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

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Class CES321918

AUTODESK. UNIVERSITY

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 - Infrabel

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

PRINCIPLE OBJECTIVE

Explain the need for design objects with the correct data and interactivity configuration

DESIGN OBJECT

OBJECTIVE 1

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

TRANSFORMING DESIGN DATA

OBJECTIVE 2

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

DESIGN ANALYSIS

OBJECTIVE 3

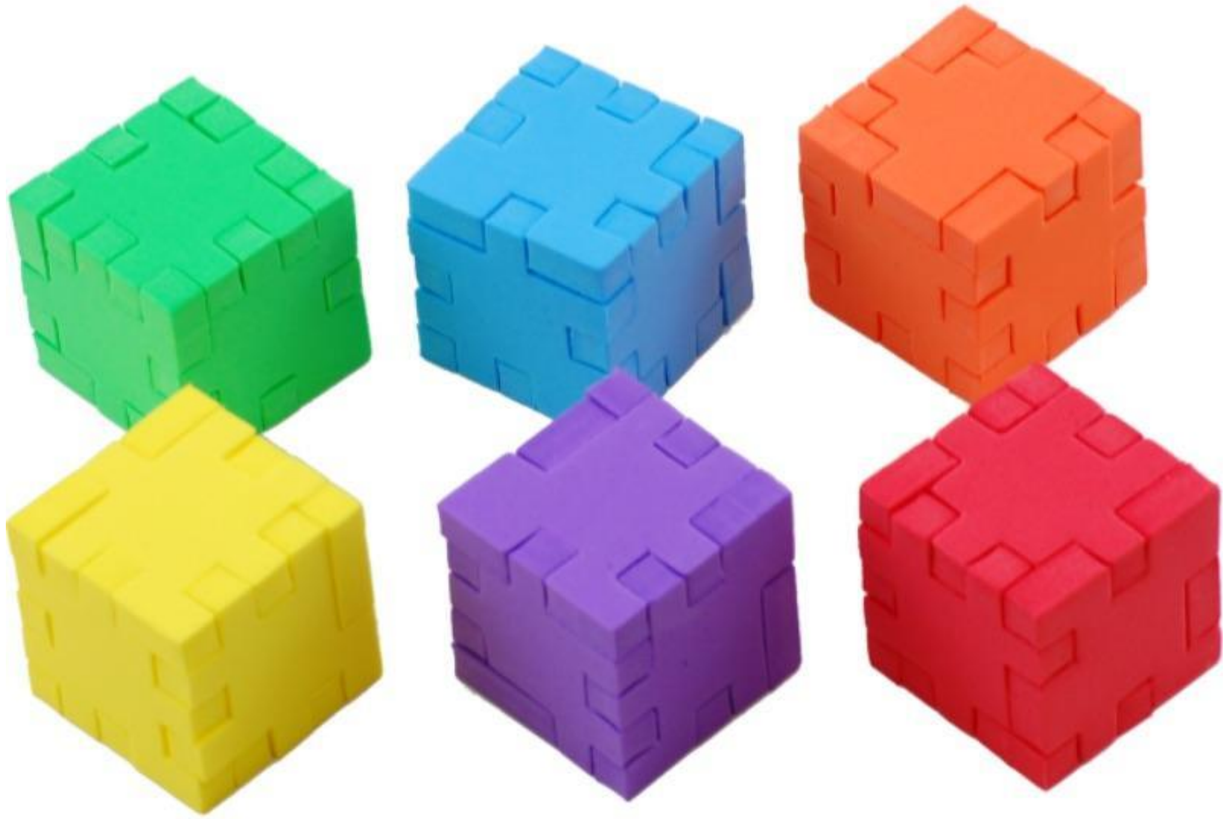
Analyze corridor data and other design objects more direct and iteratively

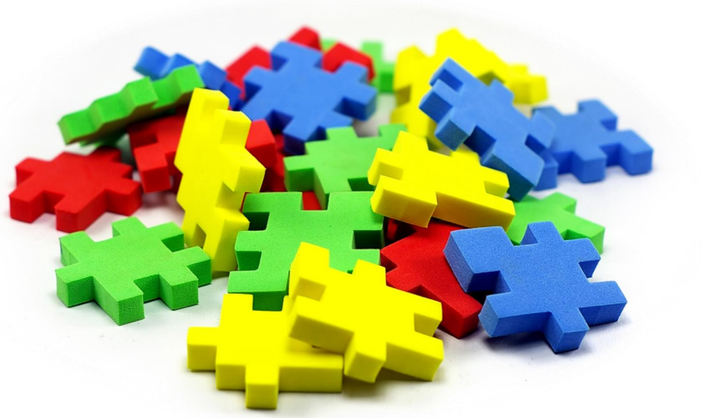
Railway and Civil Design

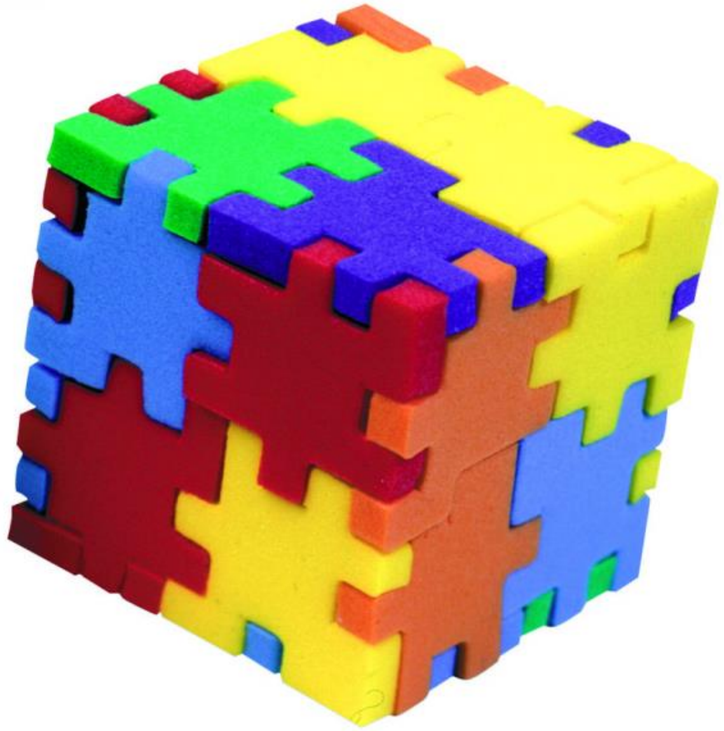
- No civil project is 100% alike, there is always something different
- Different viewpoints, different languages, different understanding
- Aligning, translating, explaining takes time
- Stable and reliable, but tentative in regards to change

Medium ≠ Design

Tool ≠ Design







Individual disciplines ≠ Design

We only trust the ruler

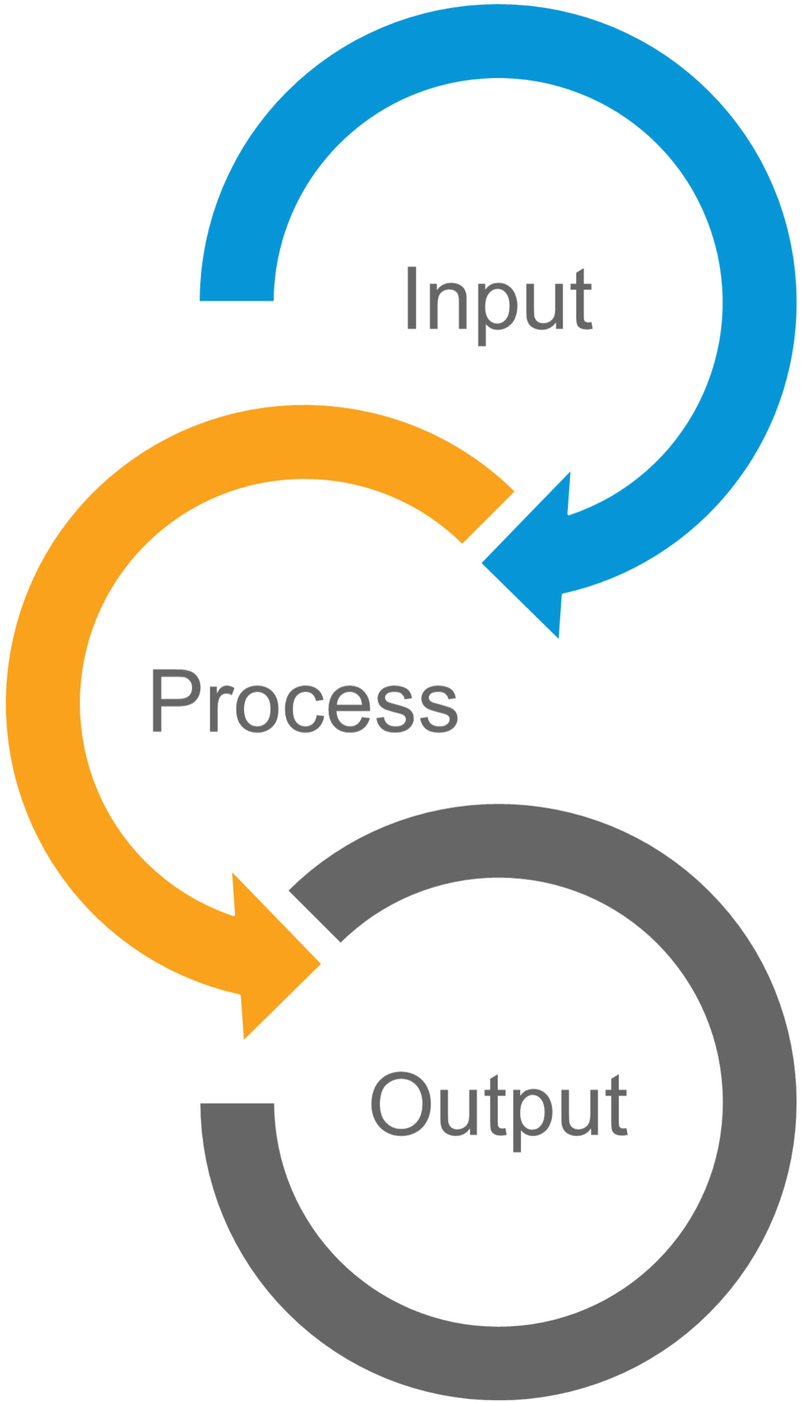
Design Object

Design Object

What work does the object need to support?

Where in the Lifecycle is it used?

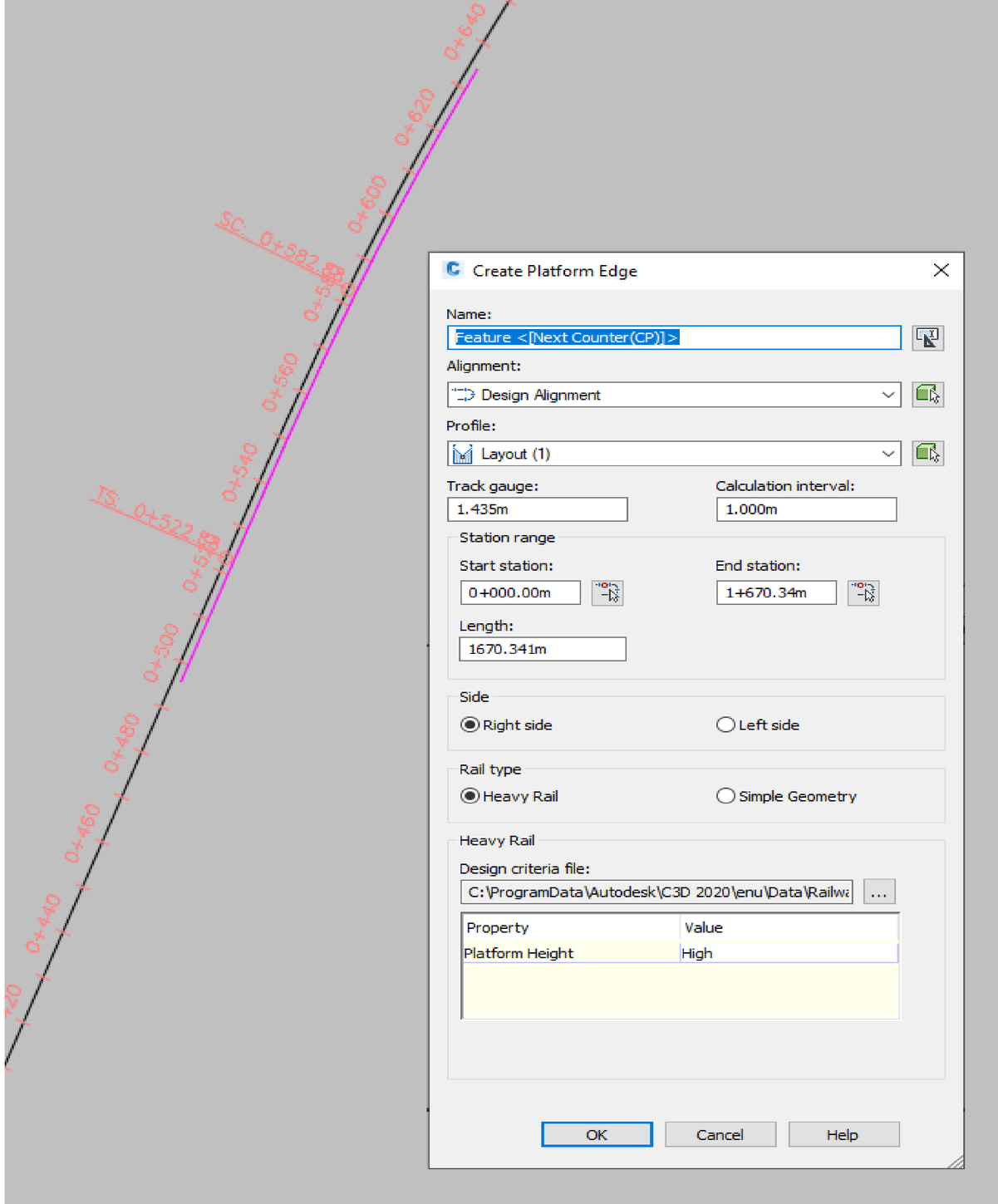
- Input:
  - design decision
  - other design objects
- Process:
  - formula
  - decision tree
- Output:
  - graphical / non-graphical
  - number / text / yes-no / choice



Platform Edge

The rail designer choses 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.

