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Effective Automatic Creation of an Intelligent Model for Road Infrastructure

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Learning Objectives

- Quickly create and accurately place road signs for your infrastructure projects with universal families in Revit and Dynamo
- Create parametric city furniture like barriers in Inventor and apply them to component roads in InfraWorks
- Manage the connection between 2D plans in Civil 3D and consolidated BIM model in NavisWorks/InfraWorks
- Effectively create a realistic aggregated BIM-model of road infrastructure with all project elements

Description

Road infrastructure consists of many simple elements - road signs, traffic barriers, traffic lights etc. Creating and placing them separately in large infrastructure projects can be very hard. In this technical presentation, we will demonstrate how to automate the creation of a BIM model for road infrastructure using Dynamo scripts and universal Revit families.

This class will teach you how to organize a GIS system of a traffic management plan in Civil 3D and to transfer it effectively to InfraWorks model; set up an effective link between 2D plan and the consolidated BIM model in accordance with the information embedded in the vector objects. We will also cover creation of parametric barriers in Inventor for InfraWorks; apply parametric barriers for component roads in InfraWorks and demonstrate of the Dynamo script that places barriers on the appropriate position in the consolidated model in accordance with the attributes of barrier's points from the 2D plan.

Speakers

Alina Yusupova is a Head of Projects and BIM specialist in INFARS. She is acting as a consultant in large multidisciplinary infrastructure projects. Alina is responsible for implementation of technical workflows in customer's BIM processes, trainings, BIM project support, management and control of BIM team. She acts as a speaker at Autodesk University Russia annually since 2013. In 2019, Alina was a speaker at Autodesk OTx EMEA, EMEA

Emerging Keynote session. She has over 8 years of design experience as a Civil Engineer. Alina is currently based in Moscow, Russian Federation.

Alexey Shcherbachev is a BIM Manager in INFARS specialized in Revit Structure and Inventor. He is responsible for implementation, management, trainings and BIM project support. He is an engineer with over 8 years of design experience, lives in Moscow, Russian Federation. Alexey was a speaker in Autodesk University Russia in 2018 and 2019.

INFARS team participated in the development of many large infrastructure projects using BIM technology.

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Introduction

Our company has completed many large infrastructure BIM projects. These projects contain a huge amount of small elements - road signs, fences, markings, etc. Creating a BIM model of such objects can take a lot of time. Therefore, we have developed some workflows to automate such processes.

All exercises that we will consider today are based on our practical experience.

Creation of road signs with «universal» families in Revit

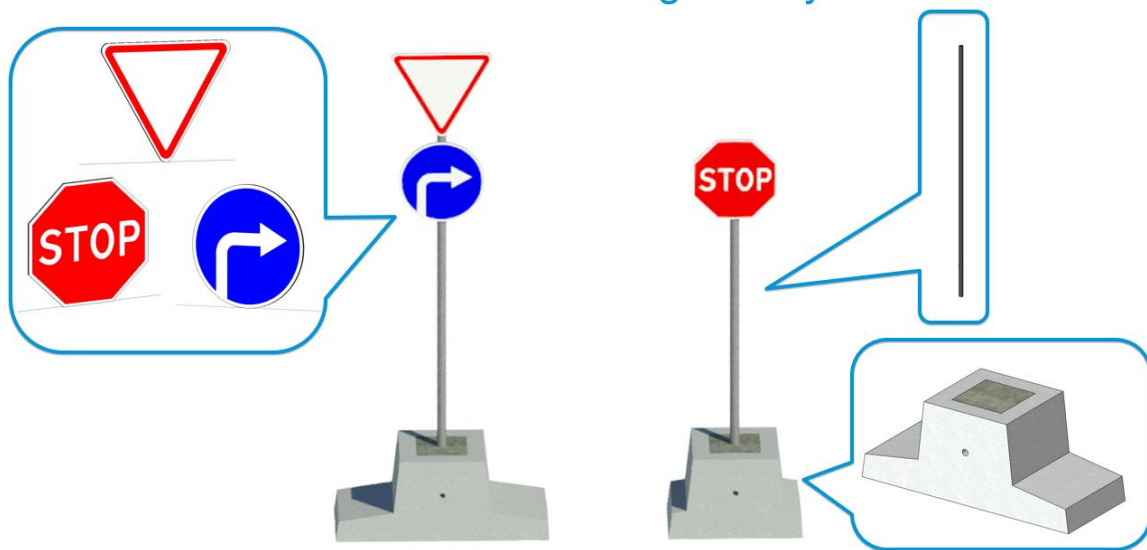
The complexity of BIM-model of traffic management creation is in a huge number of elements. For example, we developed projects with hundreds of models of road signs. Modeling these elements individually can take a lot of time. Therefore, to automate this process, Alexey developed «universal» families. This chapter is about the «universal» road sign families.

This family allows you to create a model of almost any road sign very quickly.

All you need to do is to choose the number of signs, the type of signs, the type of stand, and the type of foundation.

The process of road sign creation will take no more than a minute, even for Revit beginners.

«Universal» road sign family

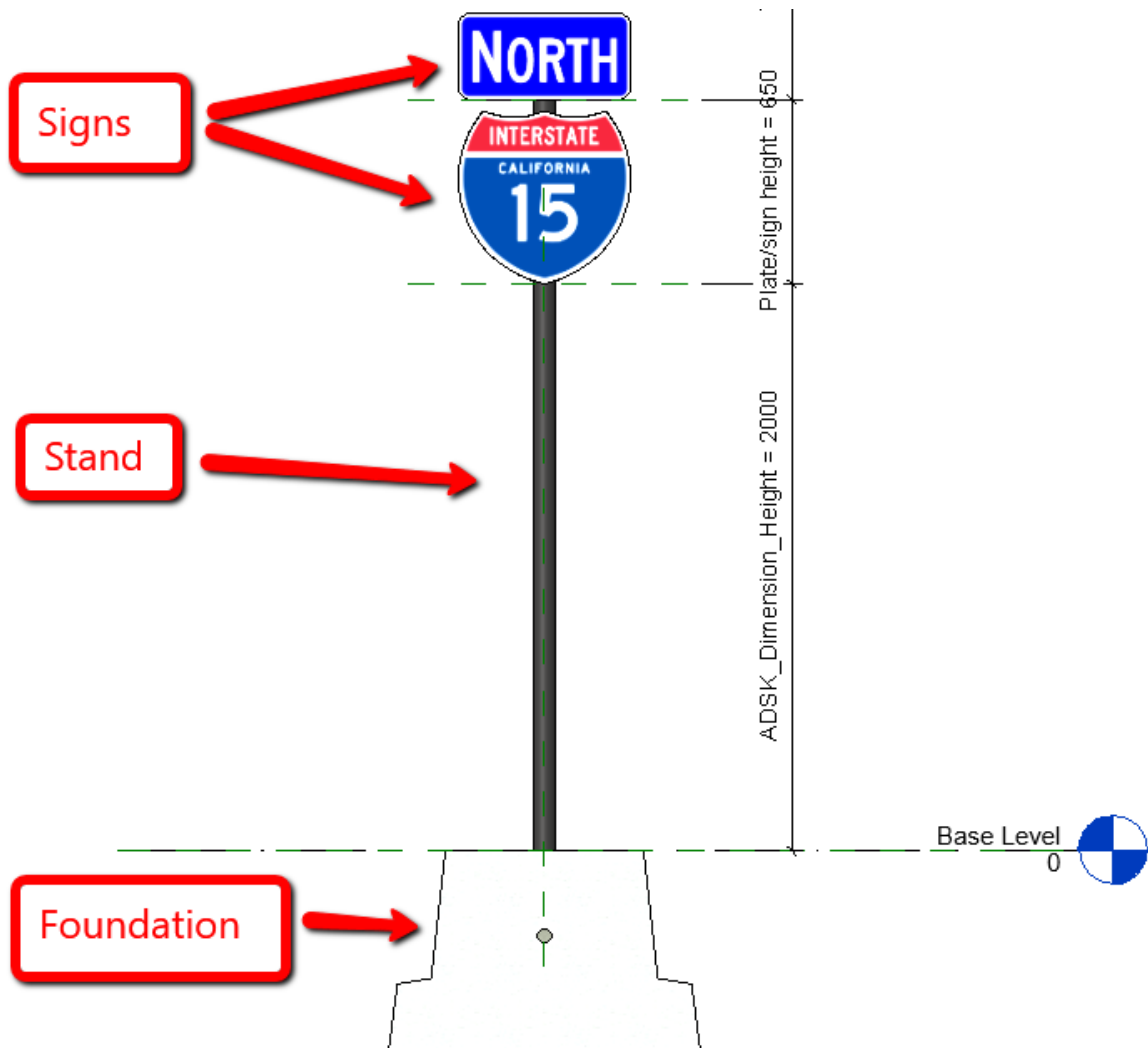


Choose the type of signs, the number of signs, the type of stand, and the type of foundation

How does it work?

