

**GPS Machine Control Grading & BIM  
(Building Information Modeling)**

**Shawn Herring**  
ProSoft  
Civil Applications Engineer  
Training & Support Manager

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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




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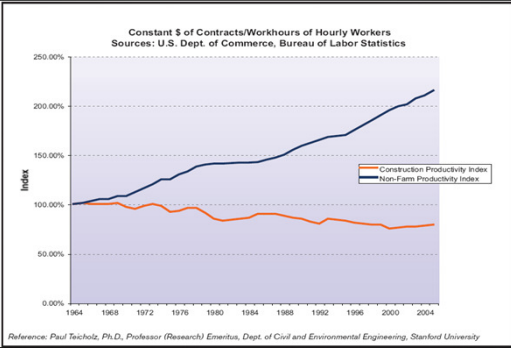
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### Civil Industry Trends - Productivity 1964-2005



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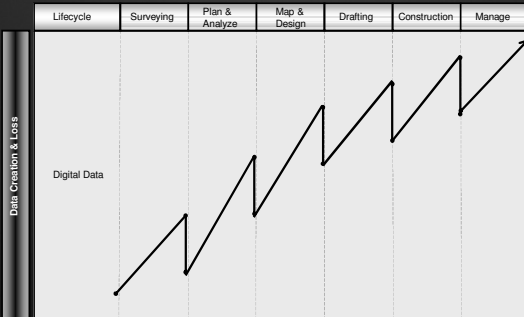
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### Data Creation and Loss



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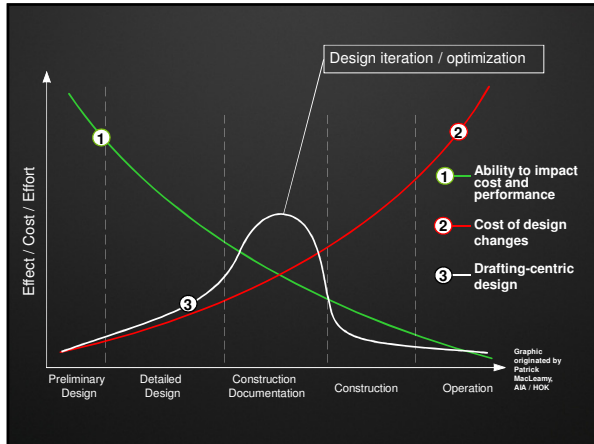
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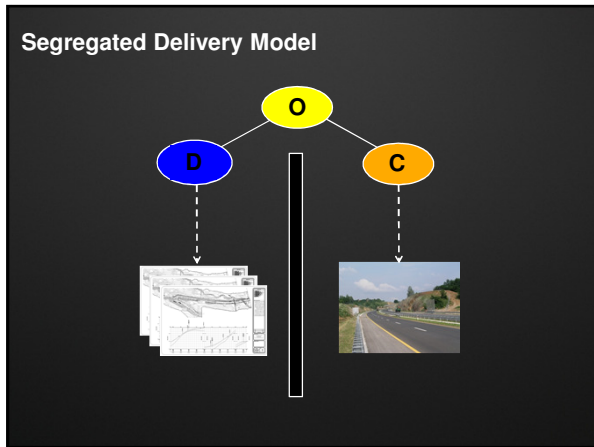
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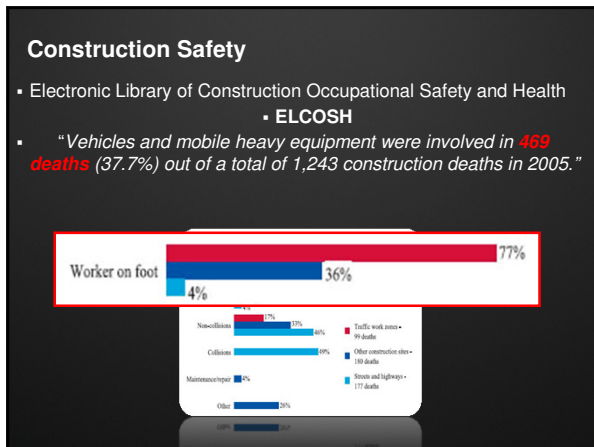
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### AutoCAD Civil 3D...

