance/Control by GPS

Disadvantages

- ❑ Height accuracy is not as good as total station applications
- ❑ Poor performance in obstructed areas (forests, urban canyons etc.)

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Control by Laser Augmented GPS

GPS (RTK) derived elevations are:

- ❑ Somewhat erratic
- ❑ Dependant upon a variety of factors such as satellite geometry, local deflection of the vertical, etc.
- ❑ Limited to an accuracy of a few centimeters

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Control by Laser Augmented GPS

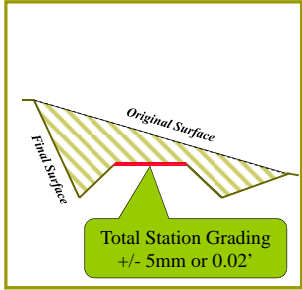


Laser augmented GPS systems delivers a few millimeters of vertical accuracy using conventional lasers capable of working on an inclined plane

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Control by Total Station




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Control by Total Station

- Started in the early 1990's with robotic motorized total stations that could track a prism mounted on a machine





- Could position the prism to high accuracy - equivalent to string lines and lasers

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Control by Total Station

- Information from the prism position could be sent to the machine, which would adjust the hydraulics accordingly.


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Control by Total Station

Advantages

- No longer needs string lines. Same accuracy can be achieved with optical methods
- Ideal for slow moving, high accurate applications - like concrete pavers




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Control by Total Station

Disadvantages

- One unit per machine
- Limited to line of site. This could be a limitation in busy building sites



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Machine Control

The Ultimate System:

- ❑ No stakes required
- ❑ No grade checker required
- ❑ Records data for quality control
- ❑ Records data for volume computation
- ❑ Data could be transmitted to engineer, inspector, or surveyor for “real time” checks

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Bulk Excavating – Scrapers/Dozers



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Bulk Excavating – Dozers



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Concrete Paving



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Trimming



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Excavating – Shaping & Compacting



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Barrier



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Curbs and Sidewalks




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The Emerging Role of Operating Engineers

- Requires education/training relating to new systems
- Pre-qualification or certification
- Clearly defined role in project specifications



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The Role of the Design Engineer

- 3D coordinate correct designs
- Build-able and not just bid-able plans
- Complete, reliable, and construct-able digital data – less reliance on “on the grade” design
- Available on very short notice for design changes


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The Role of the Surveyor

- Establishment of horizontal and vertical project control
- Data management
 - Acquiring and validating design DTM
 - Converting DTM to exchange format
 - Providing exchange format data to contractor




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The Role of the Surveyor

- Quality assurance
 - Validating TIN produced by exchange format data
- Re-measure or validate grade
- No longer available for design changes
- Post Construction Surveys



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The Role of the Inspector

- Will continue as today...
- With less support from surveyors
- With diminished ability to check constructed elements for grade, alignment, or width
- Will need additional technology to check stake-less construction

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Construction Automation Plan

In Development



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Introduction

Draft

The overall Construction Automation Plan (as envisioned today) could be developed and accomplished in (3) 2 year phases, beginning in 2009 and being fully implemented by 2015.

We fully expect that technologies will change over time, and the plan will be adjusted as necessary to adapt to those changes.

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2009-2011

Draft

- Digitally signed Contract Plans and related documents
- Continued 2½D design data – standardized and formatted to support this period's machine control and survey stakeout goals
- Digital "Engineering Data" available to contractor in stages as needed
- Machine Control focused on roadway excavation and grading, and trench excavation for pipe installation
- Continue the concept of Contract Plans as "Primary" and Engineering Data Packet as "Secondary"

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2009-2011 (cont'd)

Draft

- Construction surveyors available for high precision positioning checks, stakeout, and Post Construction Surveys
- Inspectors utilizing hand held devices to manage construction documentation – they would not have access to high precision positioning tools.
- Post Construction Surveys (short list)
- Designers, Drafters, Surveyors, and Inspectors trained to accomplish these goals

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2011-2013

Draft

- True 3D design data (short list)
- Design data should be on the new low distortion Oregon Coordinate Reference System
- Digital "Engineering Data Packet" available to contractors upon Bid Notice (short list)
- Redefine Engineering Data Packet as "Primary" and Contract Plans as "Secondary"
- Post Construction Surveys (complete)
- Designers, Drafters, Surveyors, and Inspectors trained to accomplish these goals

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2013-2015 *Draft*

- ❑ 4D design data (3D design coupled with construction schedule)
- ❑ Digital Engineering Data Packet to include all elements of construction
- ❑ Inspectors utilizing hand held high precision positioning tools with onboard design data for field verification
- ❑ Project Connected Site – Wireless data hub
- ❑ Designers, Drafters, Surveyors, and Inspectors trained to accomplish these goals

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Stay Tuned...



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