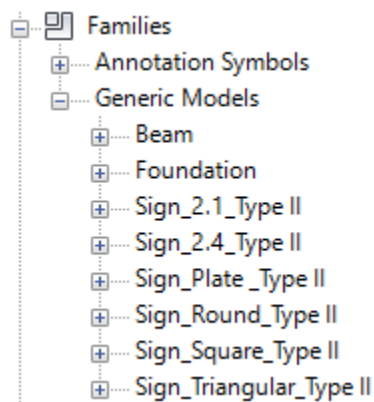
«Universal» road sign family is a parent family with nested families with interchangeable components. In the parent family have been created parameters that change components of nested families.

Let's define the names of the elements for a better understanding. The parent family of the Road sign consists of three types of nested families - signs, stand and foundation:



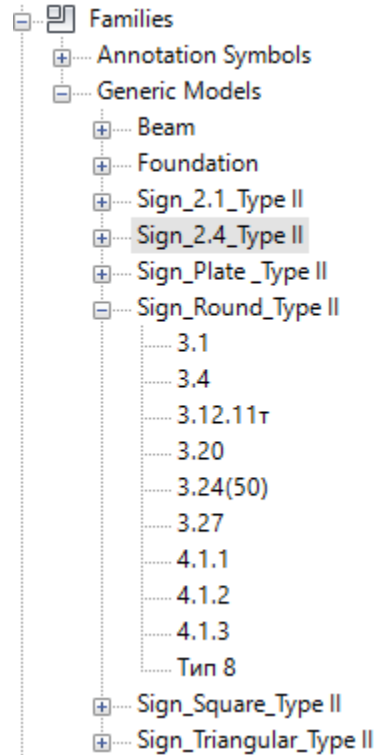
Composition of the road sign

The European system of road signs usually use only a few shapes of signs - round, triangular, rectangular, tables and few non-standard shapes. We create a nested family for each sign shape.



Nested families in «Universal» road sign family

Types of sign families have the same geometry but use different materials. As materials, we use textures of signs from free sources.



Types of families in Nested family

There are more types of sign shapes in the American system of road signs. Therefore, you need to add more sign families. However, adding new types is easy, even a Revit beginner can do this.

Watch the creation of new sign using "Universal" Revit family in the video - <https://youtu.be/06yS6WnQLh0>.

You can also create non-standard road signs using variable-sized parametric canvases.

Another family covers Cantilever Signs and traffic lights in the same way.

For example, a pedestrian crossing sign on a cantilever above the roadway:



A pedestrian crossing sign on a cantilever

Instead of a pedestrian crossing sign, you can select a traffic light object. As a result, we automate the creation of 3D models of traffic elements. Designers do not need to know Revit at a high level. They must be able to work with only several «universal» Revit families.

Management of the connection between 2D plan in Civil 3D and federated BIM model in Navisworks

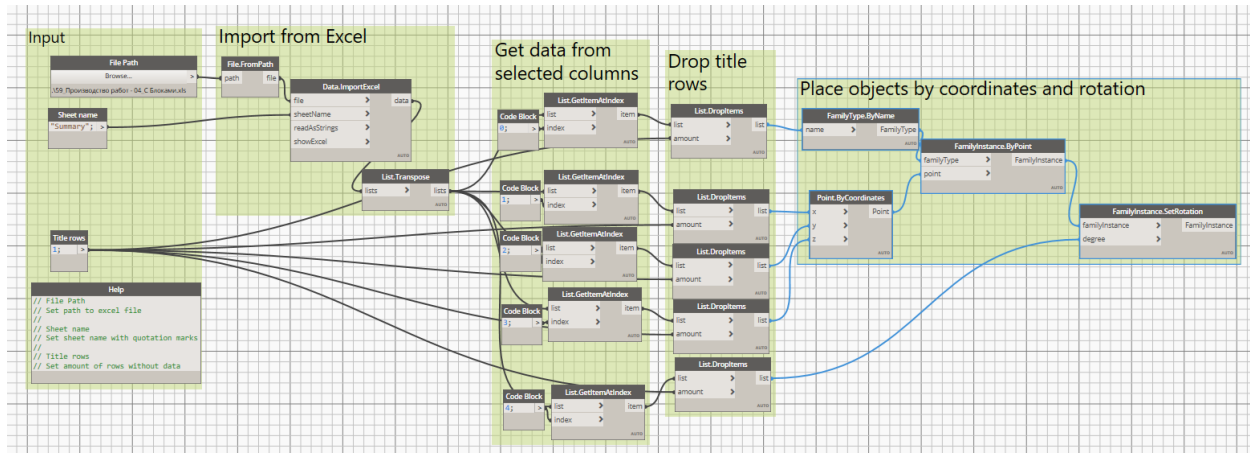
We use InfraWorks model for presentation purposes. Our customers really like how the project looks in InfraWorks. Navisworks model solves practical problems - coordination, clash detection, analysis, etc. However, we create both federated models using the same data source – blocks with attributes in Traffic Management plan. Thus, we do not duplicate the work.

As a source of data, we use same traffic management plan with blocks in Civil 3D. AutoCAD blocks contain information about the name of the object, coordinates, elevation, rotation angle. We have created 3D models corresponding to blocks using «universal» Revit families. Using this data, we need to create a consolidated 3D model of Traffic Management automatically. Dynamo can help with such a non-standard task. To do this, it is necessary to implement three stages:

1. Export the block attributes from the Traffic Management plan in AutoCAD Civil 3D to Excel table (name of element, coordinates, surface elevation, and rotation angle).
2. Prepare the 3D models for all blocks of the plan - described in details in paragraph 2.

3. Run the Dynamo script, which will automatically place 3D models in accordance with the data points from the plan.

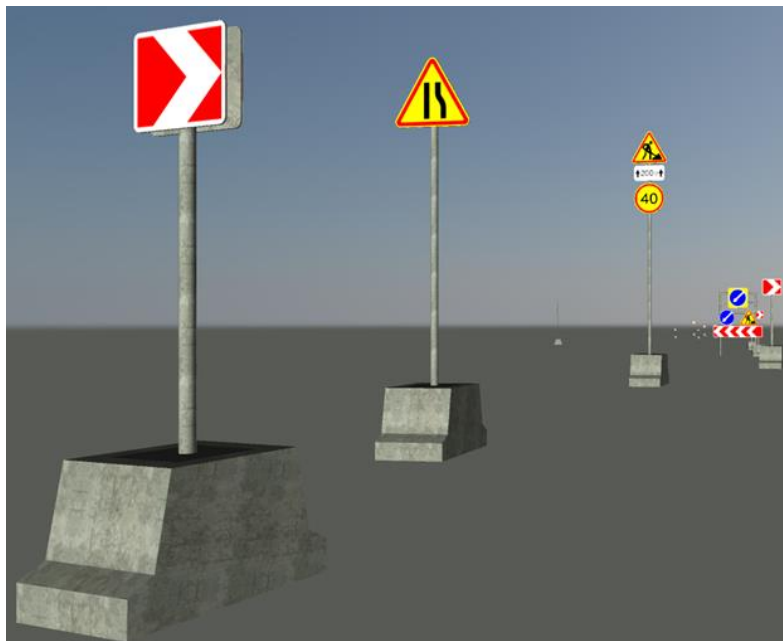
For these purposes, "INFARS" has developed a script that places 3D models in accordance with their attributes in the Revit model.