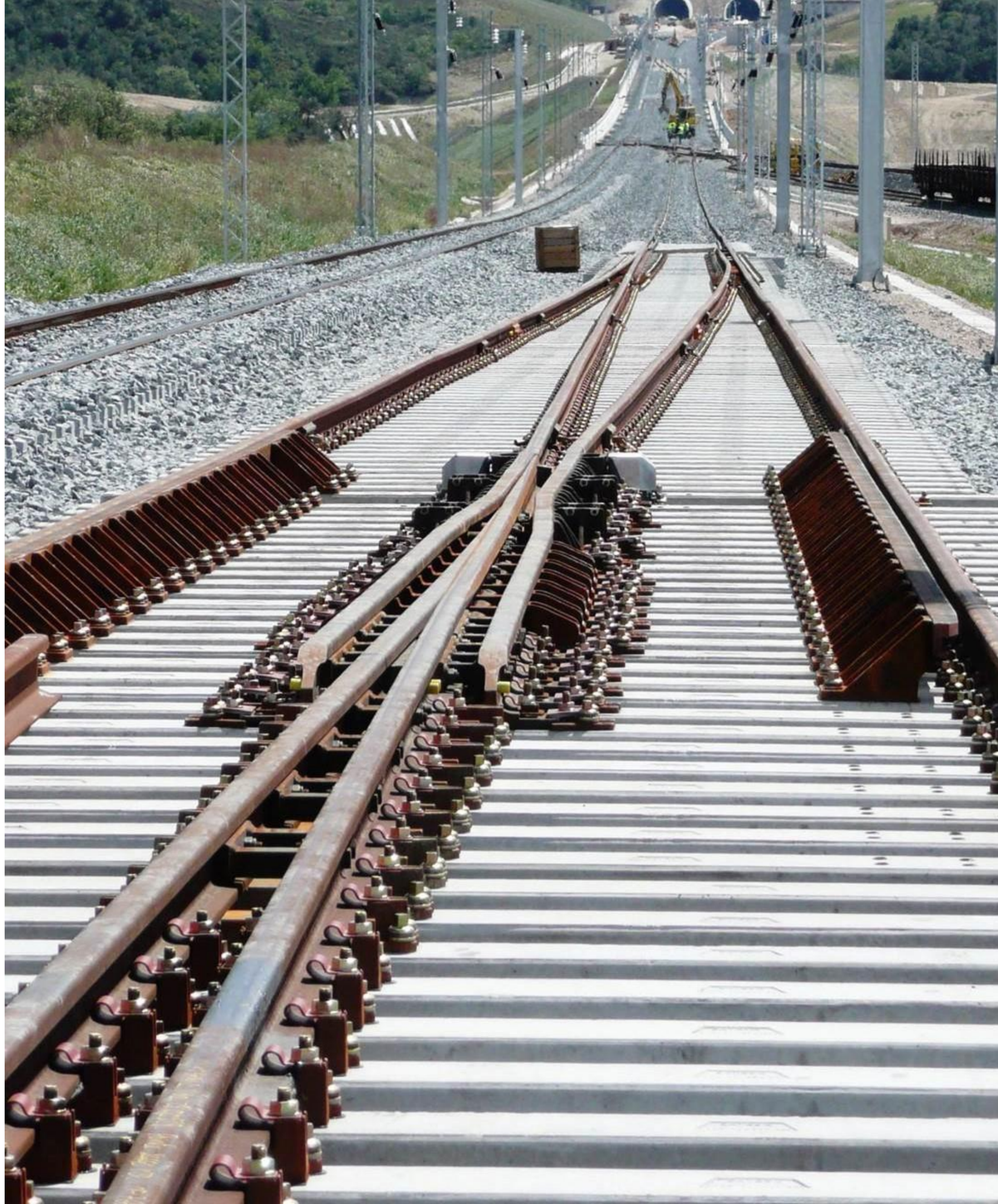
- Input:
  - decisions required by standard
  - alignment/profile
- Process:
  - apply the standard
  - calculate graphical and non-graphical data
- Output:
  - geometry for drawing production / design validation
  - coordinates for on-site execution



Switch / Turnout

The rail designer choses 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.

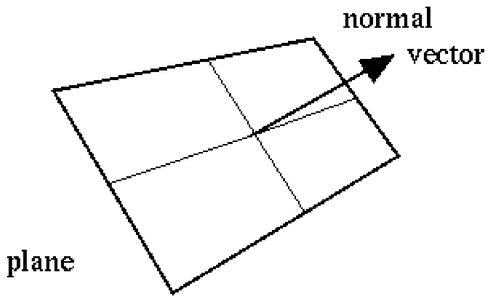
- Input:
  - manufacturing configuration (ID, order number)
  - 3D placement (alignment/profile/cant)
- Process:
  - combine design decisions
  - calculate graphical and non-graphical data
- Output:
  - geometry drawing production / design validation
  - material order information
  - coordinates for on-site execution



Blocks – Dynamic Blocks

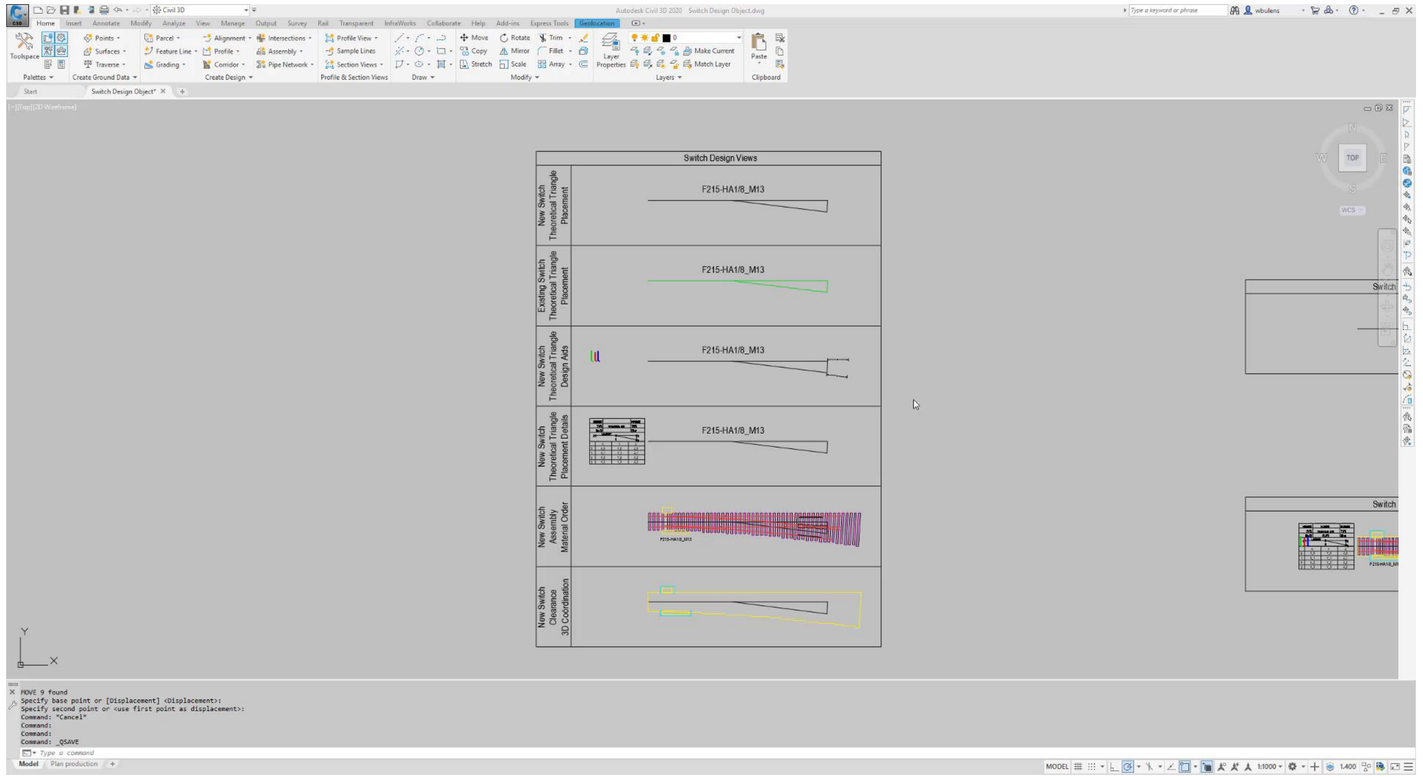
A block is essentially a block definition that includes the block name, the block geometry, the location of the base point to be used for aligning the block when you insert it, and any associated attribute data. Dynamic blocks contain rules and restrictions that control the appearance and behavior of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

