Generating, Transforming and Analyzing Railway Design Data in Civil 3D and Dynamo

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Class CES321918
About the speaker

Wouter Bulens

- Methods Coordinator/BIM Manager – TUC RAIL
- 19 years experience with Autodesk AEC solutions
- Drafter / Designer / Developer
- Civil Construction / Multidisciplinary 3D models and Process Optimization
TUC RAIL was founded in 1992 with one mission: build the Belgian High-speed network. But it did not end there, today TUC RAIL is a multidisciplinary engineering/project management firm for High-speed and conventional rail. We provide expertise and experience for the entire project life cycle and as a subsidiary of Infrabel (Belgium national rail infrastructure manager) also for the asset life cycle. TUC RAIL encompasses all railway technologies: civil, structures, systems, … . A partner in pushing the evolution of not just rail design but transport and infrastructure design as a whole forward.
Generating, Transforming and Analyzing Railway Design Data in Civil 3D and Dynamo

connect people using interactive and data driven objects/tools

- Railway and Civil Design
- 4 Industry Challenges
- Solutions:
  - Design Object
  - Transforming Design Data
  - Design Analysis
- Summary
- Q&A
Learning Objectives

OBJECTS/DATA

OBJECTIVE 1
Design dynamic blocks that are digital representations of local standards and better fit your design process

OBJECTIVE 2
Organize Dynamo nodes to connect different design data in AutoCAD and Civil 3D

OBJECTIVE 3
Analyze corridor data and other design objects more direct and iteratively
Railway and Civil Design

- No civil project is 100% alike, there is always something different
- Different viewpoints, different languages, different understanding
- Aligning, translating, explaining takes time
- Stable and reliable, but tentative in regards to change
Medium ≠ Design
Tool ≠ Design
Individual disciplines ≠ Design
We only trust the ruler
Design Object
Design Object

What work does the object need to support?
Where in the Lifecycle is it used?

• Input:
  o design decision
  o other design objects

• Process:
  o formula
  o decision tree

• Output:
  o graphical / non-graphical
  o number / text / yes-no / choice
Platform Edge

The rail designer chooses a correct platform type from the national standard and places along an alignment. After adapting and validating the design, he creates a coordinate list for construction.

- **Input:**
  - decisions required by standard
  - alignment/profile
- **Process:**
  - apply the standard
  - calculate graphical and non-graphical data
- **Output:**
  - geometry for drawing production / design validation
  - coordinates for on-site execution
Switch / Turnout

The rail designer chooses a correct switch type from a manufacturer and places it on the alignment. After adapting and validating the design, he creates plans and an order form for construction.

• **Input:**
  - manufacturing configuration (ID, order number)
  - 3D placement (alignment/profile/cant)

• **Process:**
  - combine design decisions
  - calculate graphical and non-graphical data

• **Output:**
  - geometry drawing production / design validation
  - material order information
  - coordinates for on-site execution
Blocks – Dynamic Blocks

A block is essentially a block definition that includes the block name, the block geometry, the location of the base point to be used for aligning the block when you insert it, and any associated attribute data. Dynamic blocks contain rules and restrictions that control the appearance and behavior of a block when it is inserted into a drawing or when it's later modified.

• Block Library
• 3D placement by Point and Normal
• Geometry / Attributes / Parameters / Actions / Constraints
• Grips or Controls (limited to 2D operations only)
• Layers

Graphical presentation / Variants / 3D geometry / Data management
Graphical presentation

Controlling the graphical presentation of a Dynamic Block

https://github.com/TUCRAIL/AU2019
Variants

Variant selection in a Dynamic Block

https://github.com/TUCRAIL/AU2019
3D geometry

3D geometry in a Dynamic Block

https://github.com/TUCRAIL/AU2019
Data management

Data management in a Dynamic Block

https://github.com/TUCRAIL/AU2019
Transforming Design Data
Design Data

Information contained in a Design Object that is needed to:
• Create
• Connect
• Analyze

Why not use the Design Object:
• Clear and Precise
• Reference not Copy
• Ownership
Autodesk Dynamo for Civil 3D