Script for the placement of traffic management elements in Dynamo

As a result of script working, we have got road signs placed according to the data of the corresponding blocks of the 2D plan in Civil 3D. We can automatically obtain specifications for elements of road signs (types and number of signs, racks, foundations, etc.) in Revit. If necessary, it is possible to create other types of specifications, for example, with detailed calculation.

Next, export this model to the FBX format for further import into the federated model in Navisworks.



Signs placed in NavisWorks

Watch the video for more details - <https://youtu.be/C746Zb6fwcg>.

Organization a GIS system of a traffic management plan in Civil 3D and its effective transfer to InfraWorks model

Preparation of data in Autodesk Civil 3D

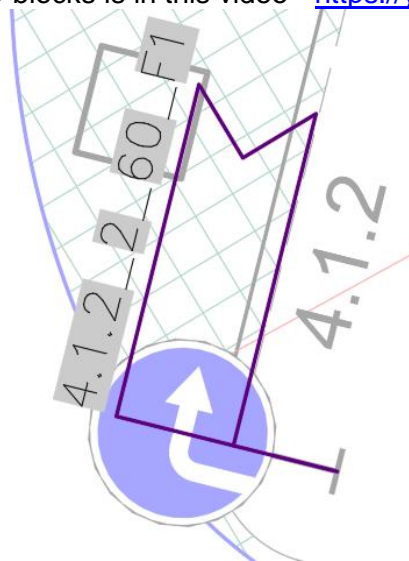
Elements of a traffic management must be placed on the plan in Civil 3D as AutoCAD blocks. In order to use the plan as source data, the blocks on the plan must meet the requirements:

- Blocks must have attributes - the name of the object, angle of rotation on the plan and other necessary information. The rotation angle attribute should be set automatically when the block is rotated in the drawing.
- The insertion point of the blocks must coincide with the 2D center of the inserted element.

The process of creating this block is in this video - <https://youtu.be/XXjwsGPMx8I>.

An example of such block is in the figure. During the design process, the specialist places these blocks and sets of the attribute values. In addition, the specialist should rotate the block relative to the plan in the design position. The rotation of attributes will assign automatically.

The process of arranging AutoCAD blocks is in this video - https://youtu.be/y_VjNiP-ugc.



Road sign block on the plan.

Attributes of Road sign block:

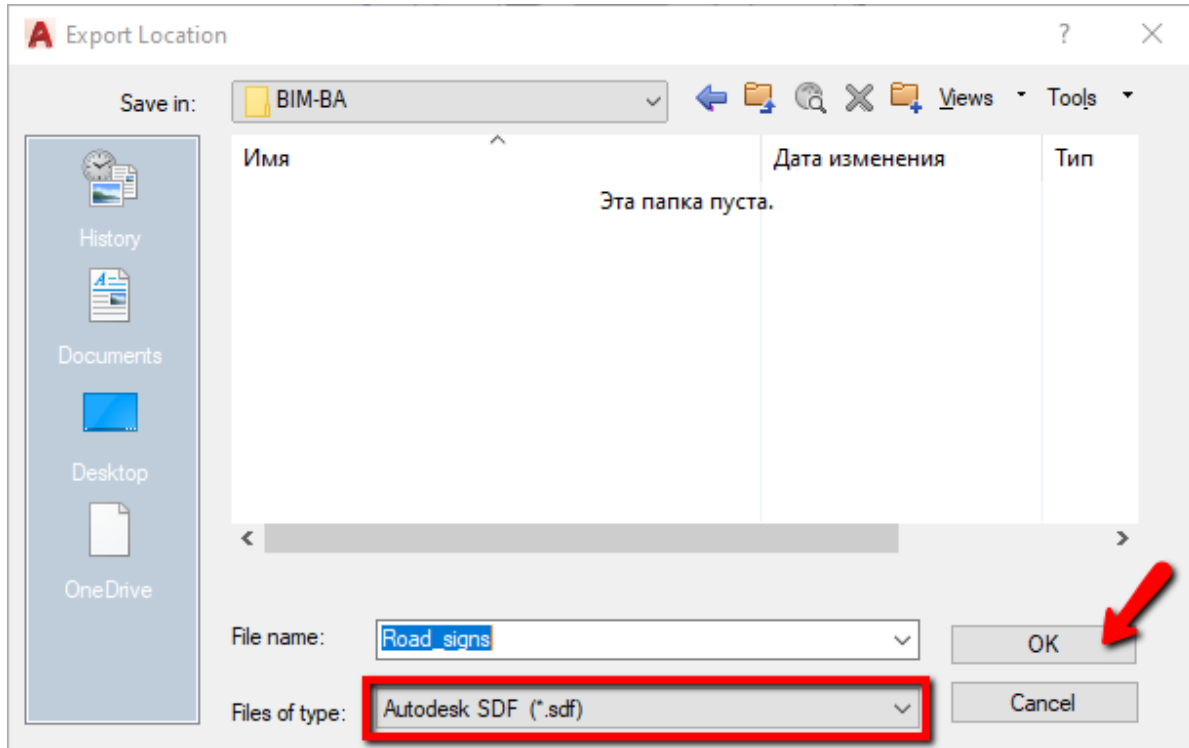
Block:Road_sign	
SIGNS	4.1.2
HEIGHT	2
PROFILE	60
TYPE_OF_FOUNDA...	F1
FULL_NAME	4.1.2_2_60_F1
ROTATION	76.0000

Attributes of the block.

As a result, on the plan in Civil 3D, all traffic management elements are presented as AutoCAD blocks with attribute information. When changes occur in the project, it is necessary to make the appropriate changes to the spatial position and attributes of the blocks. As a result, we have a GIS system of traffic management elements.