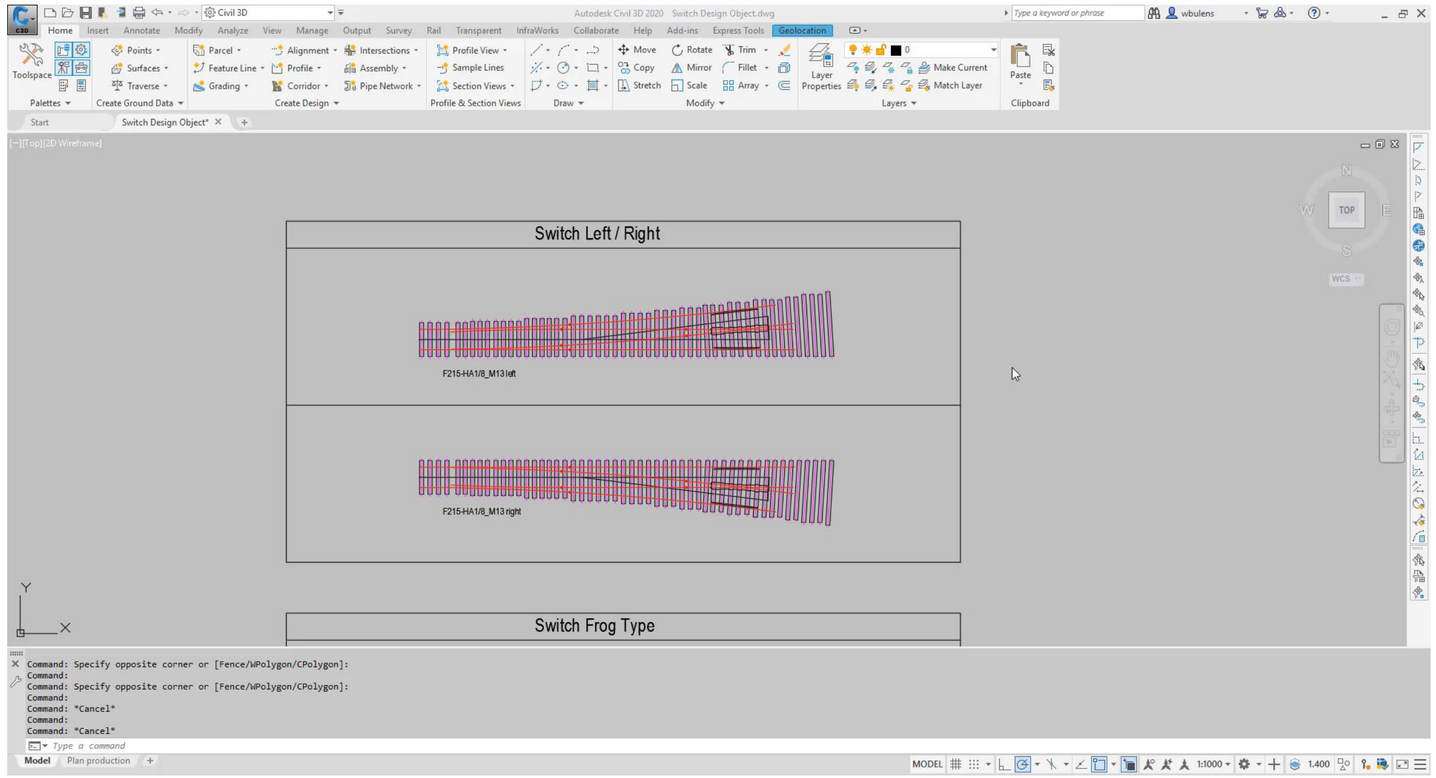
Graphical presentation



Controlling the graphical presentation of a Dynamic Block

https://github.com/TUCRAIL/AU2019

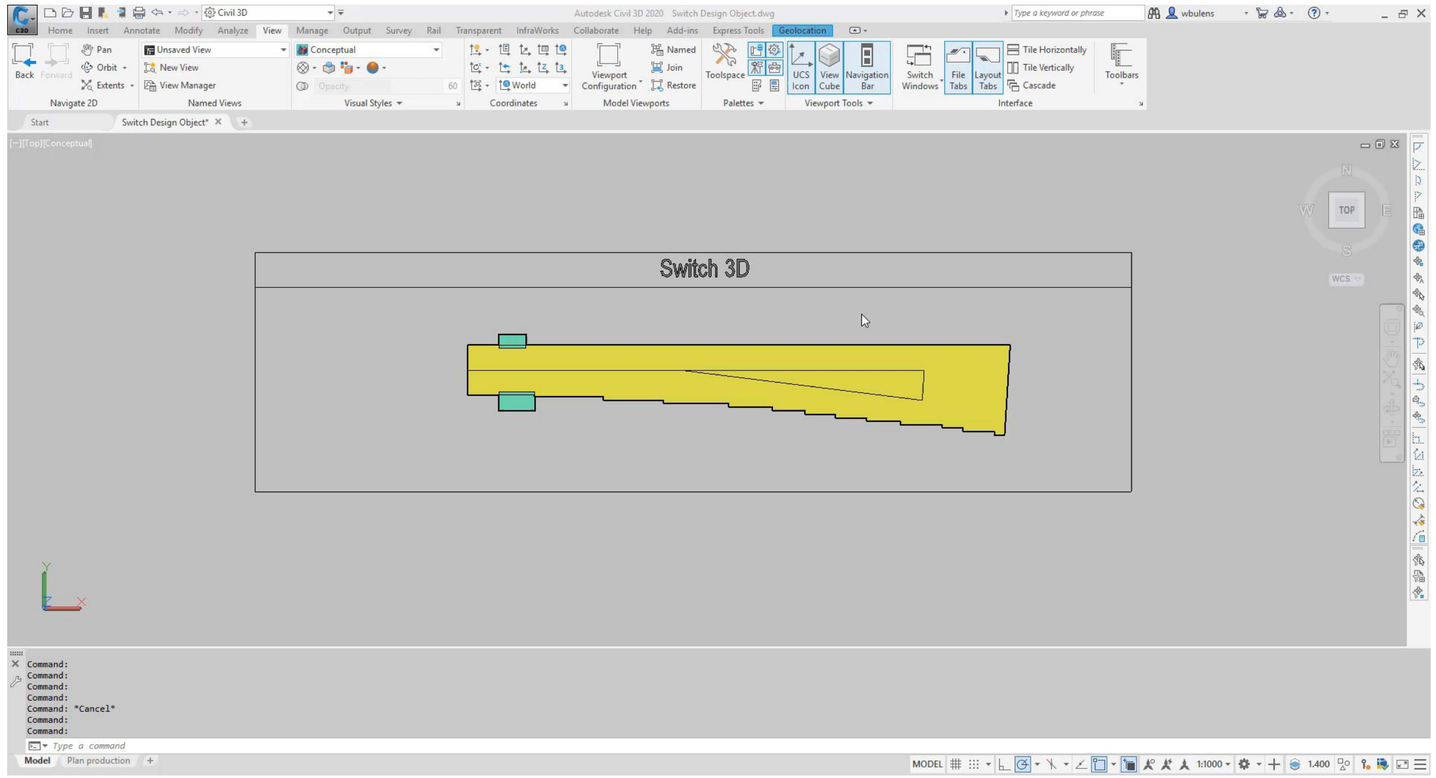
Variants



Variant selection in a Dynamic Block

https://github.com/TUCRAIL/AU2019

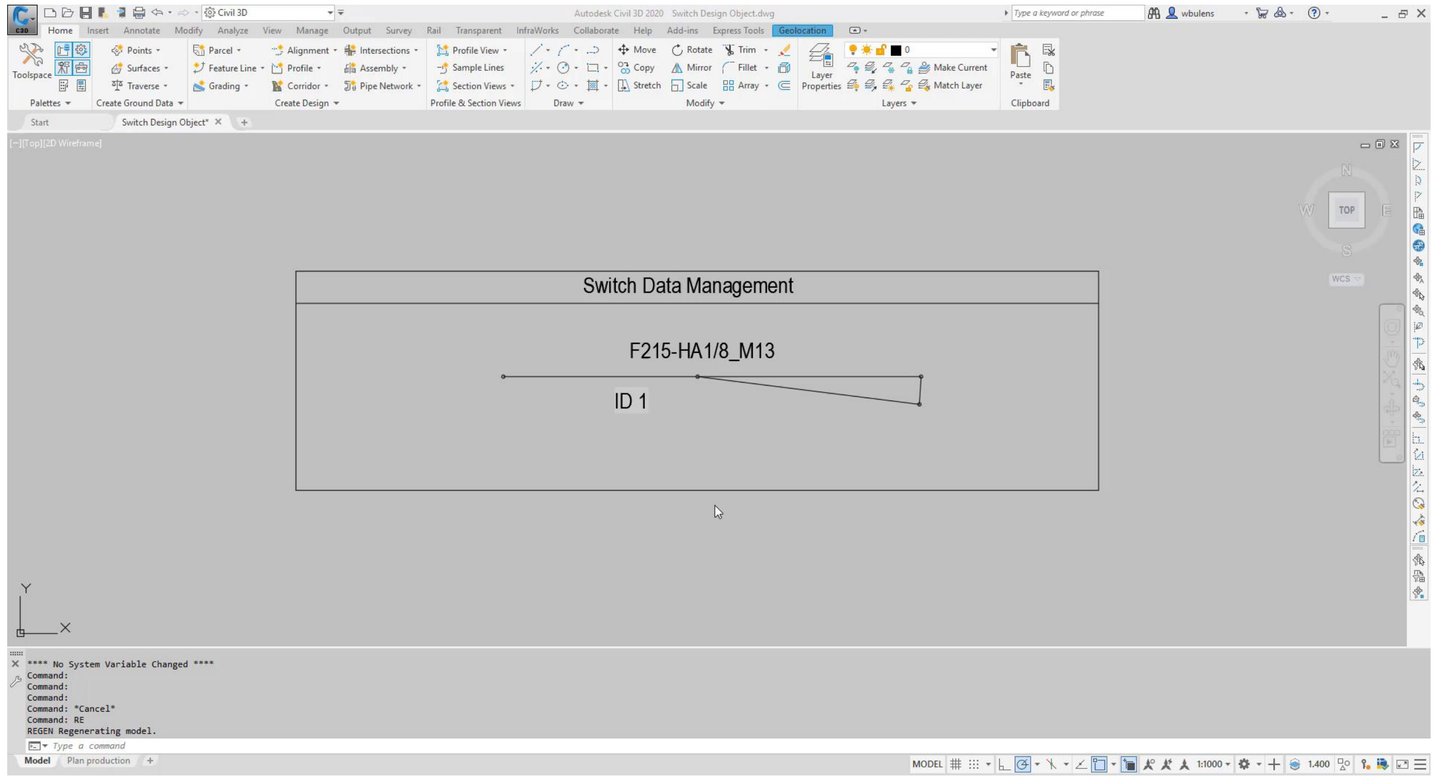
3D geometry



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

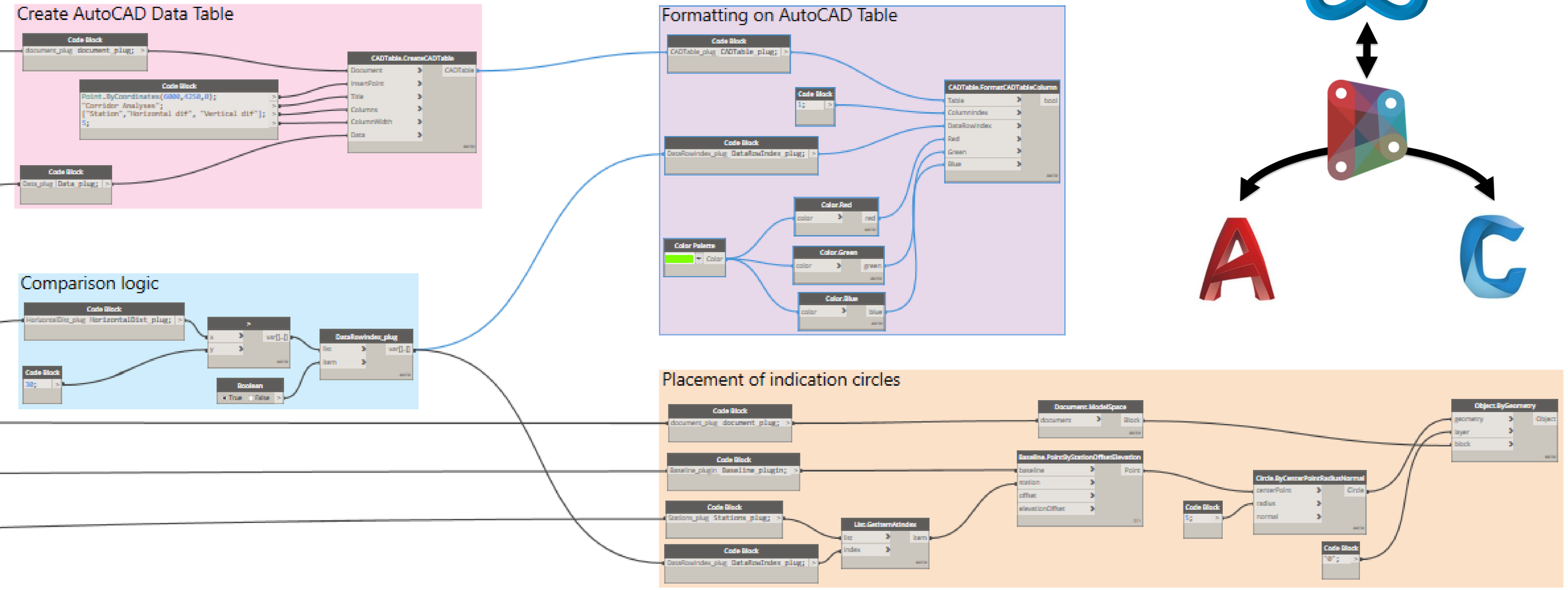
Design Data

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

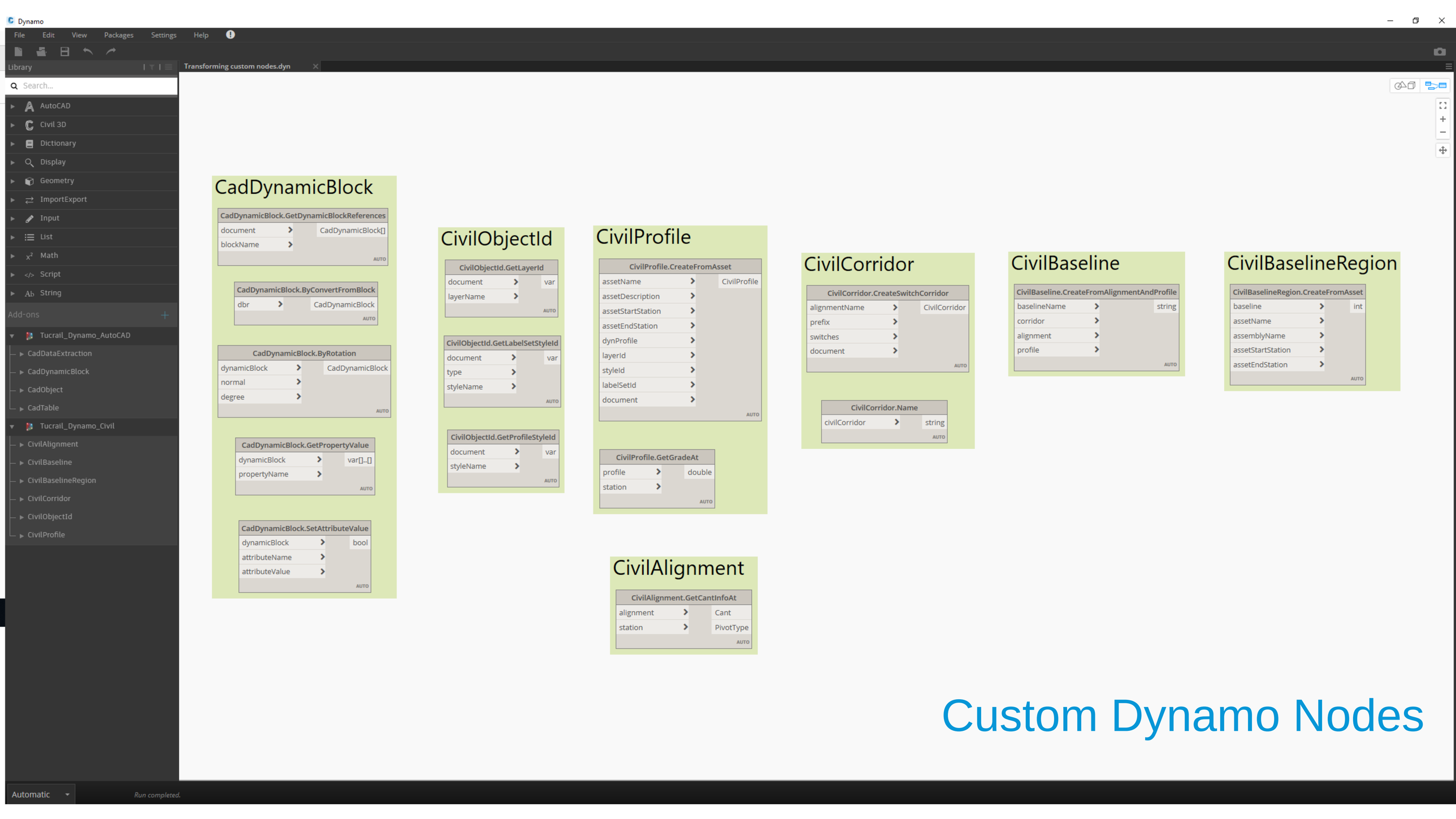
- Alignment / Profile / Cant - horizontal position, direction XY plane / vertical position, slope YZ plane / vertical delta, cant XZ plane
- Switch dynamic block – geometric data, 3D (Alignment, station data)

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


Dynamo
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AutoCAD
Civil 3D
Dictionary
Display
Geometry
ImportExport
Input
List
Math
Script
String
Add-ons
Tucrail_Dynamo_AutoCAD
CadDataExtraction
CadDynamicBlock
CadObject
CadTable
Tucrail_Dynamo_Civil
CivilAlignment
CivilBaseline
CivilBaselineRegion
CivilCorridor
CivilObjectId
CivilProfile
Transforming custom nodes.dyn
CadDynamicBlock
CadDynamicBlock.GetDynamicBlockReferences
document
blockName