Dynamo is a visual programming tool that now also works with AutoCAD and Civil 3D. Through the existing API’s it gives the users access to the underlying Objects and Data.
Dynamo Scripts

SWITCH (ASSET) PLACEMENT SYSTEM
• Alignment / Profile / Cant - horizontal position, direction XY plane / vertical position, slope YZ plane / vertical delta, cant XZ plane
• Switch dynamic block – geometric data, 3D (Alignment, station data)

SWITCH - PROFILE
• Switch dynamic block – name, theoretical triangle, alignment name, stationing
• Profile – name, description, stationing

SWITCH - CORRIDOR
• Switch dynamic block – name, type, alignment name, stationing
• Corridor – name, description, baseline, baselineregion
Custom Dynamo Nodes
Switch (Asset) Placement System

Base Alignment Information → Retrieve Position Parameters → Calculate Position and Direction → Block Selection by Name

→ Longitudinal slope calculation and rotation

→ Cross slope calculation and rotation

→ Create Block Reference
Switch (Asset) Placement System

Dynamic Block placement using Alignment, Profile and Cant data

https://github.com/TUCRAIL/AU2019
Switch - Profile

Profile creation using Dynamic Block design objects

https://github.com/TUCRAIL/AU2019
Switch - Corridor

Design Data - a data bridge between Design Objects

https://github.com/TUCRAIL/AU2019
Design Analysis
### Master Line

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<th>Diff. Angle</th>
<th>Diff. Gradient</th>
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### Calculations

- **Distance**
- **Angle**
- **Gradient**

*Seeing is believing*
Design Analysis

Take a global or detailed look at the design to:
• Support Design
• Communicate
• Build trust

Why do we need advanced or automated analysis:
• Amount of data
• Connect data and design decisions
• Insight

Stepping stone to analytics and generative design.
Data Extraction

“the ability to extract data from objects in one or more drawings. It searches for the objects you want, looks up the required attributes, links to an external file to add additional data, makes a table with a flexible format and updates”

- Only Excel Data Link (.XLSX no macro)
- Limited Data Refinement
- Single output type (Table: AutoCAD / xls / csv / mdb / txt)

Dynamo Data Extraction:
- Any data source available in Dynamo
- “Unlimited” Data Refinement
- Any output Dynamo can create
Custom Dynamo Nodes

CadDataExtraction

CadTable

CadObject

Custom Dynamo Nodes
Dynamo Data Extraction

Perform data extraction and use its results to create table and format objects

https://github.com/TUCRAIL/AU2019
Corridor Section Analyzer

Corridor:
“Calculated parametric sections (Applied assembly) placed along a 3D line (Alignment/Profile or Feature Line)”

Corridor Data:
- Baseline
  - Station
  - Elevation
- Target
  - To Option

- Subassembly
  - Point
  - Link
  - Shape
  - Parameter (Input and Output)

Automated Analysis:
- Parameter (input and output)
- Automated Ruler (point code)
Corridor Parameter Analyzer

Base Corridor Information

Retrieve AppliedSubassembly by Name

Retrieve AppliedSubassembly Parameters by Name

Create Parameter Data List

Create AutoCAD Table
Corridor Parameter Analyzer

Retrieving parameter values from every calculated section

https://github.com/TUCRAIL/AU2019
Corridor Automated Ruler

- Change Applied Subassembly Parameter
- Base Corridor Information
- Measure between 2 Points
- Create AutoCAD Table
- Evaluate Horizontal Distance
- Placement of indication objects
- Formatting AutoCAD Table column
Corridor Automated Ruler

Automated ruler that measures in every calculated section

https://github.com/TUCRAIL/AU2019
Summary

- Design Objects
  - make standards interactive
  - capture all design decisions

- Transforming Design Data
  - manage design
  - connect people

- Design Analysis
  - query your design
  - custom report

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Tool ≠ Design

Individual disciplines ≠ Design

We only trust the ruler
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connect people using interactive and data driven objects/tools

• AU 2019 - CES321918 Class Handout and Additional Class Materials
  • https://github.com/TUCRAIL/AU2019
  • wouter.bulens@tucrail.be
  • https://www.linkedin.com/in/wouter-bulens-11278319/
  • @BulensWouter