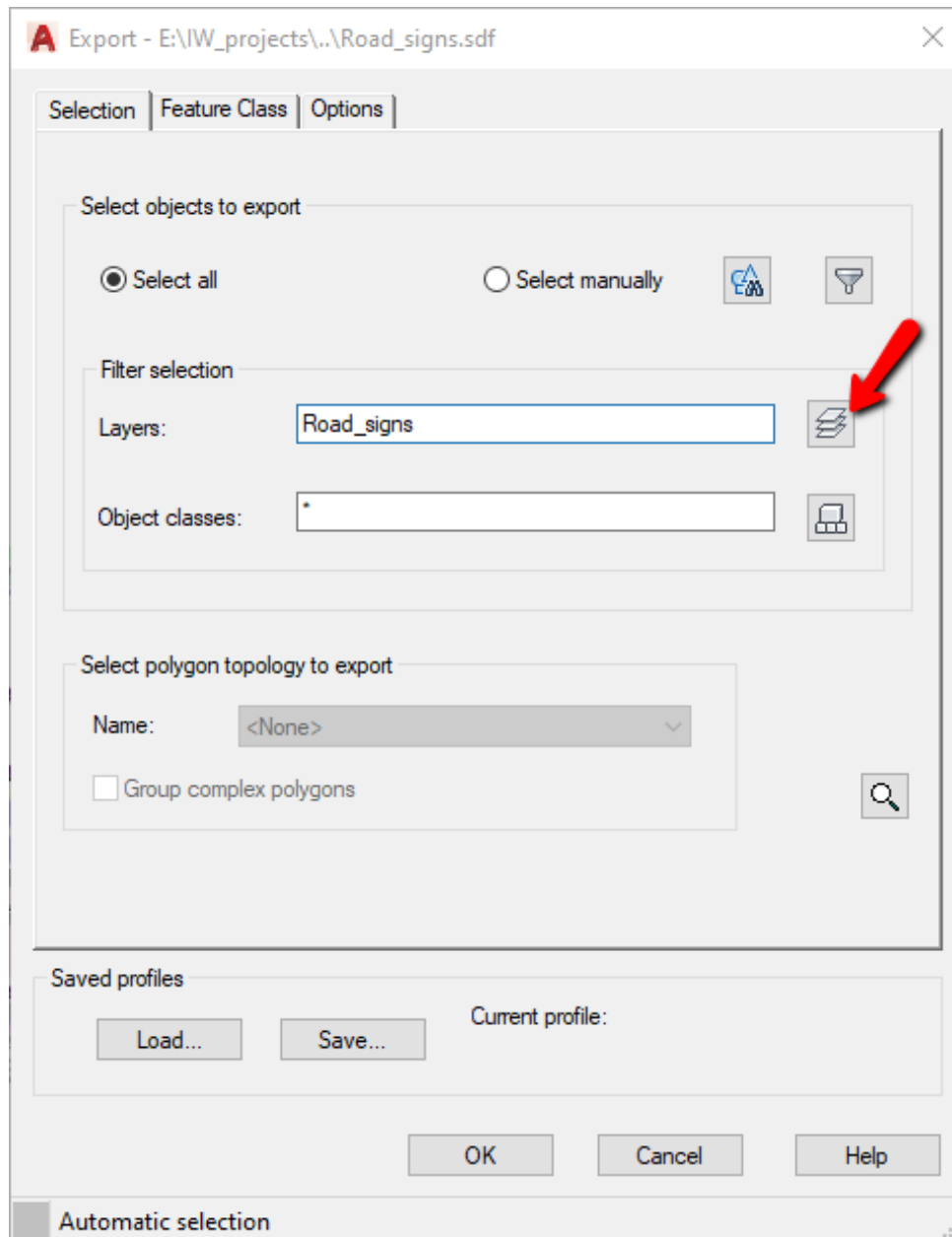
Export data to GIS format

Next, we export this data to the GIS format using the MAPEXPORT command. I prefer SDF format.



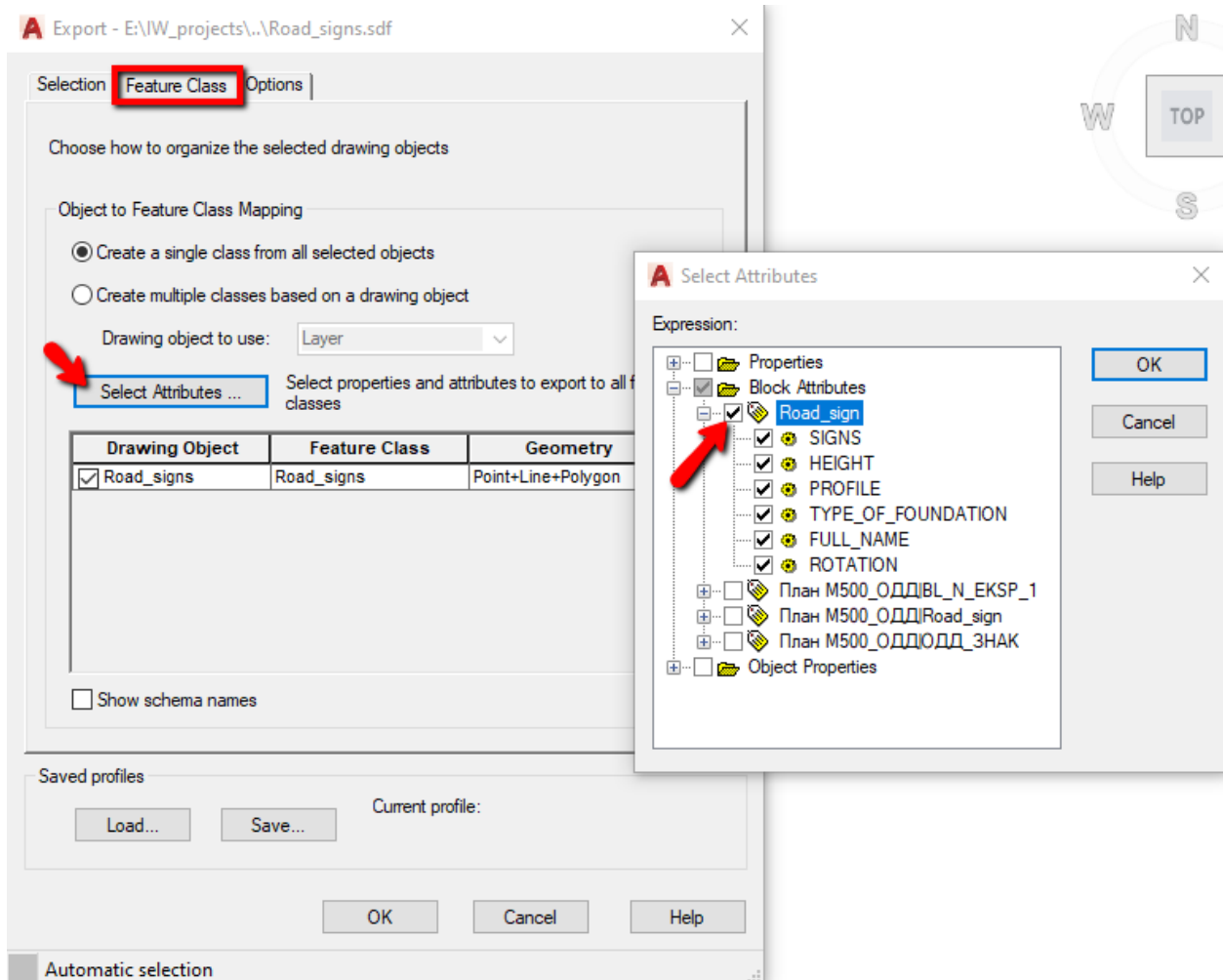
Export to SDF format

All blocks are on the «Road signs» layer. So we are choosing the filter selection by the layer:



Export to SDF format

In tab **Feature Class** open **Select Attributes** and select the attributes of the **Road_Sign** block:



Export to SDF format

Click OK.

Export of traffic management data completed.

Import and setting of traffic management data in InfraWorks

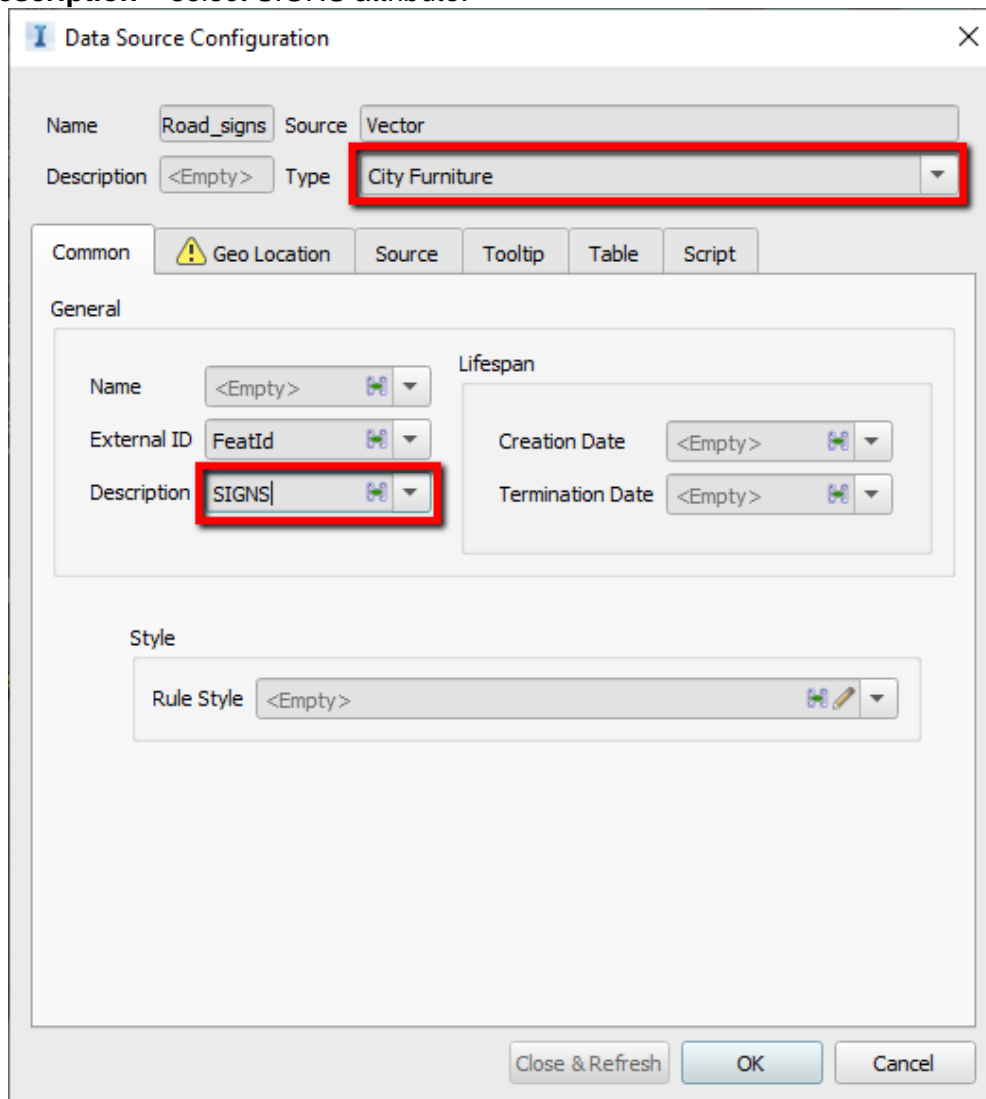
In InfraWorks, you must complete the preparation steps:

