GPS Machine Control Grading & BIM (Building Information Modeling)

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Agenda
- Industry Trends & Challenges
- BIM - Building Information Model
- GPS Machine Control Technology
- Workflow and process Old vs. New
- Building the model using Civil 3D
- Exporting to Trimble SiteVision Office
- Virtual Grading
- Challenge/Solution Scenarios
- Q & A
Civil Industry Trends - Productivity 1964-2005

Data Creation and Loss

Design Team

Bidding in 2D, Paper

Construction Team
Ability to impact cost and performance

Cost of design changes

Drafting-centric design

Segregated Delivery Model

Construction Safety

- Electronic Library of Construction Occupational Safety and Health (ELCOSH)

- "Vehicles and mobile heavy equipment were involved in 469 deaths (37.7%) out of a total of 1,243 construction deaths in 2005."
AutoCAD Civil 3D...

- Provides civil engineers, designers, surveyors, and drafters with a comprehensive package for the design, drafting, and management of all types of civil engineering projects.
- Improve productivity, efficiency, and profitability by:
  - Making design changes quickly and efficiently
  - Providing a higher degree of automated drafting
  - Leveraging AutoCAD experience
  - Using one product for all types of projects

BIM for Civil Engineering

- Create BIM for Civil Engineering
- Deliver Building Information Modeling
- Visualize Construction Data Creation and Loss
- Analyze Digital Data Lifecycle Surveying Plan & Design Drafting Construction Manage

Data Creation and Loss
Ability to impact cost and performance

Cost of design changes

Drafting-centric design

Model-centric design

Design iteration / optimization with BIM

Improved Project Coordination

Information Model

Construction Team

AMOUNT OF RESPONSIBILITY

Planning  Preliminary Design  Design Development  Construction Documents  Construction

TIME

Improved Project Coordination

Documentation  Digital Fabrication

Analysis  Project Model

Visualize  Simulate  Analyze
What is GPS Machine Control

- The use of Global Positioning System (GPS) technology for machine guidance in construction

An estimated 85% of all new construction equipment comes equipped for GPS machine guidance.

What is Driving Adoption??

- Efficiency
  - Accuracy results is less rework
- Productivity
  - Less machine hours
- Health & Safety
  - Keeps workers out of harm's way
- Workforce Challenges
  - More accurate results with less experienced workers

www.gpsworld.com

What is Driving Adoption?

- Economic
  - 30% to 80% faster and 70% less rework
- Environmental
  - Reduced emissions
- Workplace
  - 40% less LTIF

www.gpsworld.com
GPS Machine Control is for the Complete Cycle of the Project

Dozers

GPS Machine Control is for the Complete Cycle of the Project

Scrapers

GPS Machine Control is for the Complete Cycle of the Project

Excavators
Benefits of GPS Machine Control

- A faster more accurate process
  - Everyone using the same model
  - Put the design in front of the machine operators
  - Less experienced operators can get it right the 1st time
  - Project isn’t interrupted for staking & grade checking
  - No “bumped” stakes
  - Reduction in change orders ~ 70%

Benefits of GPS Machine Control

Better tools to manage jobs

- Production can be measured
- Progress can be tracked
- Deadlines can be met

Benefits of GPS Machine Control

- More Accurate Billings
  - Generate accurate material reports daily
  - Document how much earth was moved and when
  - Never move earth for free again
Benefits of GPS Machine Control

• ROI – return on investment
  • One major job of a year and the package pays for itself
  • Increase production 35%-50%
• Significant materials savings
  • Precise rough grading
    • Grade crown in rough grading

www.constructionequipment.com

Reduce Environmental Impact

• Optimize equipment on site
  • Increased productivity
    • Grade once in less time
• Avoid environmentally sensitive areas
  • Define avoidance zones
• Accurate representation of design intent
  • Less importing or removal of materials
  • Ensure water runoff is treated properly
• Only dig in required areas to specified depths
  • Less earth scarification
  • Less sediment in rivers and ponds

Satellite Systems

• GPS (Global Positioning System)
• GLONASS (Global Navigation Satellite System)
• GALILEO – Coming Soon European Union
• Compass – Coming Soon China