CadDynamicBlock[]
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CadDynamicBlock.ByConvertFromBlock
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CadDynamicBlock
CadDynamicBlock.ByRotation
dynamicBlock
normal
degree
CadDynamicBlock.GetPropertyValue
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CadDynamicBlock.SetAttributeValue
attributeName
attributeValue
bool
CivilObjectId
CivilObjectId.GetLayerId
layerName
var
CivilObjectId.GetLabelSetStyleId
type
styleName
CivilObjectId.GetProfileStyleId
CivilProfile
CivilProfile.CreateFromAsset
assetName
assetDescription
assetStartStation
assetEndStation
dynProfile
layerId
styleId
labelSetId
CivilProfile.GetGradeAt
profile
station
double
CivilCorridor
CivilCorridor.CreateSwitchCorridor
alignmentName
prefix
switches
CivilCorridor.Name
civilCorridor
CivilBaseline
CivilBaseline.CreateFromAlignmentAndProfile
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profile
CivilBaselineRegion
CivilBaselineRegion.CreateFromAsset
baseline
assetName
assemblyName
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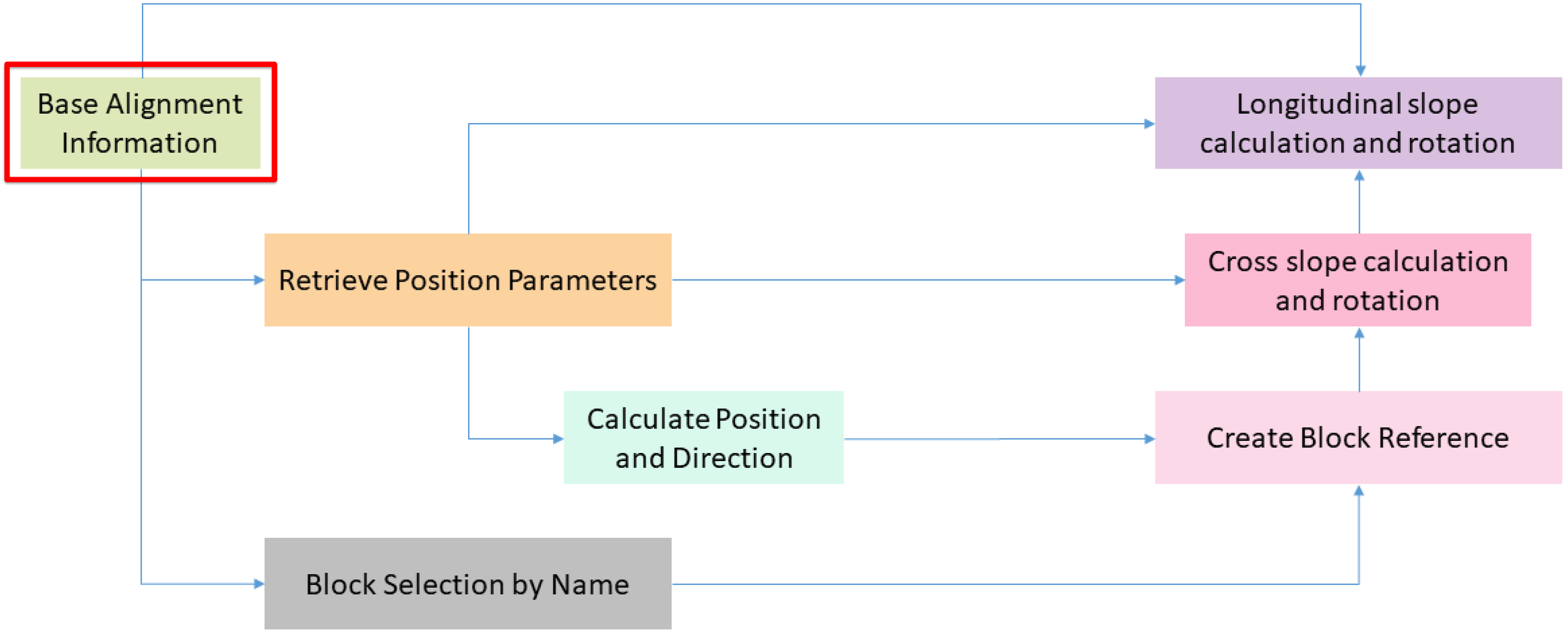
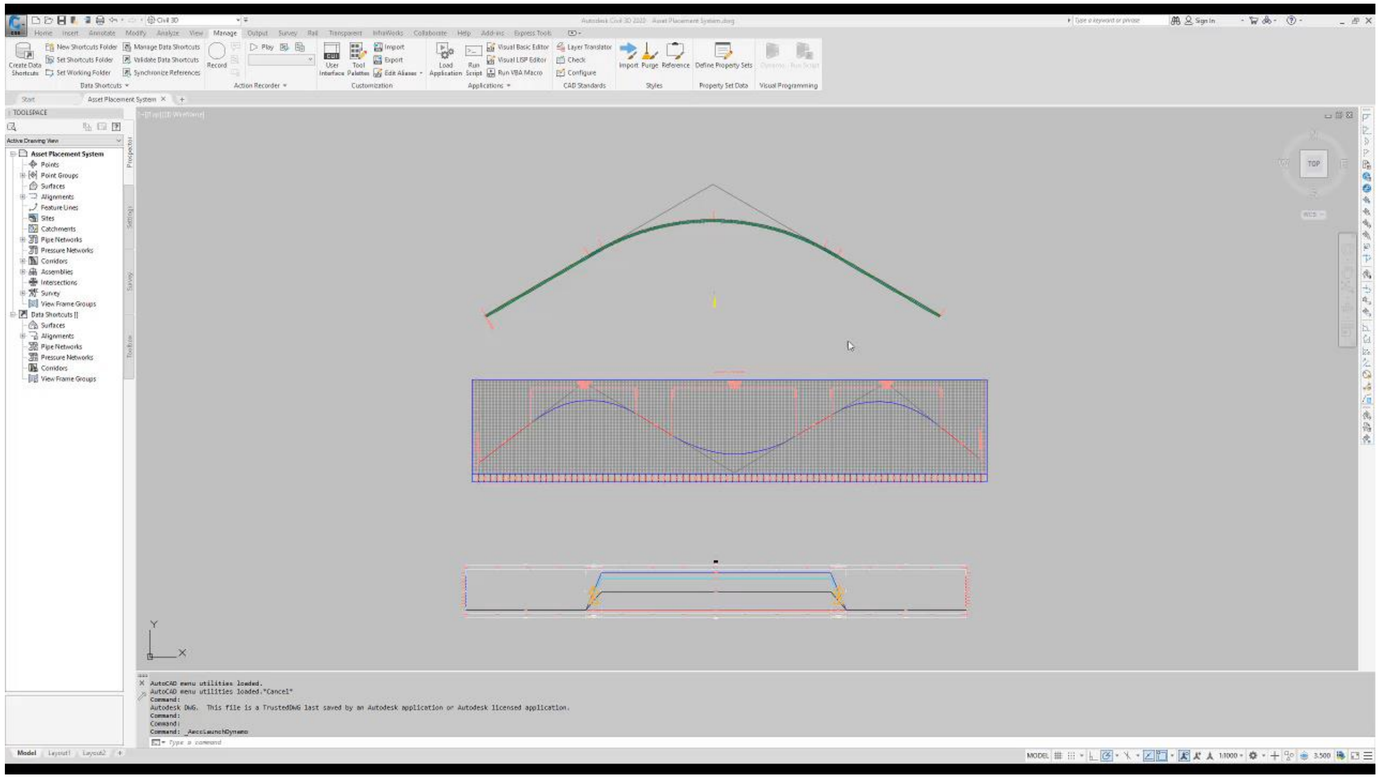
int
CivilAlignment
CivilAlignment.GetCantInfoAt
Cant
PivotType
Automatic
Run completed.
Custom Dynamo Nodes