- 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



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### BIM for Civil Engineering



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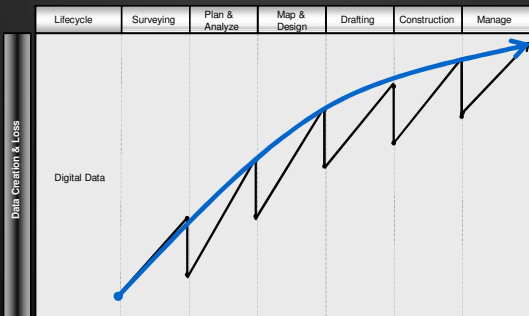
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### Data Creation and Loss



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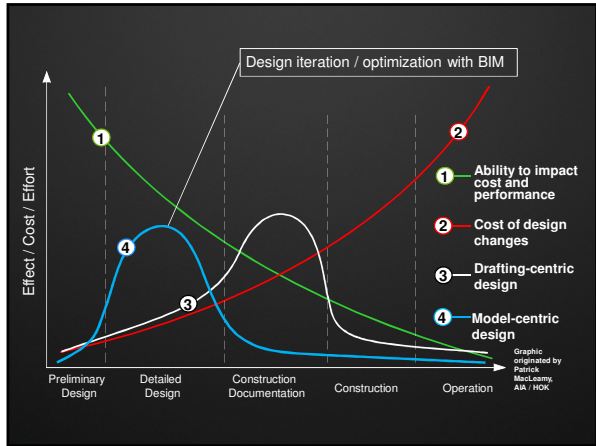
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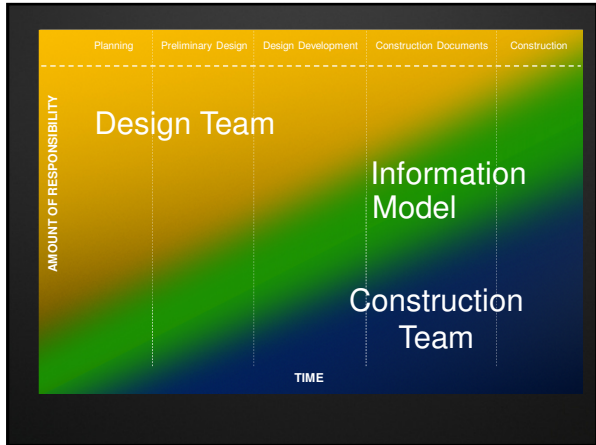
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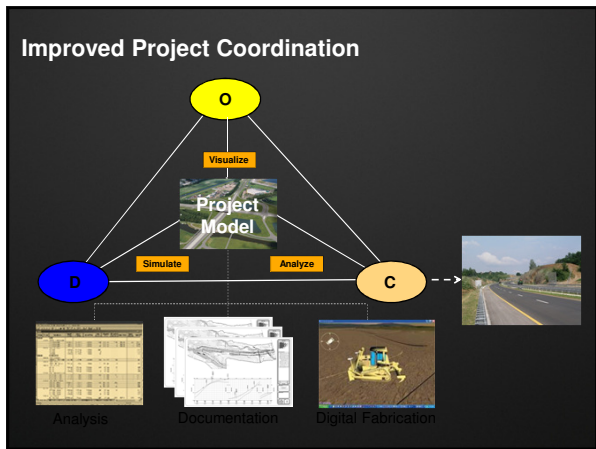
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### What is GPS Machine Control

- 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.



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### What is Driving Adoption??

- Efficiency
  - Accuracy results in 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](http://www.gpsworld.com)

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### What is Driving Adoption?