• Interesting Facts:
  • Orbit the Earth every 12 hours
  • 12,600 miles above the Earth
  • Omit a radio signal at a known wavelength and time
  • Each satellite can be measured to 1/16" of an inch
Glonass & GPS

- Global Navigation Satellite System (GNSS)
- Using both systems gains access to 33% more satellites
- Ensure accurate positioning (PDOP)

GPS Accuracy

- PDOP (Positional Dilution of Precision)
- Need to be locked onto 4 satellites
- 8 or more for site grading accuracy
- Z axis calculations more challenging
GPS Accuracy

- Refraction
  - Bending of radio waves by atmosphere
  - GPS units correct for refraction
  - Standard GPS units accurate to 8-10 feet

- Differential GPS
  - Base stations required for correction
    - RTK – Use radio frequency
    - RTK with Laser
    - Permanent
    - VRS – Internet and Cell phone technology

RTK Base Station

- RTK - Real Time Kinematics
  - Error correcting for a local site
  - Send error correcting signal 20 times per second
  - Accurate to within a half inch

RTK with Millimeter GPS Accuracy w/ Lazer Zone

- Laser augmentation for vertical accuracy
  - Airport Runways
  - Roadway Grading
  - Site Finish Grading
  - Asphalt Paving & Milling

- Benefits
  - 3 times more accurate
  - Meet strict requirements
Permanent Network Base Station

- Permanent Base Stations
  - Mining operations
  - Metropolitan areas need to work off same system
  - Companies host base station
  - Broadcast a radio signal over a 20 mile radius
  - Pay a fee to connect to signal

- Benefits
  - Reduction in equipment cost
  - Equipment setup simplified
  - No need for known points
  - Municipalities confident with data
  - Everyone using same base station
    - Surveyors / Contractors / Inspectors

VRS – Virtual Reference Station

- Virtual Reference Stations
  - Many fixed base stations
  - Transmitted via the Internet to a central server
  - Cell phone technology correction out to rovers
  - Broadcast corrections covering the entire network

- Benefits
  - Accuracy
  - Reduction in equipment cost
  - Equipment setup simplified
  - No need for known points
  - Municipalities confident with data
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Construction Layout

- Old Way
  - Tedious staking process
  - Constant grade checking
  - Line of sight
  - Daylight activity
  - 24-48 hours change order
Traditional Software With GPS

- Survey is collected in 3D
- Engineers design site 2D using traditional methods
- 2D Plots are submitted to Grading Contractor
- Contours are digitized off paper plots
- Contours are used to build a surface
- Surface is downloaded into GPS equipment

BIM Impact on Surveying and Engineering Firms

- Consulting firms are being asked for electronic deliverables
- Pressured by owners who are looking to save money
- BIM is becoming a requirement for Qualification Based Selection
- Conventional design tools don’t produce the necessary models

Construction Layout

- New Way
  - Automated, model-based and GPS-guided grading
  - No staking
  - No delay for dust
  - BIM very reactive to change
Construction Advances

- Cost savings in construction is clear
- GPS Machine Guidance is becoming mainstream
- Units are affordable

Hardware Manufacturers

- Leica
  - SiteSmart
- Trimble
  - SiteVision Office
  - Trimble Link Utility
- Topcon
  - 3D Office
### Industry Scenarios

**PLAN**
- MANAGE
- DESIGN
- BUILD

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### BIM for Infrastructure

**Planning**

What if you were able to...
- Aggregate disparate data
- Accurately evaluate existing conditions
- Identify problems before breaking ground
- Communicate potential impact

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### BIM for Infrastructure

**Challenge**
- Excessive amounts of data exist but are difficult to assimilate.
- Specialized expertise is often necessary to use the information that is available.

**Solution**
- Integrate design data and geospatial data more easily
- Integrate data from different coordinate systems to maximize usage of readily available data
BIM for Infrastructure

**Challenge**
- Conceptual design is often disconnected from final design. Processes are often duplicated, wasting time and eating into project schedules.
- Create infrastructure models that represent the natural and built environment.
- Evaluate multiple conceptual designs for infrastructure projects all in one model.
- Communicate project proposals more effectively.

**Solution**
- Creating powerful visuals that help stakeholders better understand how the project will perform is time-consuming and often disconnected from the design process.
- Interactively navigate and change data in real time.
- Quickly shift between design alternatives.
- Produce rendered images and video animations.