1. Import the SDF file
2. Create styles for all elements.
3. Create style rules.

Import of SDF

First, we import the traffic management data from the plan as an SDF file. We set **Common** tab in the **Data Sources** palette:

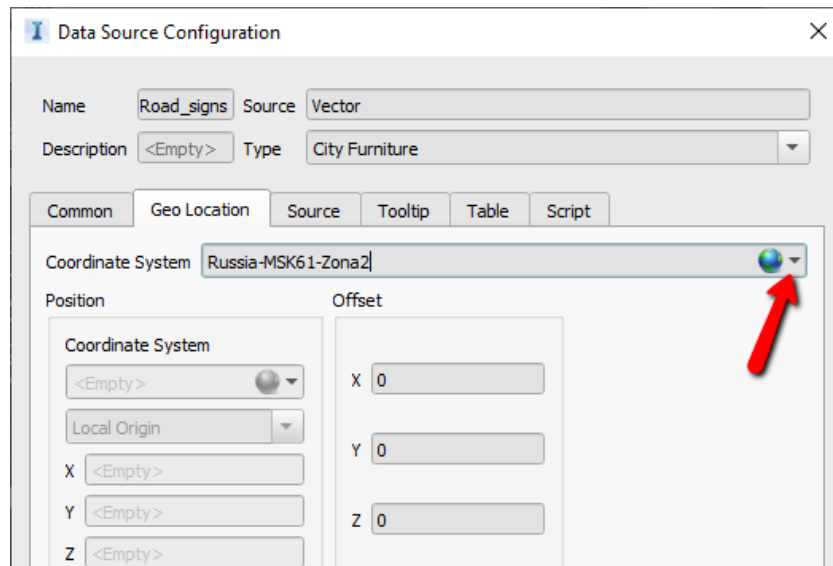
- **Type** – City Furniture;
- **Description** – select SIGNS attribute.



The image shows the 'Data Source Configuration' dialog box for a data source named 'Road_signs'. The 'Source' is set to 'Vector'. The 'Type' is set to 'City Furniture', which is highlighted with a red rectangle. Below the tabs, the 'General' section is active. In the 'General' section, the 'Description' is set to 'SIGNS', which is also highlighted with a red rectangle. The 'Lifespan' section contains 'Creation Date' and 'Termination Date' fields, both set to '<Empty>'. The 'Style' section contains a 'Rule Style' field set to '<Empty>'. At the bottom, there are buttons for 'Close & Refresh', 'OK', and 'Cancel'.

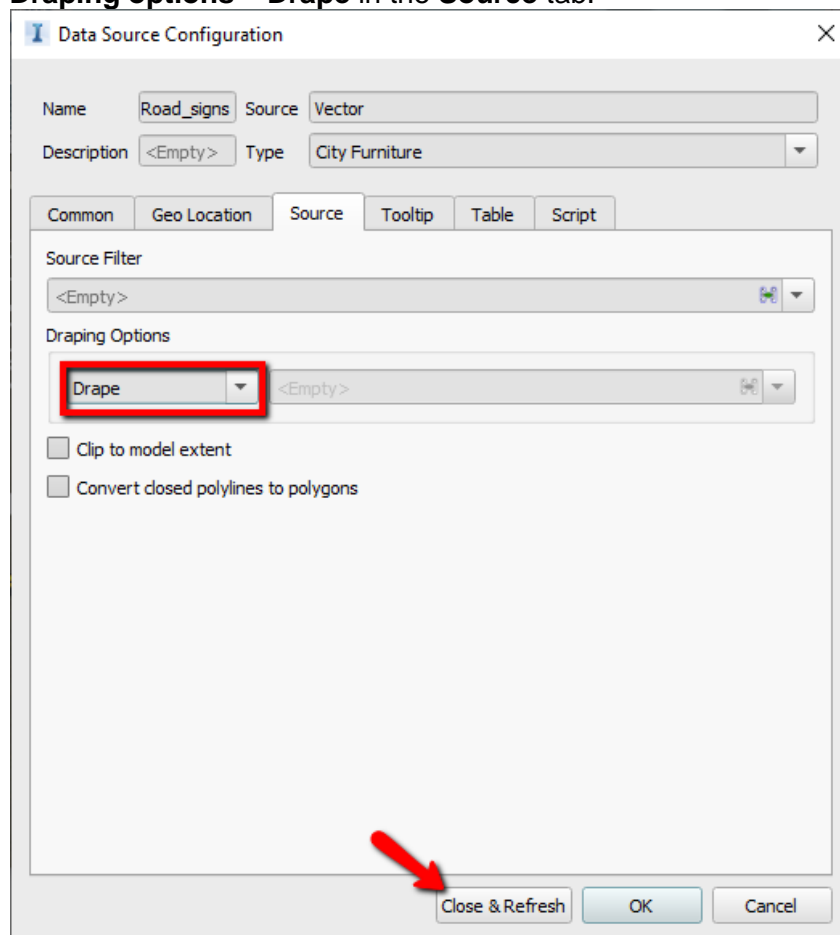
Import of SDF file – road signs

In the **Geo Location** tab select coordinate system of project in the **Geo Location** tab:



Import SDF file – road signs

Then select for **Draping options – Drape** in the **Source** tab.



Import SDF file – road signs

Then click **Close & Refresh**.

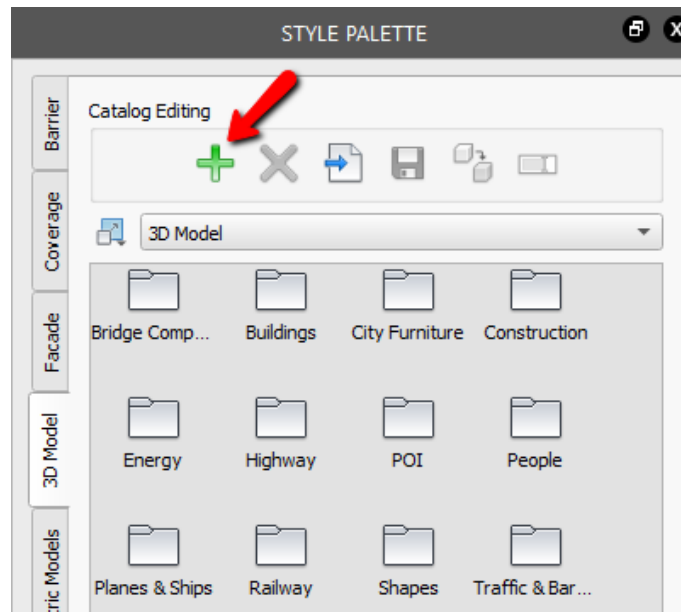
After that, the road signs are imported, but in the form of a InfraWorks cube.