Switch (Asset) Placement System



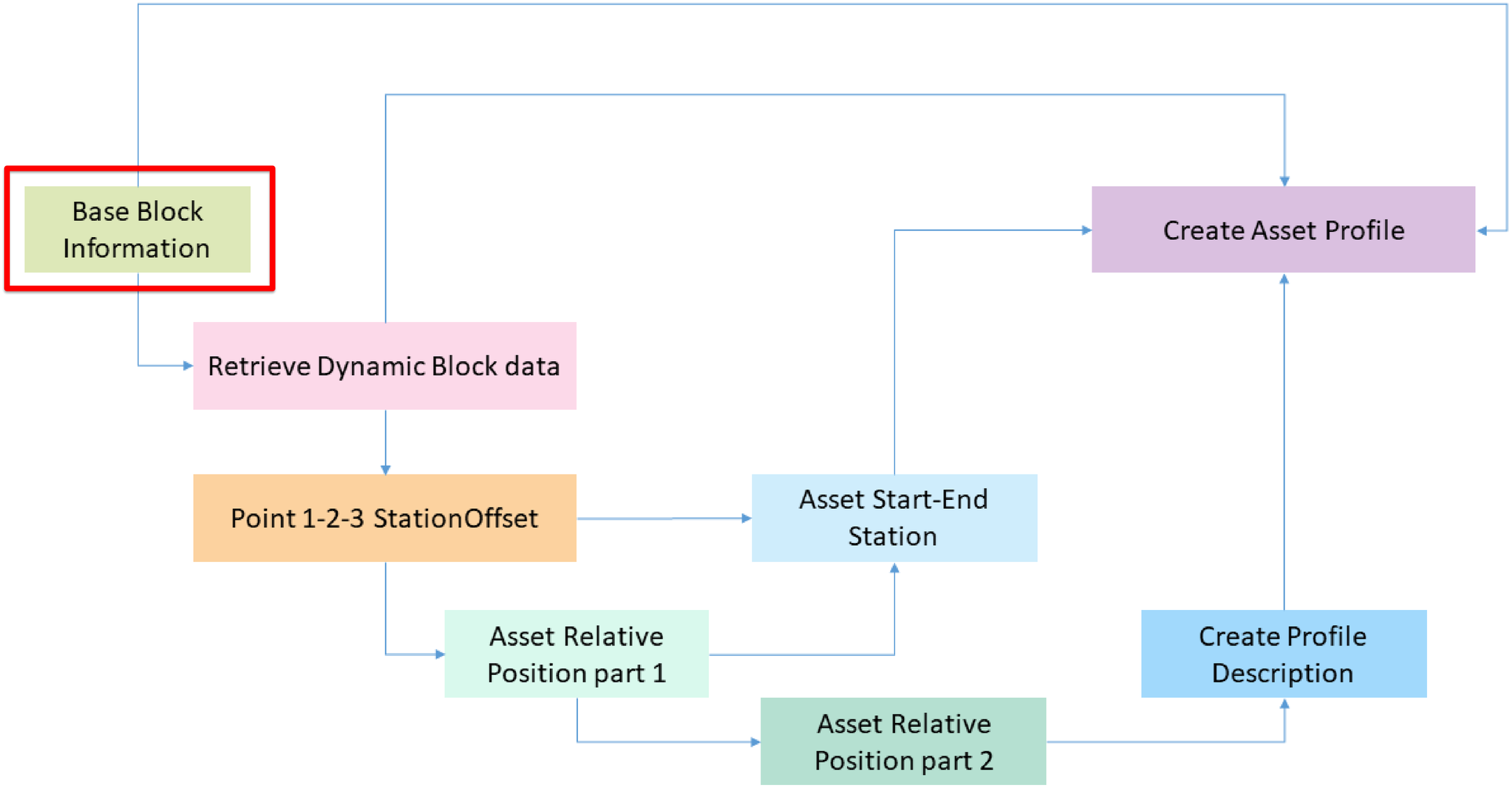
Switch (Asset) Placement System



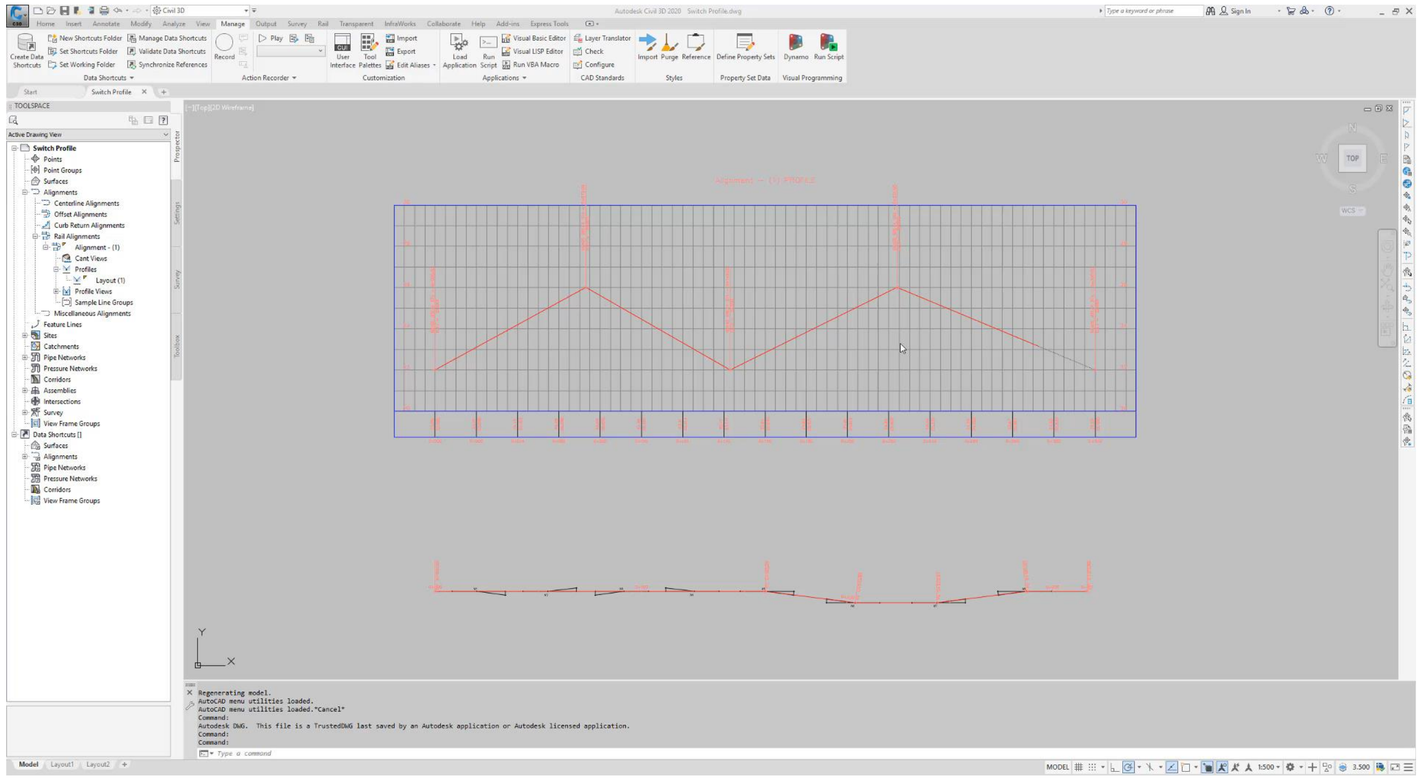
Dynamic Block placement using Alignment, Profile and Cant data

https://github.com/TUCRAIL/AU2019

Switch - Profile



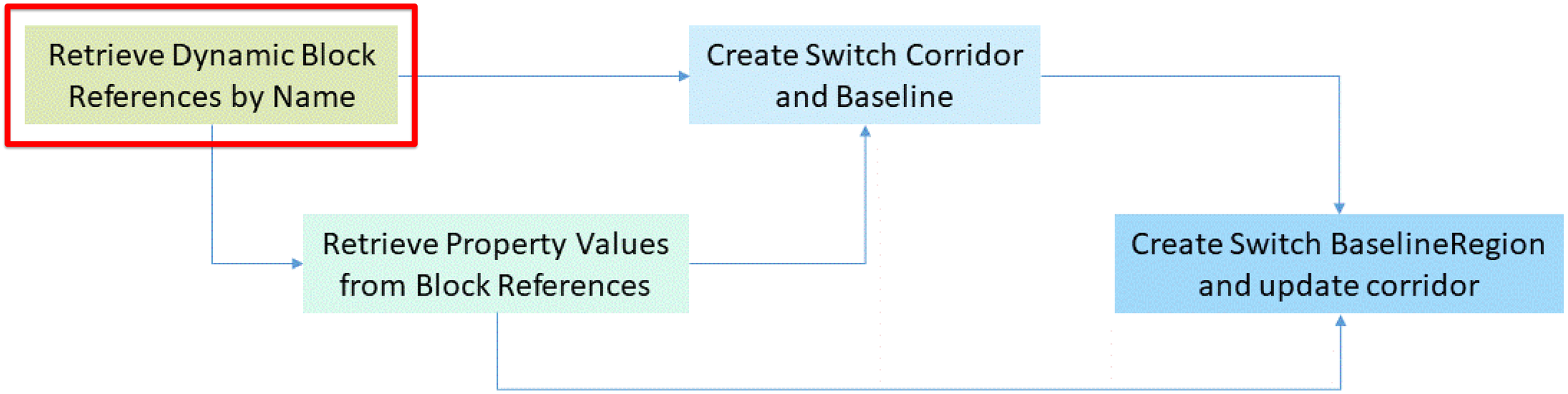
Switch - Profile



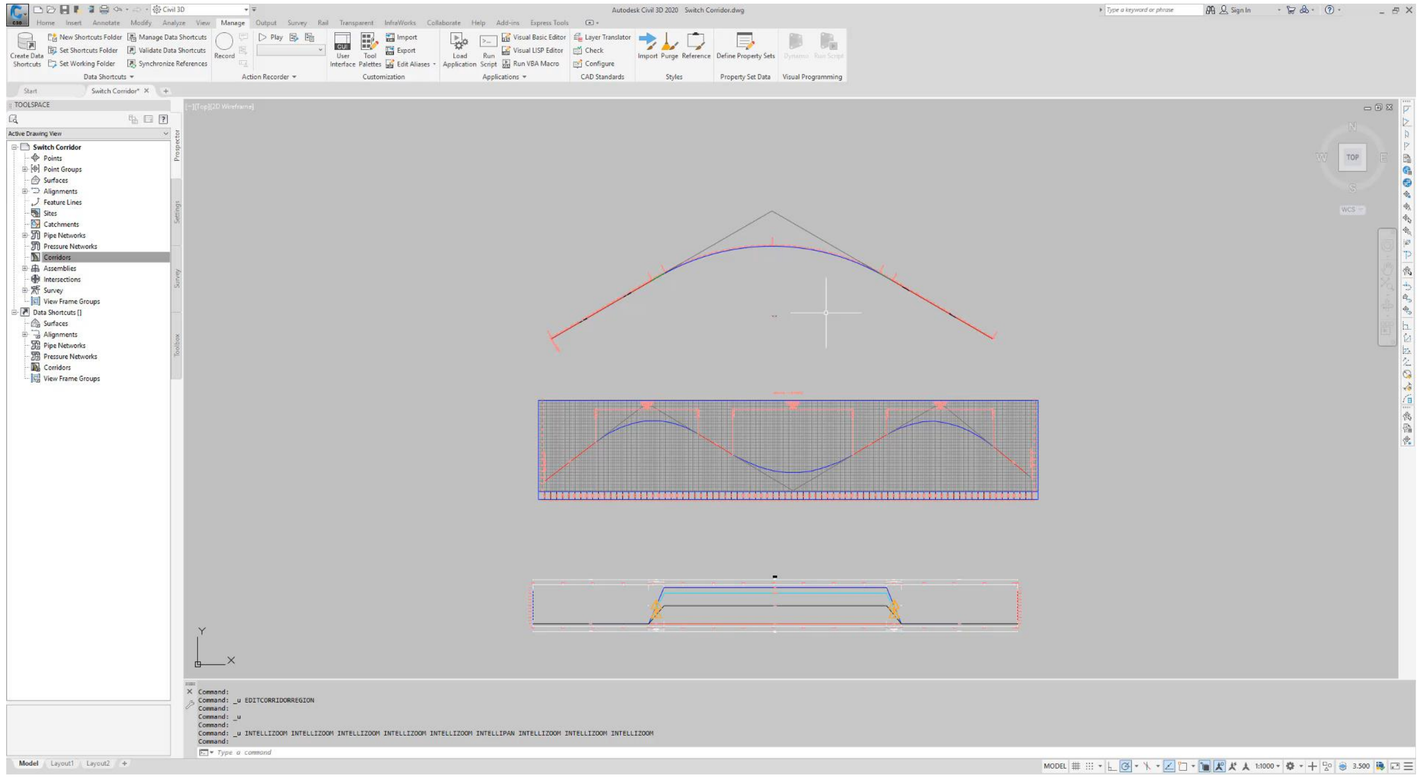
Profile creation using Dynamic Block design objects

https://github.com/TUCRAIL/AU2019

Switch - Corridor



Switch - Corridor



Design Data - a data bridge between Design Objects

https://github.com/TUCRAIL/AU2019

Design Analysis

Distance between alignments (002).xlsx [Read-Only] - Excel

File Home Insert Page Layout Formulas Data Review View Tell me what you want to do... BULENS Wouter

Cut Copy Format Painter Paste Clipboard

Calibri 11 Font

Wrap Text Merge & Center Alignment

General Number

Conditional Formatting Format as Table

Normal Bad Good Neutral Calculation Check Cell Explanatory ... Input Linked Cell Note Styles