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

[www.gpsworld.com](http://www.gpsworld.com)

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**GPS Machine Control is for the Complete Cycle of the Project**

Dozers



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**GPS Machine Control is for the Complete Cycle of the Project**

Scrapers



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**GPS Machine Control is for the Complete Cycle of the Project**

Excavators



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**GPS Machine Control is for the Complete Cycle of the Project**

Graders



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**GPS Machine Control is for the Complete Cycle of the Project**

Compactors



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**GPS Machine Control is for the Complete Cycle of the Project**

Pavers



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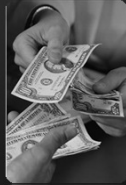
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### Benefits of GPS Machine Control

- 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 1<sup>st</sup> time
  - Project isn't interrupted for staking & grade checking
  - No "bumped" stakes
  - Reduction in change orders ~ 70%



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### Benefits of GPS Machine Control

#### Better tools to manage jobs

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



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### 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



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### 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](http://www.constructionequipment.com)

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### 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



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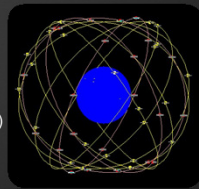
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### Satellite Systems

- 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
  - Emit a radio signal at a know wavelength and time
  - Each satellite can be measured to 1/16<sup>th</sup> of an inch



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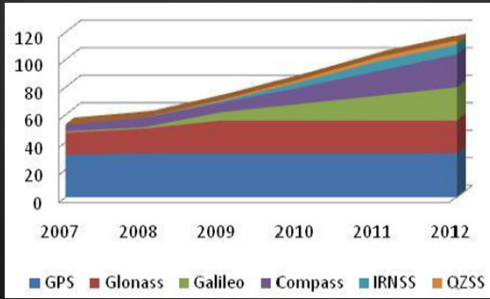
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### Planned Launch Schedule



www.gpsworld.com

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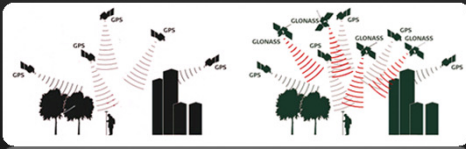
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### GLONASS & GPS

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



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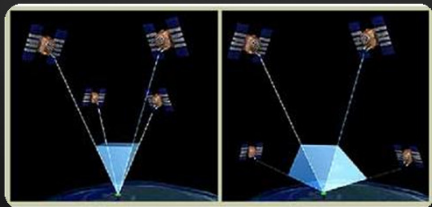
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### GPS Accuracy

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



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### 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



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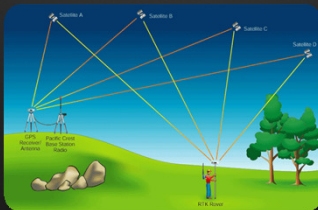
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### RTK Base Station

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



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### 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



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### 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



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### 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
  - Everyone using same base station
    - Surveyors / Contractors / Inspectors



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### Construction Layout

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



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### 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



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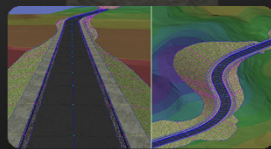
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### BIM Impact on Surveying and Engineering Firms

- 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



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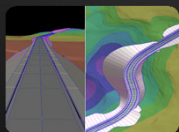
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### Construction Layout

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



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### Construction Advances

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



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### Hardware Manufacturers

Leica



SiteSmart

Trimble



SiteVision Office

Topcon



3D Office

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### Trimble Link Utility



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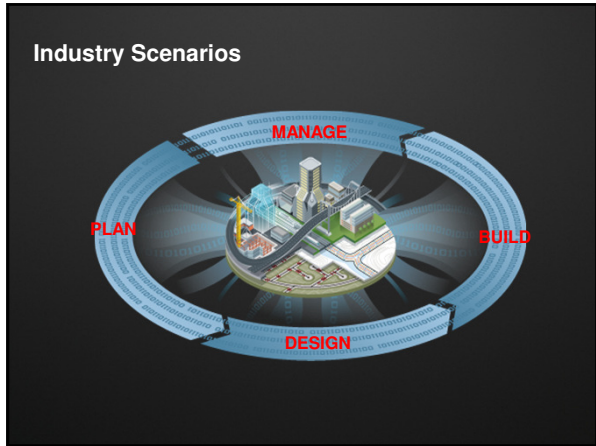
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### BIM for Infrastructure

#### 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

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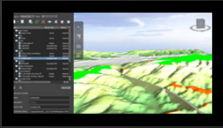
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### BIM for Infrastructure


**Challenge**

- Conceptual design is often disconnected from final design. Processes are often duplicated, wasting time and eating into project schedules.