Model after import of SDF file. Road signs as standard models of InfraWorks

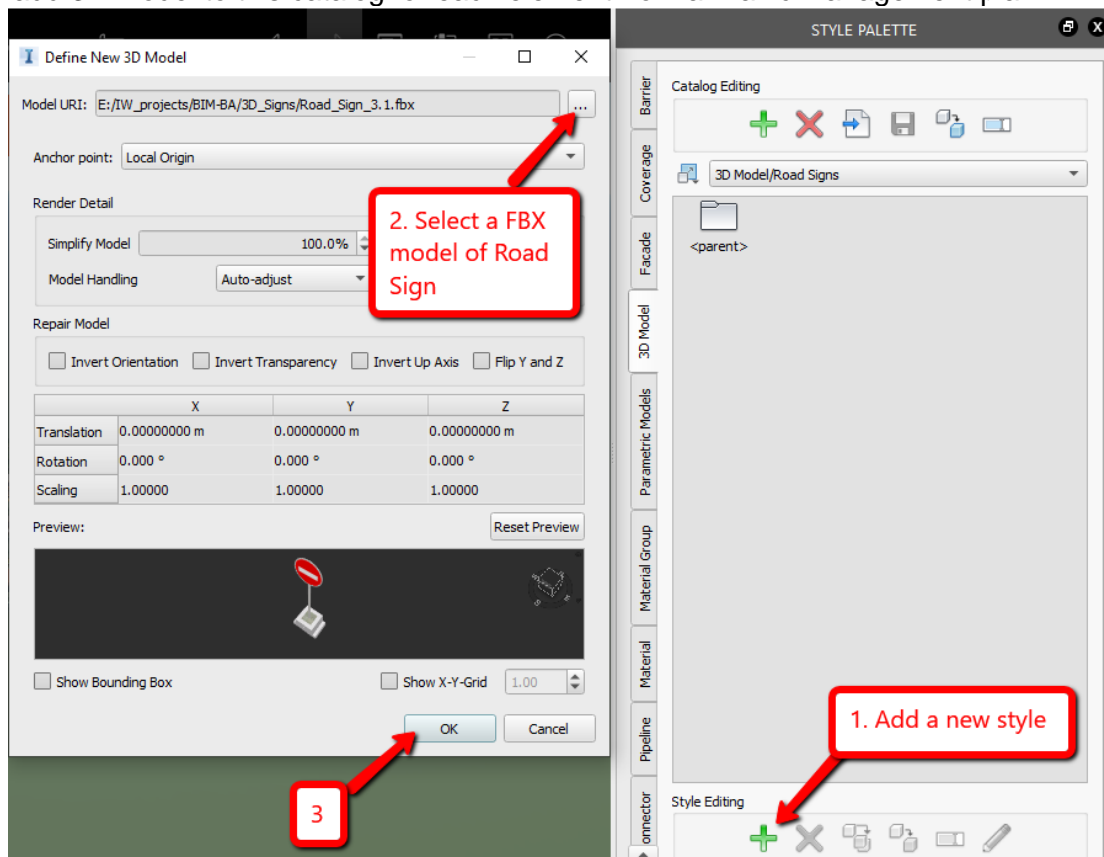
Creation of styles for all elements

Then you need to add 3D models corresponding to all blocks from the traffic management plan in the Style Palette. We recommend creating a new style catalog for these models:



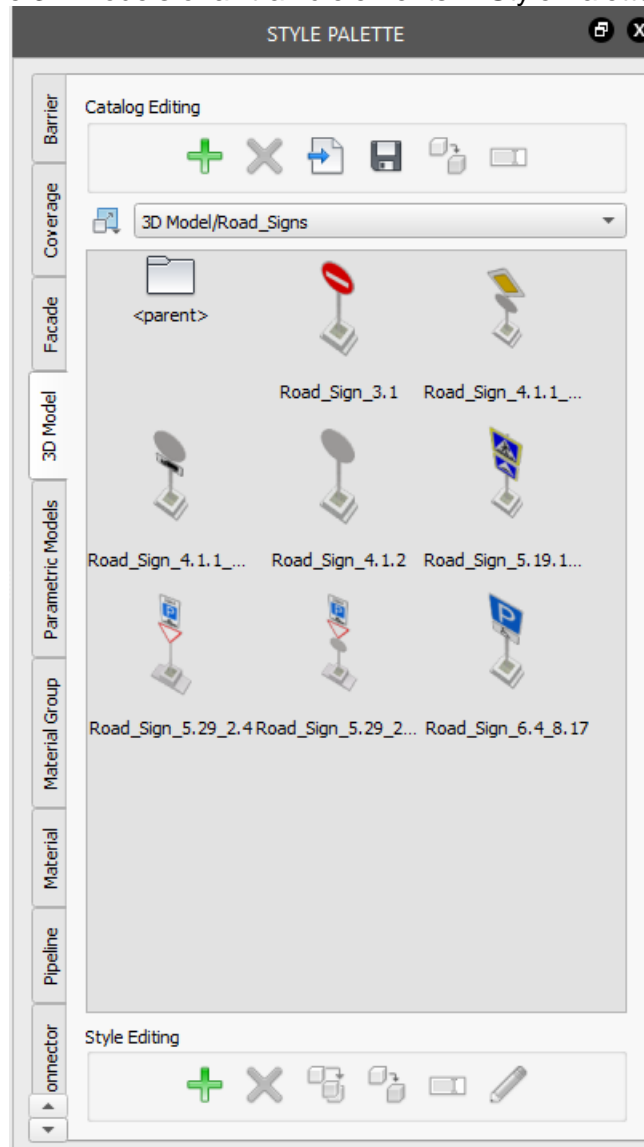
Add a new style catalog

Then add 3D model to this catalog for each element from a Traffic Management plan:



Add a new style

As a result, we have the 3D models of all traffic elements in Style Palette:

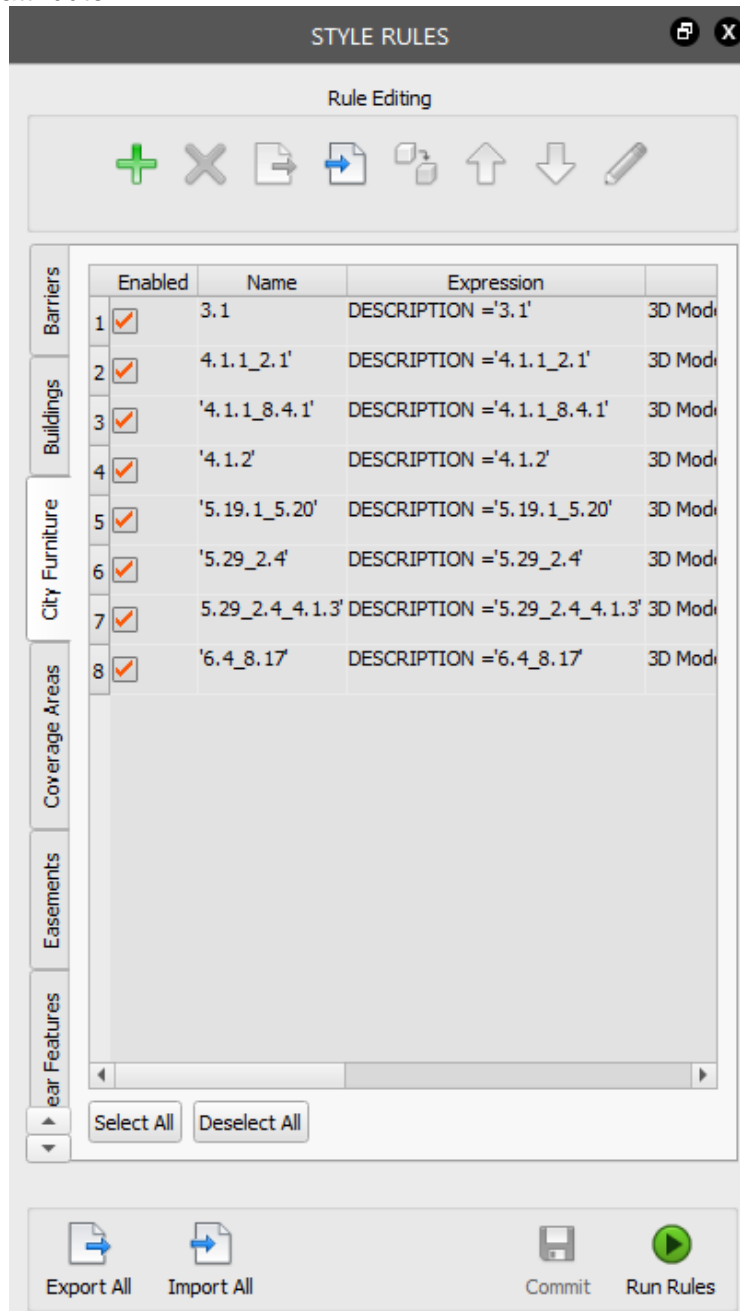


Style Palette

It is very important to develop a system for naming objects and styles at this stage. Each item must be assigned a unique name. This will make it possible to unify the work and apply the acquired library of objects in other projects. The result of this work is a folder in the style palette with all used elements of traffic management. It will be necessary to add only styles for individual objects with such library of styles in new projects.