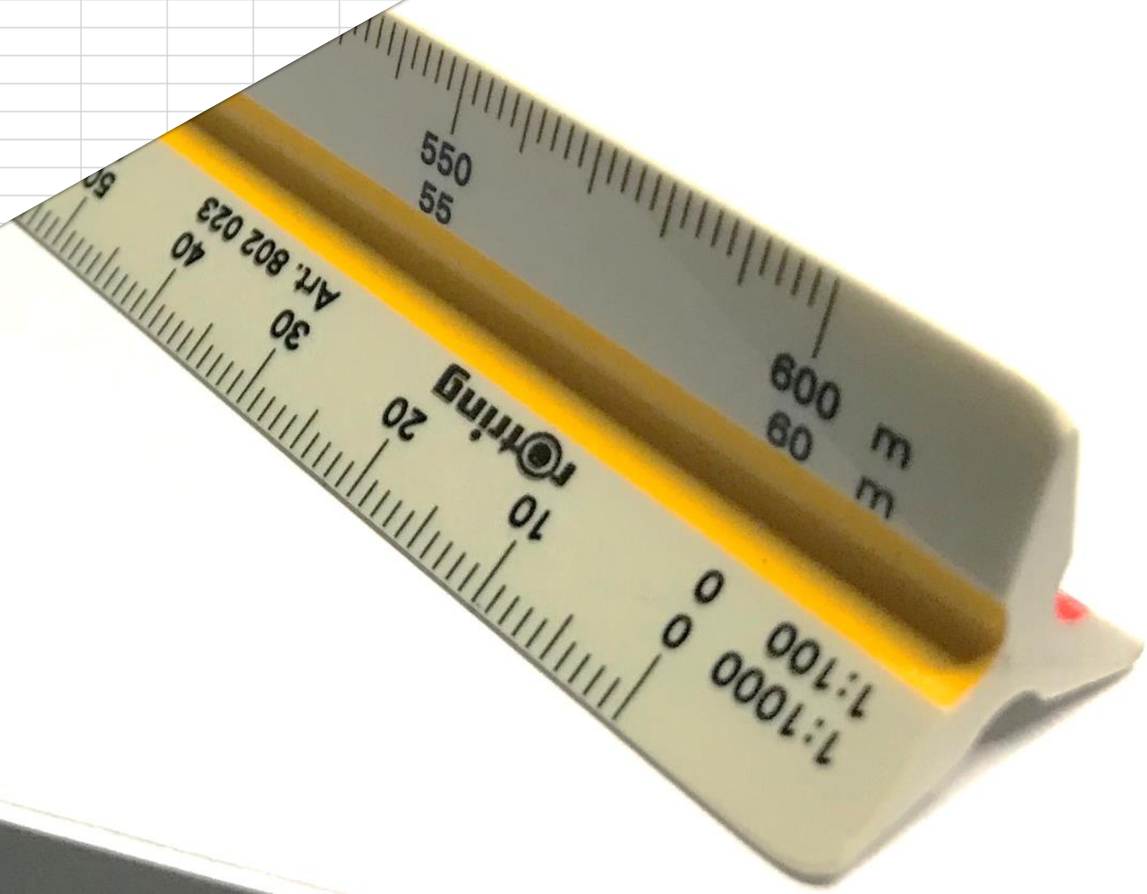
Insert Delete Format Cells

AutoSum Fill Clear Sort & Filter

A1 Master line

	A	B	C	D	E	F
1	Master line					Second line
2	Station	Hor. distance	Ver. distance	Diff. Angle	Diff. Gradient	Station
3	1 288 732	4060.000	0.000	0.796	0.000	1 289 094
4	1 298 732	4199.000	0.000	0.796	0.000	1 299 060
5	1 308 732	4337.000	0.000	0.796	0.000	1 309 026
6	1 318 732	4462.000	0.000	0.522	0.000	1 318 990
7	1 328 732	4511.000	0.000	0.046	0.000	1 328 953
8	1 338 732	4511.000	0.000	0.003	0.000	1 338 949
9	1 348 732	4511.000	0.000	0.003	0.000	1 348 949
10	1 358 732	4510.000	0.000	0.003	0.000	1 358 949
11	1 368 732	4509.000	0.000	0.003	0.000	1 368 949
12	1 378 732	4509.000	0.001	0.003	0.000	1 378 949
13	1 388 732	4508.000	0.001	0.003	0.000	1 388 949
14	1 398 732	4508.000	0.001	0.003	0.000	1 398 949
15	1 408 732	4507.000	0.001	0.003	0.000	1 408 949
16	1 418 732	4506.000	0.001	0.003	0.000	1 418 949
17	1 428 732	4506.000	0.001	0.003	0.000	1 428 949
18	1 438 732	4505.000	0.001	0.003	0.000	1 438 949
19	1 448 732	4505.000	0.001	0.003	0.000	1 448 949
20	1 458 732	4504.000	0.001	0.003	0.000	1 458 949
21	1 468 732	4503.000	0.001	0.003	0.000	1 468 949
22	1 478 732	4503.000	0.002	0.003	0.000	1 478 949
23	1 488 732	4502.000	0.002	0.003	0.000	1 488 949
24	1 498 732	4502.000	0.002	0.003	0.000	1 498 949
25	1 508 732	4501.000	0.002	0.003	0.000	1 508 9
26	1 518 732	4586.000	0.002	0.883	0.000	1
27	1 528 732	4736.000	0.001	0.862	0.00	
28	1 538 732	4883.000	0.000	0.840		
29	1 548 732	5025.000	-0.001	0.817		
30	1 558 732	5164.000	-0.001	0.79		
31	1 568 732	5298.000	-0.001			
32	1 578 732	5428.000	-0.001			
33	1 588 732	5553.000	-0.			
34	1 598 732	5674.000				
35	1 608 732	5791.000				
36	1 618 732	5903.00				
37	1 628 732	6				
38	1 638 732					
39	1 648 732					

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.

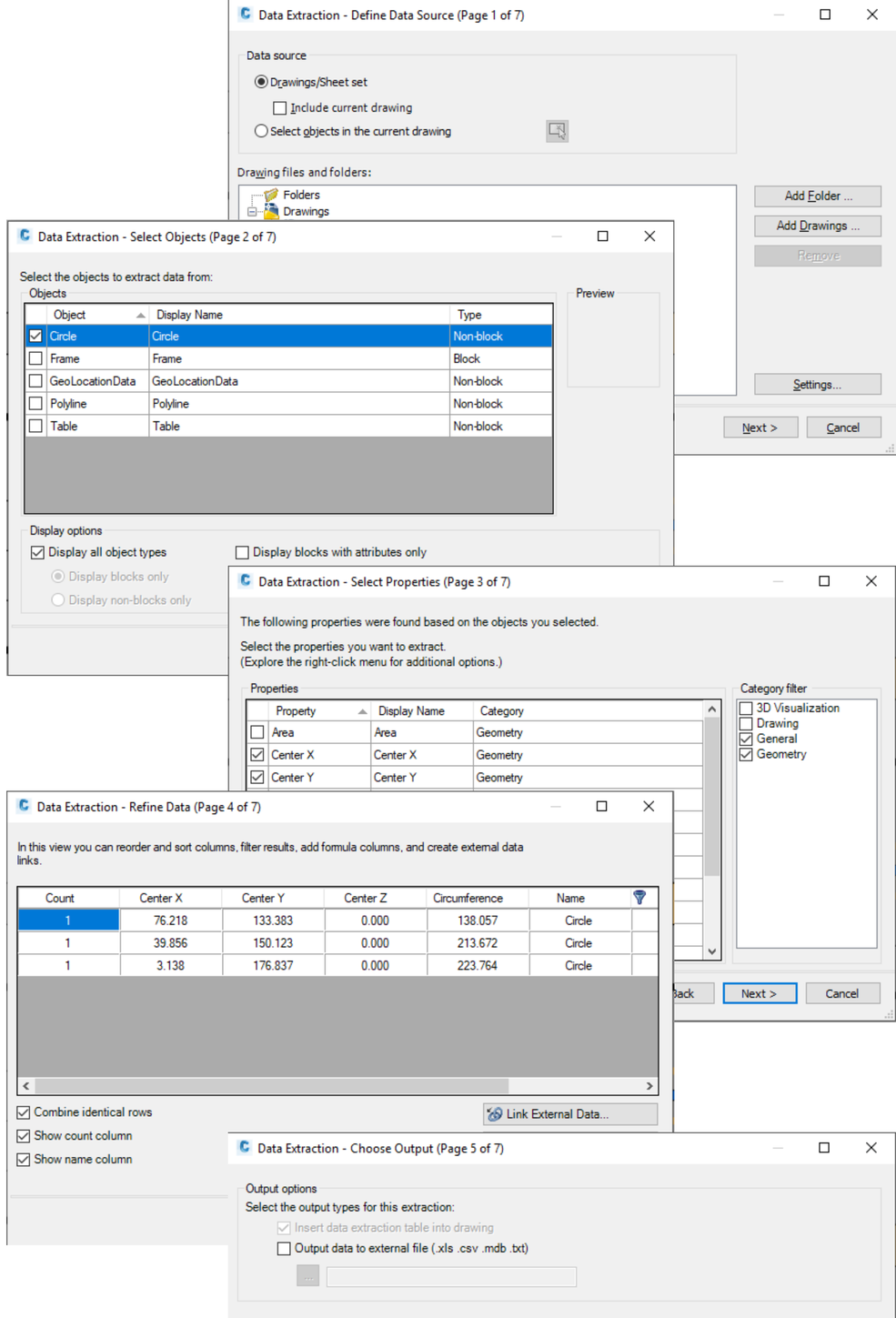
Data Extraction

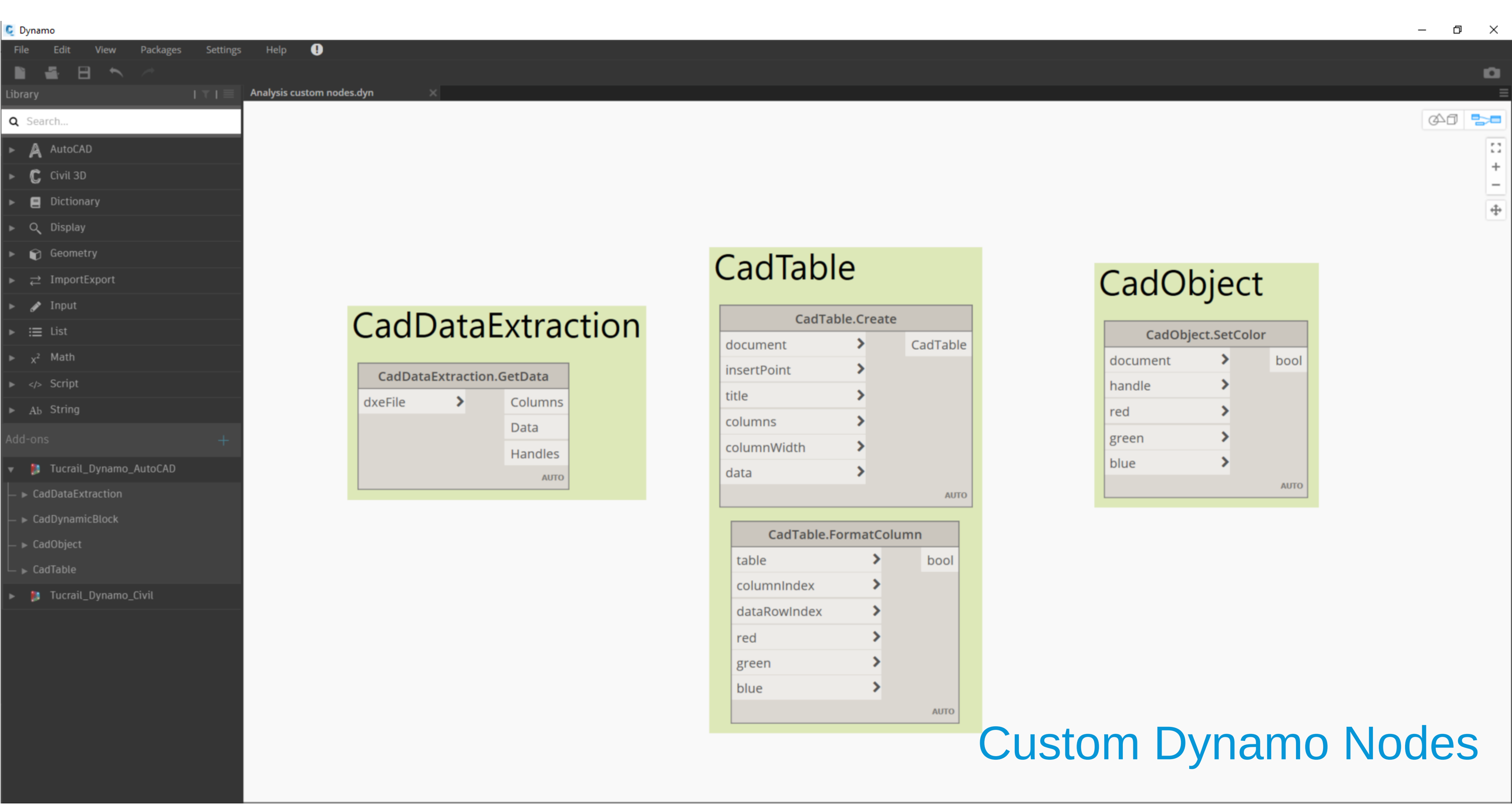
“the ability to extract data from objects in one or more drawings. It searches for the objects you want, looks up the required attributes, links to an external file to add additional data, makes a table with a flexible format and updates”