**Design**
What if you were able to...
- Make changes without affecting the schedule.
- Integrate analysis and simulation.
- Easily produce more accurate documentation.
BIM for Infrastructure

**Challenge**
- Creating powerful visuals that help stakeholders better understand how the project will perform is time-consuming and often disconnected from the design process.
- Visualization that is a by-product of design so when a design change is made, the visualization can be updated more easily.
- Ability to more quickly develop 3D renderings that help bring the project to life and convey design intent.

**Solution**
- Creating detailed 3D intersection models is avoided because it is too time-consuming.
- Built-in wizard helps streamline time-consuming tasks, such as laying out intersection geometry and creating corridor regions.
- Intersection geometry becomes part of the model, so when changes are made, the 3D model of the intersection updates.
- Geometry in the intersection model is interrelated.

**Challenge**
- Drafting standards differ by customer.
- Standards for typical cross sections differ by client and location.

**Solution**
- Drafting standards differ by customer.
- Take better control over aspects of display with styles.
- Standards for typical sections:
  - Extensive library of customizable cross sectional components
  - Define shapes, input parameters, and target parameters
  - Use geometric relationships to set and control subassembly points, links, and shapes.
BIM for Infrastructure

**Challenge**
- Road and highway designs need to consider drainage, stormwater management, and erosion control

**Solution**
- Design and analyze stormwater systems with integrated tools
- Help reduce post-development runoff, and prepare reports to support sustainability requirements for stormwater quantity and quality
- Prepare more accurate construction documents to assist in evaluating the design and helping to support public safety

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**Challenge**
- Bridge engineers and roadway designers do not collaborate on a regular basis, resulting in inconsistency and costly errors.

**Solution**
- Provide interoperability between structural design software and roadway design software
- Integrate structural design earlier in the overall roadway design process

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**Challenge**
- Accurate construction task sequencing is critical to uncover potential design problems before construction begins.

**Solution**
- Verify design component locations to help identify and resolve potential construction issues
- Integrate construction schedules (time) with design models (3D) to create 4D simulation
- Simulate what-if scenarios and site logistics to help uncover design problems
**BIM for Infrastructure**

**Challenge**
- Creating and delivering construction documentation is one of the most time-consuming, error-prone tasks in any infrastructure project.
- Dynamically connect construction drawings and reporting to the design so design changes are automatically reflected.
- Built-in wizard helps streamline the time-consuming task of developing sheets and sheet sets.
- Make more of your AutoCAD® expertise.

**Solution**
- Quantity takeoff is a manual, error-prone procedure.
- Pay item lists can be imported.
- Pay items can be assigned to objects in the drawing.
- Pay items can be assigned to features in a corridor.

**Challenge**
- Project teams are scattered and need to communicate design changes in a timely and effective manner.
- Real-time project collaboration.
- Changes made are reflected throughout the model and are more quickly accessible to all team members.
- Multiple teams and team members are better coordinated with one source of information.

**Solution**
**BIM for Infrastructure**

**Build**

What if you were able to...

- Create 3D models for Automated Machine Guidance (AMG)
- Perform clash detection
- Identify scheduling conflicts

**Challenge**

- It is difficult to transfer traditional 2D cross-sectional models of roadways to the automated machine guidance systems used in construction.

**Solution**

- 3D model can be directly exported
- Updates to the model can be made to the design model in the field, which can be passed directly to contractors

**Challenge**

- Different disciplines working on a roadway project do not always share design models before construction begins.

**Solution**

- Integrate design elements from different disciplines and automatically check for cross-discipline interferences
- Support the design development workflow by helping to identify issues early in the design process
- Help identify and resolve conflicts before construction begins in order to support the reduction or elimination of costly change orders
BIM for Infrastructure

Manage

What if you were able to…

• Maintain as-built data reliably
• Enforce data quality standards
• Better support future decision making

Challenge

• It is difficult to manage project information at every stage of the project in order to use it for decisions made in operations and maintenance.
• As-built plan data is not stored digitally and tends to be scattered and difficult to use.

Solution

• Store as-built plan data with important attributes
• Geospatial databases can be created and updated using information extracted from as-built project data
• Access information via mobile devices
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