3D Design Models to Construction (Data Centric Approach)

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Why e-Construction?

- INDOT’s main initiative was to implement and leverage 3D intelligent Computer Aided Design (CAD) models for AMG, e-Construction and Asset Management.
- Focus was on the transition from 2D to 3D for their Construction project delivery process aligned with the Federal Highway Administration (FHWA) Every Day Counts program.
- The main effort has been an emphasis on e-Construction that leverages 3D models in construction and provides as-built asset information to Maintenance Operations.
- Identify many benefits to INDOT, including cost savings, and improved safety and quality.
Why e-Construction?

- One aspect of e-Construction is to create a document centric approach focused on reducing paper.
- INDOT wanted to take this further by adding a data centric approach:
  - focuses on the transfer of data from 3D design models to construction
  - and then to asset management
Mission Statement

- The use of intelligent 3D CAD models to support the lifecycle of transportation assets (roads and bridges) that provides predictive analysis and reporting capabilities that is data driven and allows the agency to make better operational and strategic management decisions.
e-Construction

- FHWA
  - Every Day Counts (EDC) Initiative
  - Paperless Construction

- INDOT
  - Data Centric Approach
  - Leverage findings from study by Purdue University, SPR-3707
The Business Opportunity

**Figure 5.2** Asset data flow in the current practice at INDOT.

**Figure 5.3** The suggested data flow.
3D Model Data Lifecycle

Planning → Survey → Asset Management → Design → Construction → Maintenance and Operations
e-Construction Current Efforts

- CAD Software Platform Upgrade
- Gap Analysis Study
- HP Tablets Supplied to INDOT Construction Inspectors
- Construction Inspection Application
Complete by Bentley Systems, Inc.

- CAD Workspace and Design Software upgraded from SS2 InRoads to SS4 OpenRoads
- March – July 2016
Gap Analysis Study

- Completed by Bentley Systems, Inc.
  - Determine the road map for INDOT to utilize 3D CAD Models from Design in Construction and Asset Collection
- Completed and presented September 2016
Gap Analysis Study

- Areas of emphasis:
  - Automated machine Guidance (AMG)
  - Asset Collection during construction
Pilot project on I-65 near Lafayette, IN

- Designed by consultant in current SS2 CAD platform
- Bentley converted project files to SS4 OpenRoads platform
- Provided SS4 design models to the contractor
- Contractor analyzed the new models and provided feedback
AMG

- Expected Key Benefits
  - Ability to obtain better bids for construction
  - Save time and money during construction
  - Improved site design
  - Improved safety
Recommendations

- Develop project selection criteria
- Develop QA/QC specifications for 3D Models
- Develop specifications for electronic deliverables
- For AMG projects the construction staff need to be involved early in the design process
- Determine contractor AMG requirements
- Develop an organizational change plan
Recommendations

- INDOT currently uses 2D plans for project delivery. It is assumed based on other DOT’s and FHWA EDC that the following sequence will be followed:
  - 3D models are created by INDOT’s consulting community and internal design staff, but are used to create 2D plans
  - The above 3D models are provided for “information only.” The 2D plans are still provided and remain the contract document
  - Long-term, 3D models become the contract document with 2D plans provided with supplemental information
  - Longer-term, a 3D model has all information including those previously provided on 2D plans. 2D plans are not provided
Asset Collection

“Experiments”

- Drone Imagery for Asset Collection
- Radio Frequency Identification (RFID) Tags
Drone Imagery

- **Experiment Details**
  - Can imagery be utilized to collect assets and assist INDOT Construction?
  - Scheduling and liability issues prevented the use of a Unmanned Aircraft System (UAS)/drone
  - Used handheld camera on an extension pole to take images around the Indiana Government Center complex
Drone Imagery
Drone Imagery
Drone Imagery

- **Experiment Recommendations**
  - Using handheld camera to acquire images is a viable option for collecting small areas.
  - Control points are necessary to accurately geo-coordinate the imagery to real world.
  - Potential use in calculating areas, volumes.
RFID Tags

Experiment Details

- Can RFID tags be used to uniquely identify INDOT Assets?
- Future asset inventory verification process?
RFID Tags
RFID Tags

- **Experiment Recommendations**
  - Determine which INDOT asset types are suitable for tagging
  - Determine if the asset owners see a benefit to tagging
  - Conduct a Proof of Capability study on one or two asset types
HP Tablets

Details

- Supplied to INDOT Construction Inspectors and Engineers
- Spring of 2016
- Approximately 550 tablets
- HP Elite X2 tablet with Windows 10 operating system
HP Tablets

Key Benefits

- Office software installed for easy access
- Wi-Fi capable for internet access
- Ability to complete daily tasks in the field
- Access documentation in the field without printing
- Access to Field Assistant and SiteManager applications
- Ability to use the camera for mobile conferencing
Construction Inspection Application

- Inspection Problem

[Diagram showing the flow of construction, inspection, and maintenance processes.]
Construction Inspection Application

- Proposal

- Design

- Contractors

- Built Environment

- Field Review

- Inspection

- Operations & Maintenance

- 3D Design Content

- Data Flow

- Contractor Instructions to Inspectors

- Inspection Data passed to O&M

Workflow
## Current 2D Model vs. 3D Model

<table>
<thead>
<tr>
<th>2D Model</th>
<th>3D Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to Hundreds to Thousands of pages</td>
<td>Limited number of design files</td>
</tr>
<tr>
<td>Difficult to find location on plans</td>
<td>GPS on devices will auto locate</td>
</tr>
<tr>
<td>Multiple pages and locations for full information on design element</td>
<td>Can have multiple views on one screen</td>
</tr>
<tr>
<td>Design Intent/Interpretation can be difficult</td>
<td>Design Intent/Interpretation clearer</td>
</tr>
<tr>
<td>Cross Section every 50 ft.</td>
<td>Cross Section every 5 ft.</td>
</tr>
</tbody>
</table>
Current 2D Model
Current 2D Model