- 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




Dynamo
File
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AutoCAD
Civil 3D
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Geometry
ImportExport
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List
Math
Script
String
Add-ons
Tucrail_Dynamo_AutoCAD
CadDataExtraction
CadDynamicBlock
CadObject
CadTable
Tucrail_Dynamo_Civil
Analysis custom nodes.dyn
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Data
Handles
AUTO
CadTable
CadTable.Create
document
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AUTO
CadTable.FormatColumn
table
columnIndex
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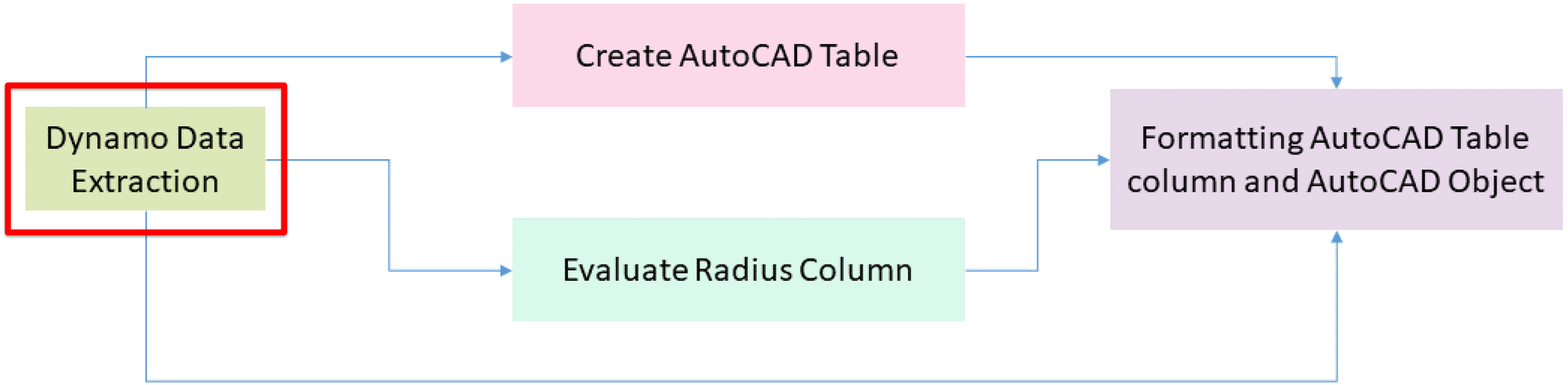
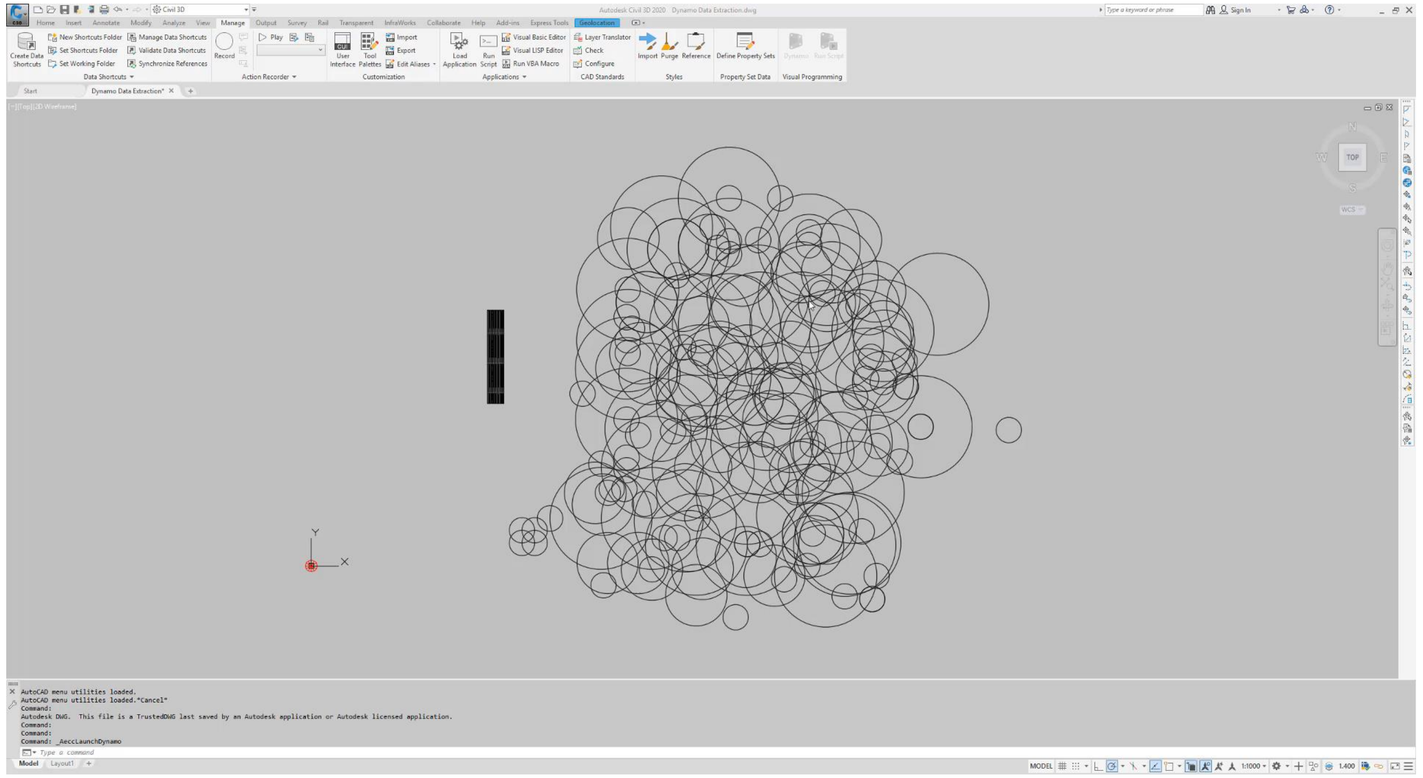
red
green
blue
bool
AUTO
CadObject
CadObject.SetColor
document
handle
red
green
blue
bool
AUTO
Custom Dynamo Nodes

Dynamo Data Extraction



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:

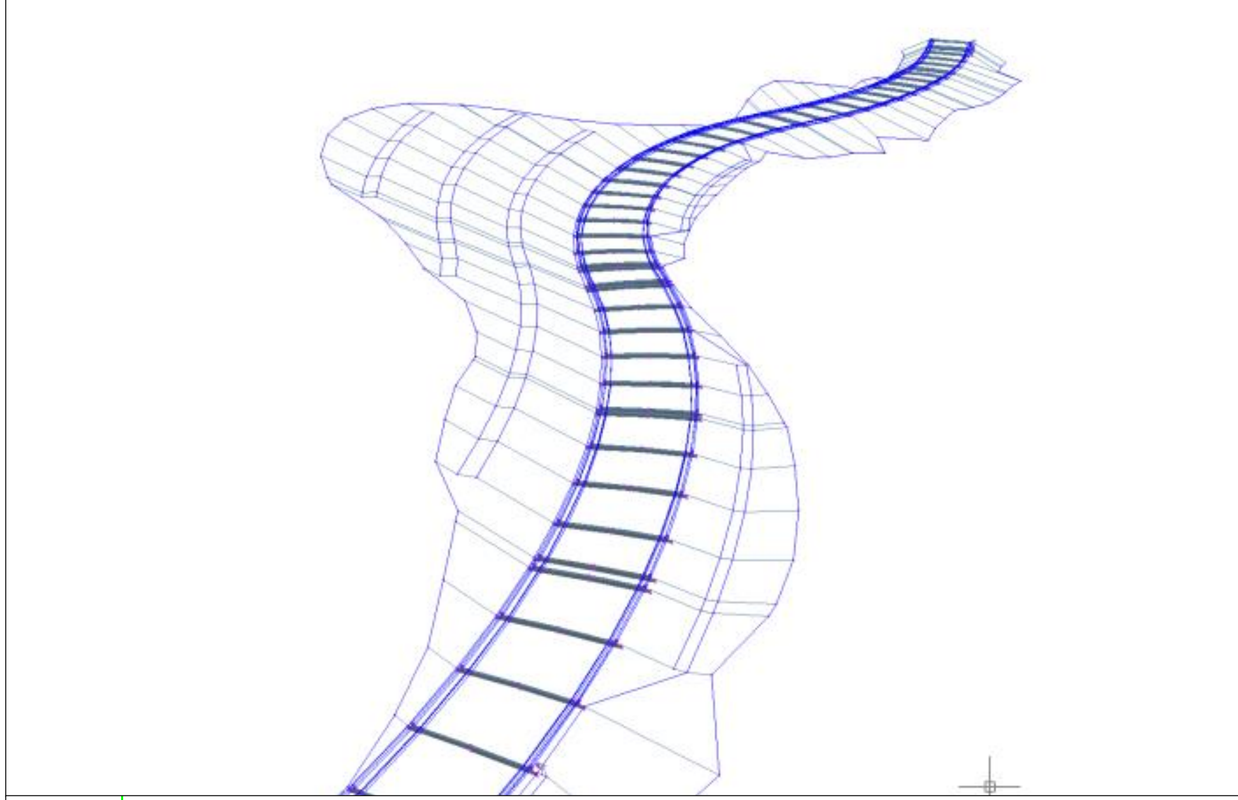
“Calculated parametric sections (Applied assembly) placed along a 3D line (Alignment/Profile or Feature Line)”

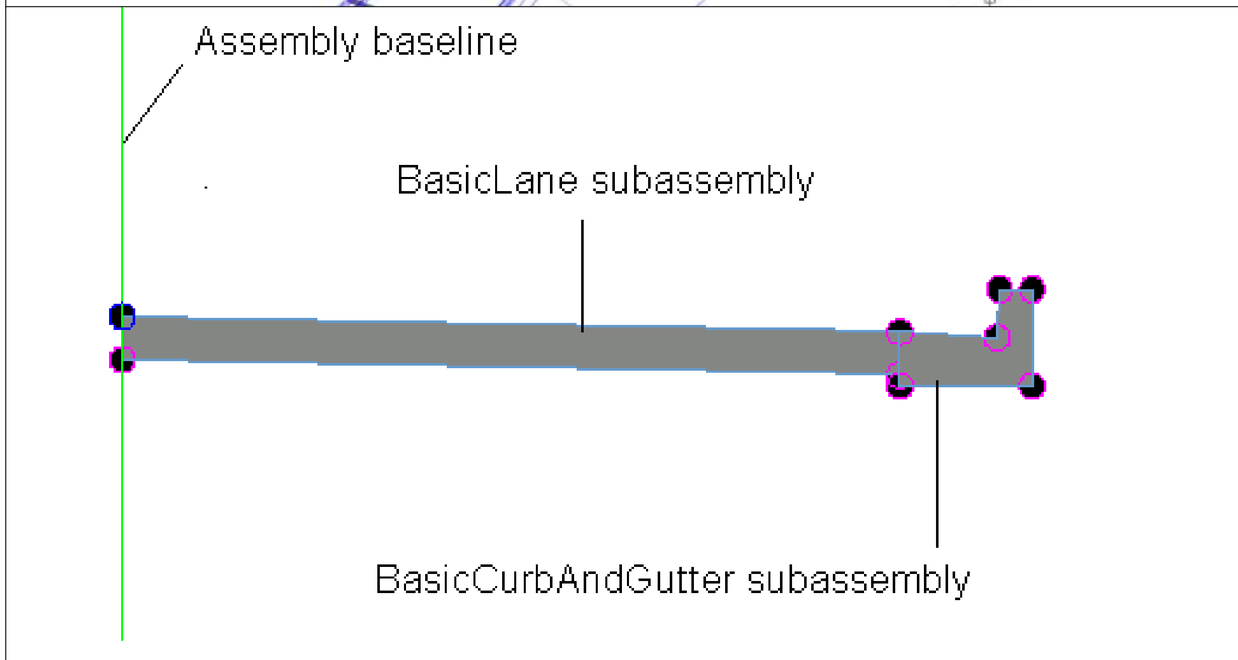
Corridor Data:

- Baseline
  - Station
  - Elevation
- Target
  - To Option
- Subassembly
  - Point
  - Link
  - Shape
  - Parameter (Input and Output)