**Solution**

- 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



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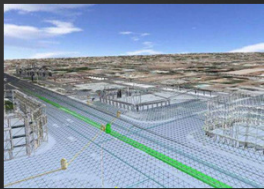
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### BIM for Infrastructure

**Challenge**

- Creating powerful visuals that help stakeholders better understand how the project will perform is time-consuming and often disconnected from the design process.



**Solution**

- Interactively navigate and change data in real time
- Quickly shift between design alternatives
- Produce rendered images and video animations

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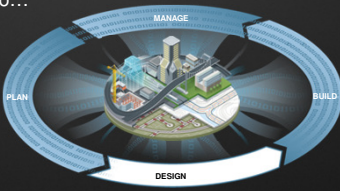
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### BIM for Infrastructure

**Design**

What if you were able to...

- Make changes without affecting the schedule
- Integrate analysis and simulation
- Easily produce more accurate documentation



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### 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.

**Solution**

- 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.



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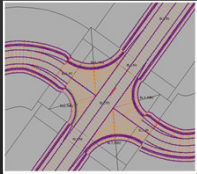
### BIM for Infrastructure

**Challenge**

- Creating detailed 3D intersection models is avoided because it is too time-consuming.

**Solution**

- 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



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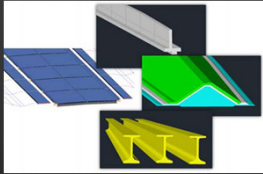
### BIM for Infrastructure

**Challenge**

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

**Solution**

- Drafting standards
  - 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



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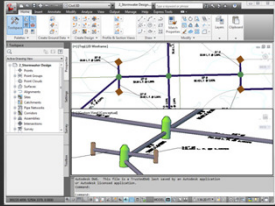
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### BIM for Infrastructure

**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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### BIM for Infrastructure

**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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### BIM for Infrastructure

**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 a 4D simulation
- Simulate what-if scenarios and site logistics to help uncover design problems

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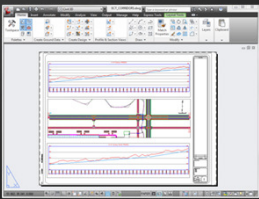
### BIM for Infrastructure

**Challenge**

- Creating and delivering construction documentation is one of the most time-consuming, error-prone tasks in any infrastructure project.

**Solution**

- 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



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### BIM for Infrastructure

**Challenge**

- Quantity takeoff is a manual, error-prone procedure.

**Solution**

- 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



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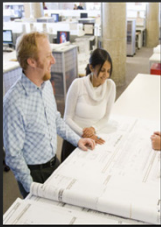
### BIM for Infrastructure

**Challenge**

- Project teams are scattered and need to communicate design changes in a timely and effective manner.

**Solution**

- 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



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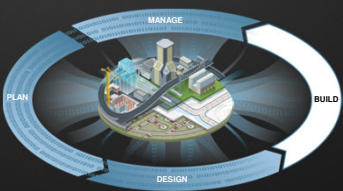
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### BIM for Infrastructure

**Build**

What if you were able to...

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



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### BIM for Infrastructure

**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



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### BIM for Infrastructure

**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

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### BIM for Infrastructure

#### Manage

What if you were able to...

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



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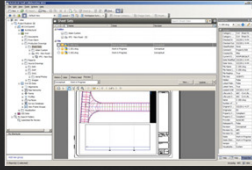
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### BIM for Infrastructure

#### 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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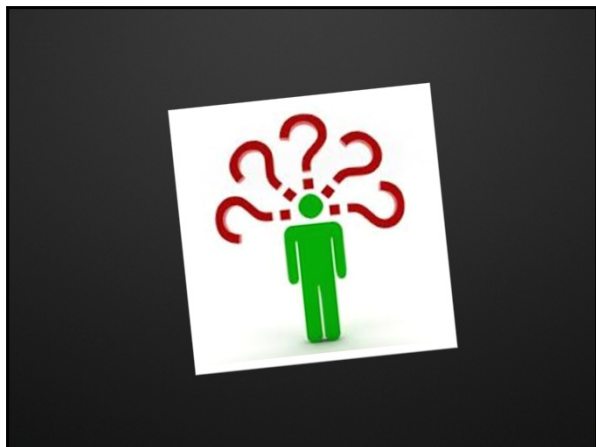
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