STA. 5+50 "PR-SWN" DITCH GRADE BREAK

STA. 5+00 "PR-SWN" BEGIND DITCH GRADE

I-465 EASTBOUND

LINE "PR-SWN"

LINE "EBL"

EMERGENCY SPILLWAY

STA. 50+05 "DR-1-A” BEGIND SILT FENCE

79 TONS OF CLASS I RIPRAPP ON 131 SYS. GEOTEXTILES REQ’D.
Current 2D Model

[Diagram of spillway profile and sediment basin]

**PRINCIPAL SPILLWAY PROFILE & DAM**

**SECTION B-B**

**PLAN VIEW**

**SEDIMENT BASIN**

**NOT TO SCALE**

**FURTHER GUIDANCE:**

FOR WATER TO FLOW INTO AND CONTROLLED WATER

**CHANNEL**

**EMERGENCY SPILLWAY**

- PERFORATED RISER PIPE
- SEDIMENT BAND
- BOTTOM ELEVATION AT TOP OF ANTI-FLOATION BLOCK
- ANTI-FLOATION BLOCK TO BE FASTENED TO RISER PIPE
- DISCHARGE PIPE TO BE FASTENED TO RISER PIPE
- Ø5-0" MAX
- Ø3-0" MIN
- 12" DIA PIPE
- 10"-12" MAX
- 2-0" MAX
- EARTH DAM
- 8-5/8"
- 5.5 MAX
- 3.5 MAX
- 2-0" MIN
- Ø5-0" MAX
- Ø3-0" MIN
- Ø5-0" MAX
- Ø3-0" MIN
- Ø5-0" MAX
- Ø3-0" MIN
- Ø5-0" MAX
- Ø3-0" MIN
Current 2D Model
3D Model
3D Model
**Contractor Instruction**
Installing underdrains around stations 370+00 to 420+00

**Model Component**
Select pipe

**Construction Steps**
- Trench
- Bedding
- Lay Pipe
- Backfill

**Inspection Checklist**
- Ensure excavation width no greater than specified
- Ensure unsuitable material removed and replaced
- Check minimum bedding thickness
- Has the bedding material been compacted to standards?
- Has the contractor installed the culvert components to the horizontal & vertical tolerances specified?
- Has the backfill been placed and compacted uniformly in layers?
- Has the side and overlay zone been compacted to the specified requirements?

**Inspection Data (INDOT Pay Items)**
- Field Collect
  - Geotextile (718-99153)
  - Aggregate Volume (718-52610)
- Field Collect
  - Date
  - Length (715-05203)
  - Begin Station
  - Begin Offset
  - End Station
  - End Offset
  - Line
  - Pipe Size
- Field Verify
  - Pipe Size Pass Through
  - Begin Elevation
  - End Elevation
### Item 206 Lime Stabilized Subgrade

<table>
<thead>
<tr>
<th>District:</th>
<th>Date:</th>
<th>Project No.:</th>
<th>Co/Rt/Sec:</th>
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</thead>
<tbody>
<tr>
<td>Contractor:</td>
<td>Project/District Contacts:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reviewed “Y”:</td>
<td>Specification Conformance Statement</td>
<td>CMS/ CIM</td>
<td>Measurements</td>
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<tr>
<td></td>
<td>Was the correct soil type stabilized?</td>
<td>206.02/189</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Was specification lime used?</td>
<td>206.02/189</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Did the soil weight at least 100 lbs/ft³?</td>
<td>206.02/190</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Were the limits in 206.03 followed?</td>
<td>206.03/190</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Was the subgrade line and grade properly checked?</td>
<td>206.03/237</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Was the subgrade properly test rolled?</td>
<td>206.03/190</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Was the Contractor lime percentage report accepted by the Project?</td>
<td>206.06/192</td>
<td></td>
</tr>
</tbody>
</table>
Help construction engineers/inspectors to mentally link construction activity (received notification), plan asset (physical structures), and pay items (for documentation) and record quantities for identified pay items.
Inspection Checklist

- Leverage similar capabilities from Field Assistant Application

- Number pads and drop downs for easily entered numerical data
- Drop down for easy input without errors
- Step-by-step instructions
- Checksheets are submitted only if all the tasks are completed
Construction Inspection Application

- Improves efficiency of the Construction Inspector in the field
- Easier access to manuals, plans, and project information
- Ability to sign electronic documents remotely
- Provides as-built information including location as part of the work flow
- Transparency—documents available for viewing by all project partners
- Ability to integrate with other core systems such as asset management
- Provides accurate location and asset information
- Provides the ability to create as-built information that can be provided to Programming in the future
e-Construction Future Efforts

- ProjectWise access for INDOT Construction Inspectors
- Pilot construction projects that were designed in the SS4 OpenRoads environment
- Develop prototype construction inspection application
e-Construction Future Efforts

- Quantities from 3D CAD design model
- Provide asset information from the Operations and Maintenance groups to the Planning and Programming group for use in future project determination and funding
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Questions?