Creation of style rules

Next, in accordance with the attributes, we will set the appropriate styles for each block. To do this, for each new style from the InfraWorks library, you will need to create an appropriate style rule. A style rule assigns a 3D model style to a block from the traffic management plan with the corresponding attribute.



[Create style rules](#)

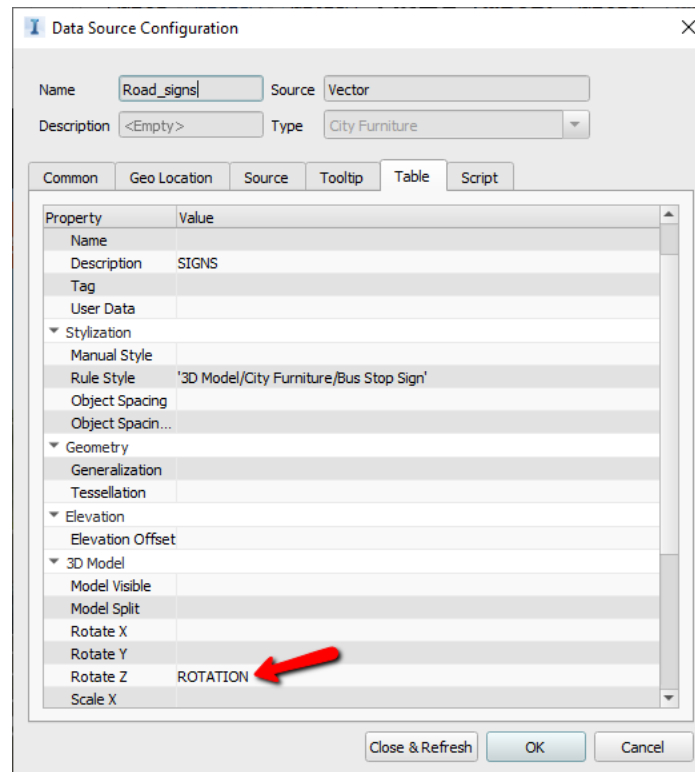
After applying the style rules, all the points turn into 3D models corresponding to their attributes:



Model after applying style rules

Then the last step is to adjust the angles of rotation of traffic signs. Open the **Data Sources** panel and set the attribute – **ROTATION** on the **Table** tab for **Rotation Z** parameter.

After that, we have 3D elements corresponding to the blocks from the Traffic Management plan. This is a dynamic system, which is very convenient to make changes.



Setting the Rotation



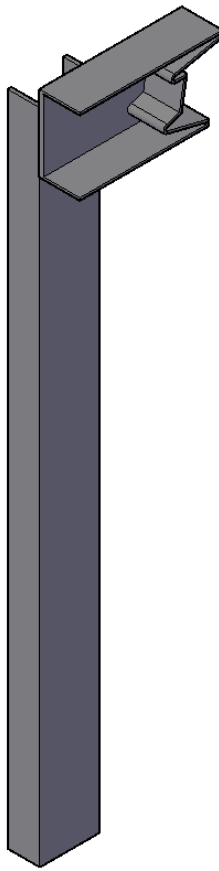
Model after applying the style rules and setting the rotation angle

Creation of 3D guardrail in Civil 3D

Sometimes in large infrastructure projects, we need to create BIM-model of guardrail many kilometers long. To automate this process, we have developed these workflows.

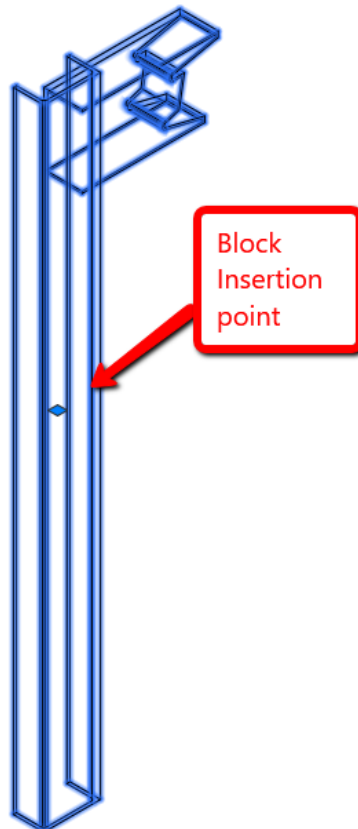
Creation of guardrail post as AutoCAD 3D block

First, create a post 3D model and transform it into AutoCAD block.



Guardrail post as AutoCAD 3D block

The insertion point of the block should be in the center of the post at the level of insertion into the surface.



The insertion point of the post block

We have a quite detailed post model, but you can use a very simple form. If you have a guardrail model in Revit or Inventor, you can export it to DWG format and create block in Civil 3D. Define material for the post model to make it more realistic (MAT command). We want to create a BIM model of guardrail. Therefore, add the necessary information to the post block using block attributes or Property Data set.

Placing of post blocks along polyline

Then we need a polyline of the guardrail path on the plan.

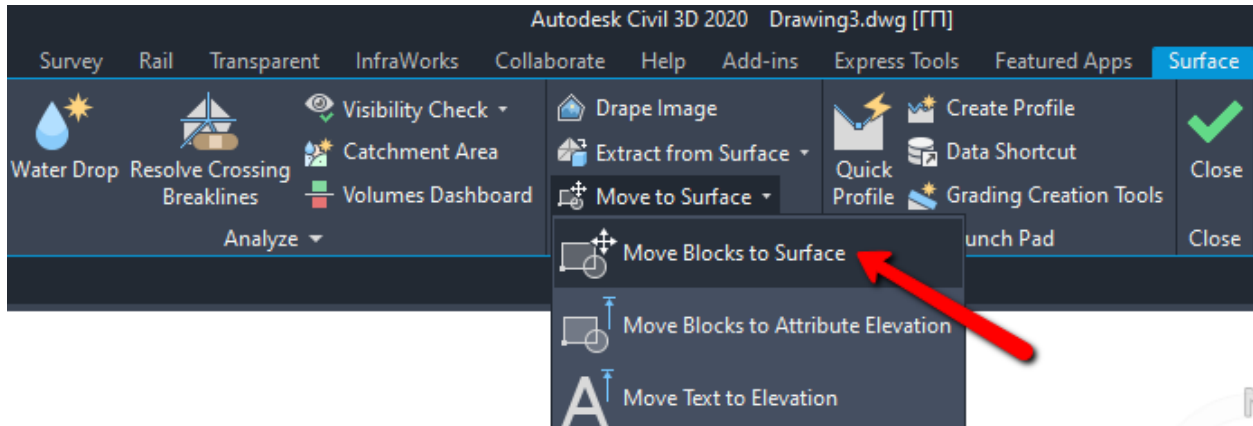
Use MEASURE for placing post blocks along polyline.

Enter **MEASURE** command on the Command Line. Then:

- **Select object to measure** – select polyline of the rail guard;
- **Specify length of segment or [block]** – click “block” on the Command line;
- **Enter name of the block to insert** – enter name of the post block;
- **Align block with objects? [Yes No]** – click Yes.
- **Specify length of segment** – enter distance between posts.