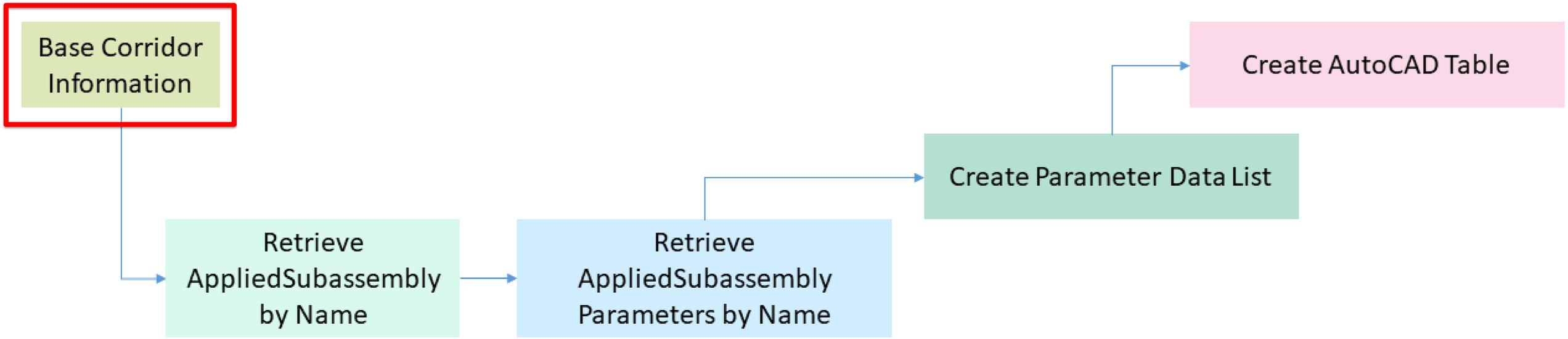
Automated Analysis:

- Parameter (input and output)
- Automated Ruler (point code)

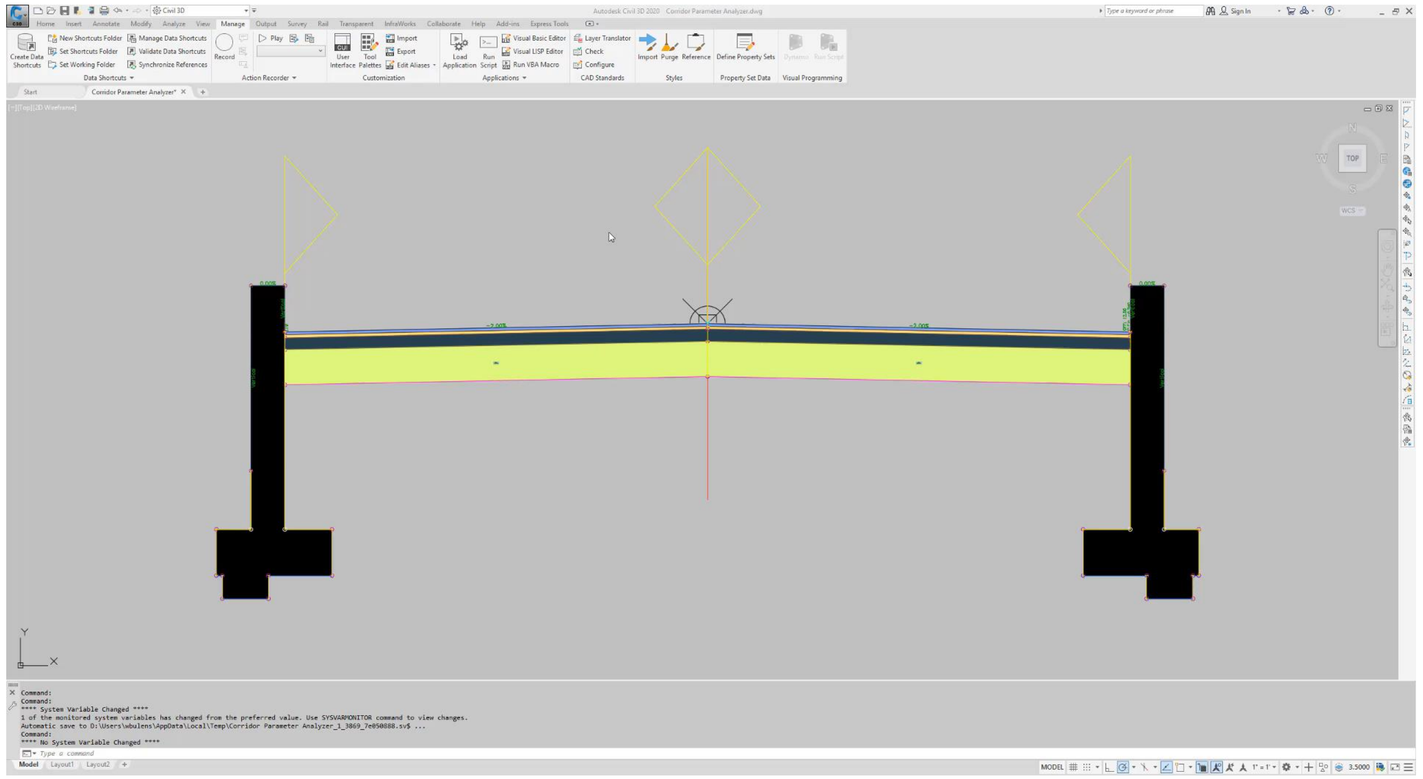




Corridor Parameter Analyzer



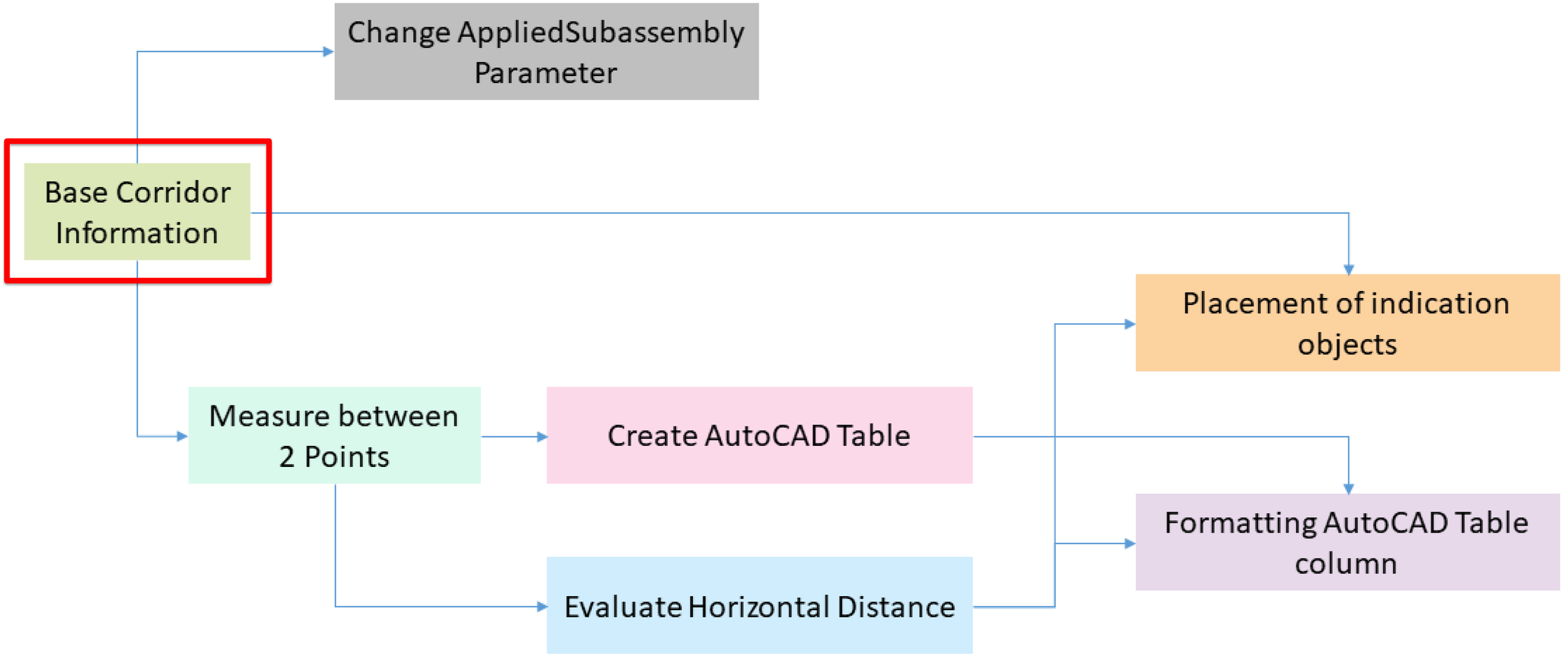
Corridor Parameter Analyzer



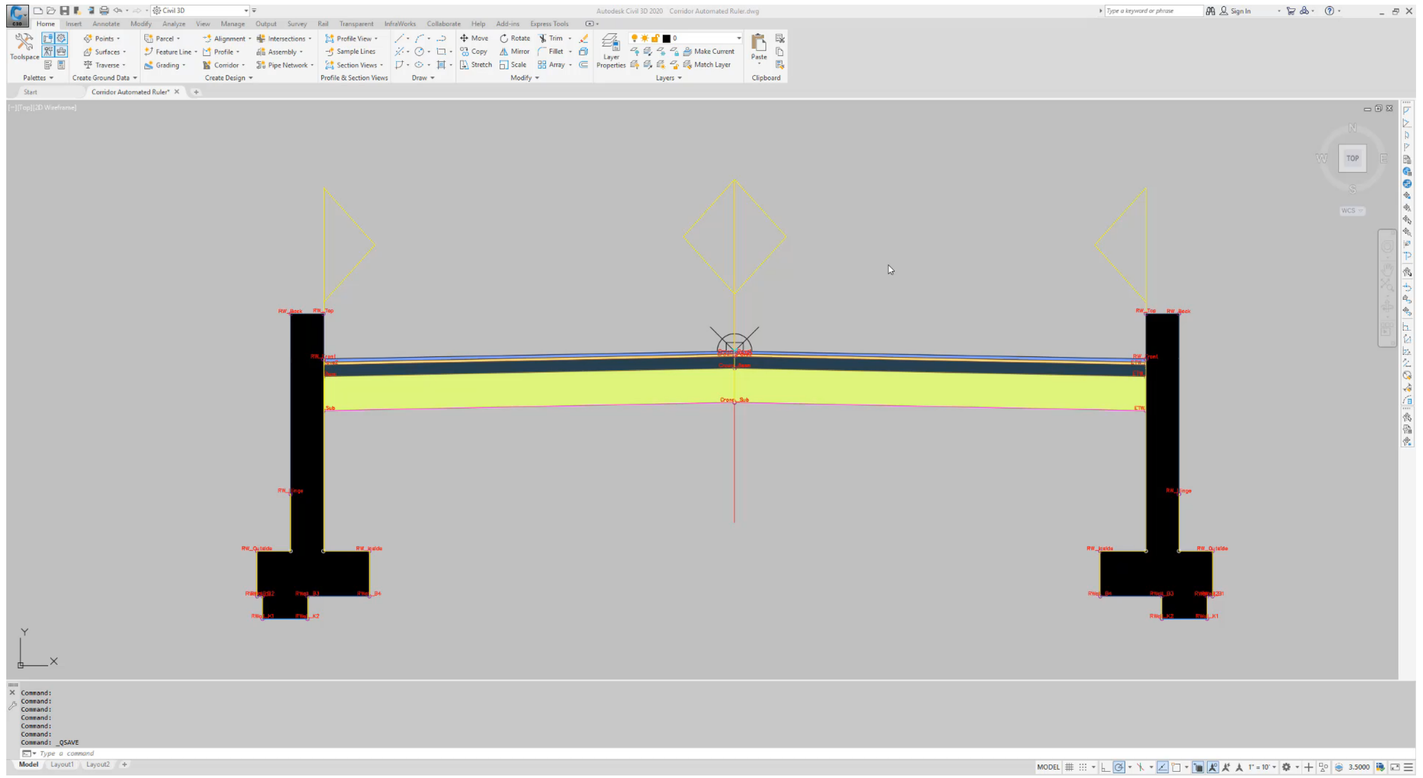
Retrieving parameter values from every calculated section

https://github.com/TUCRAIL/AU2019

Corridor Automated Ruler



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

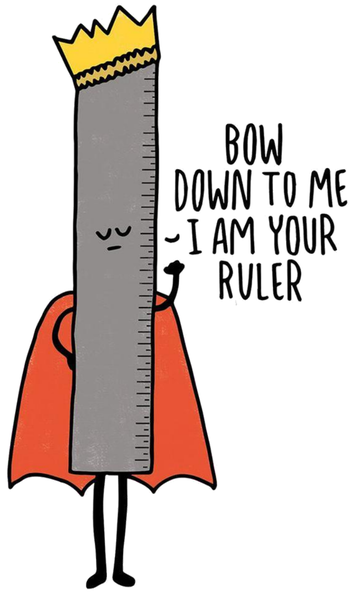
Generating, Transforming and Analyzing Railway Design Data in Civil 3D and Dynamo

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



By Leeann Walker

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Make anything™