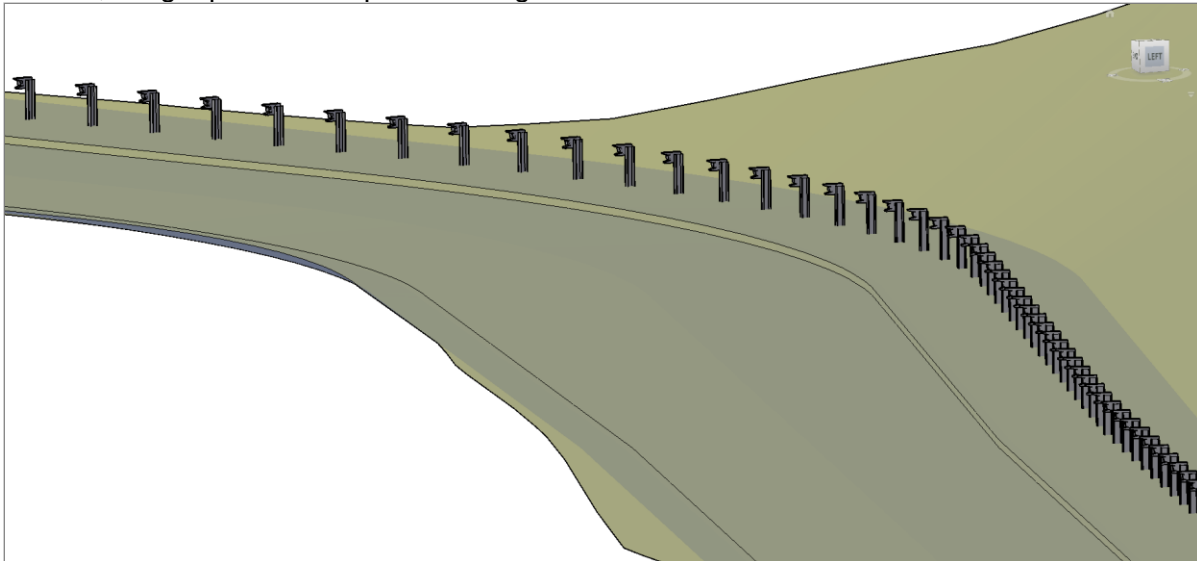
You can also use ARRAYPATH command instead of command MEASURE.

Then move block to surface to assign correct elevation.



Move blocks to Surface

After that, we get post blocks placed along the line on the surface.



Post blocks placed in a line on the surface

Creation of a rail between posts

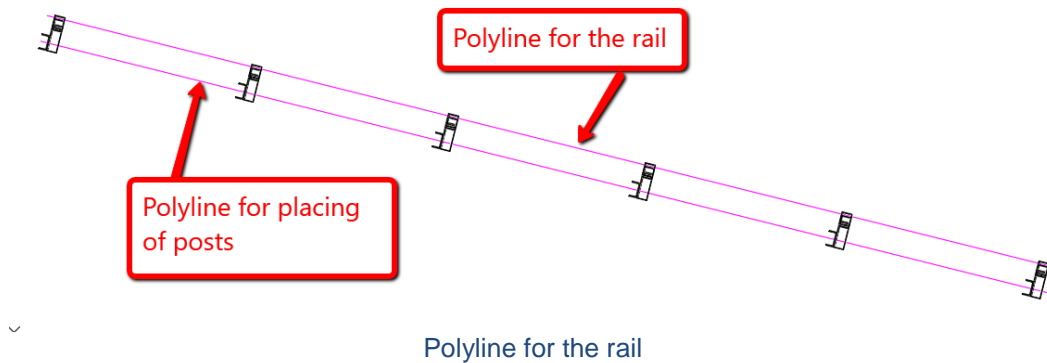
Next, we need to create a rail between posts.

For this, first, prepare a rail profile as closed polyline.

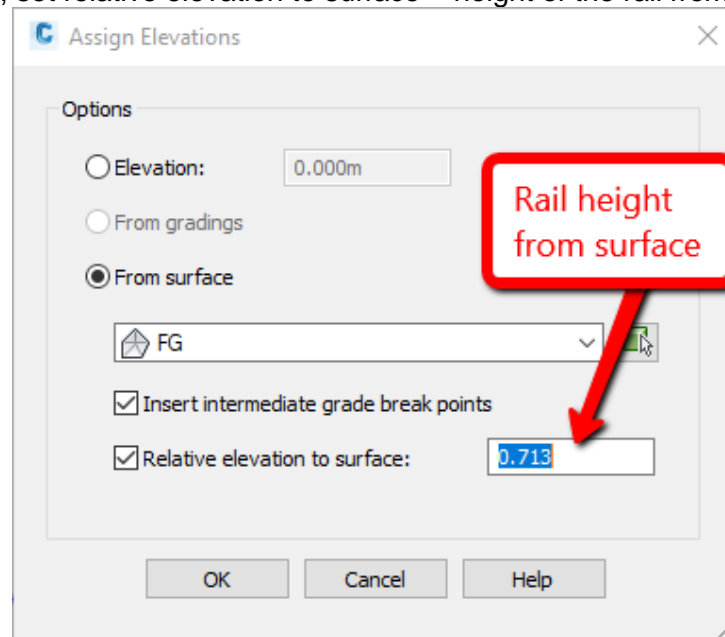


Profile of rail

Then we have to prepare 3D polyline. For that, offset polyline of the rail guard path.



Then, create feature line from this polyline, assign surface elevations to the feature line, add intermediate points, set relative elevation to surface – height of the rail from surface.

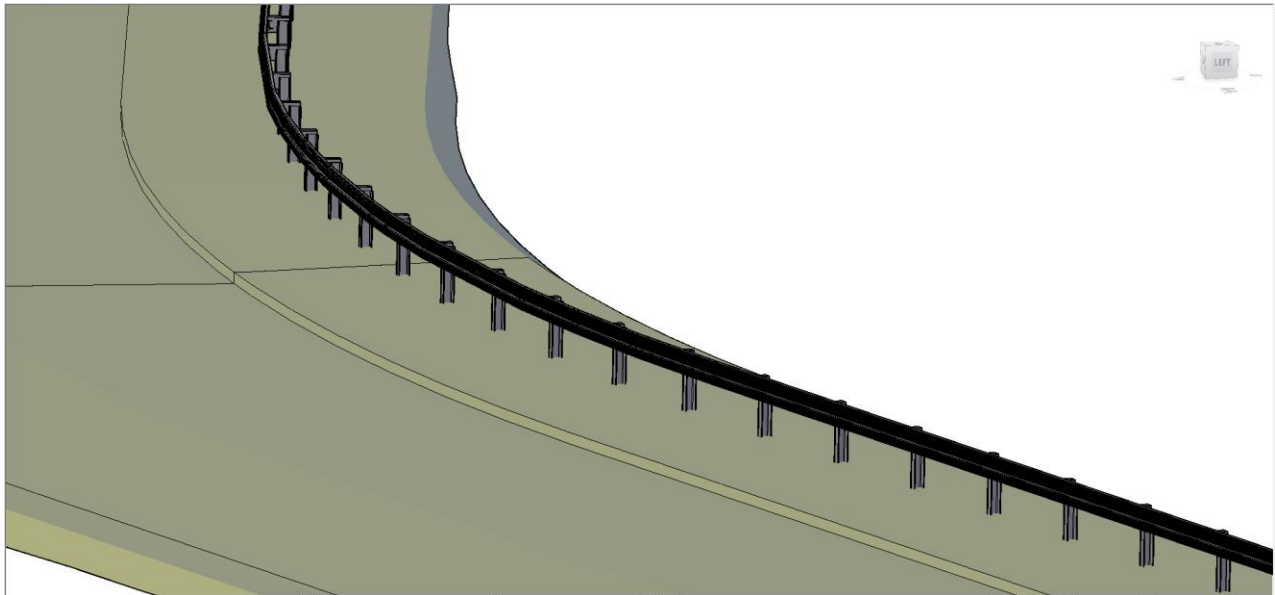


Creation of feature line for the rail

Then explode this feature line and we get 3D polyline for the rail. Enter **SWEEP** command on Command line. Then:

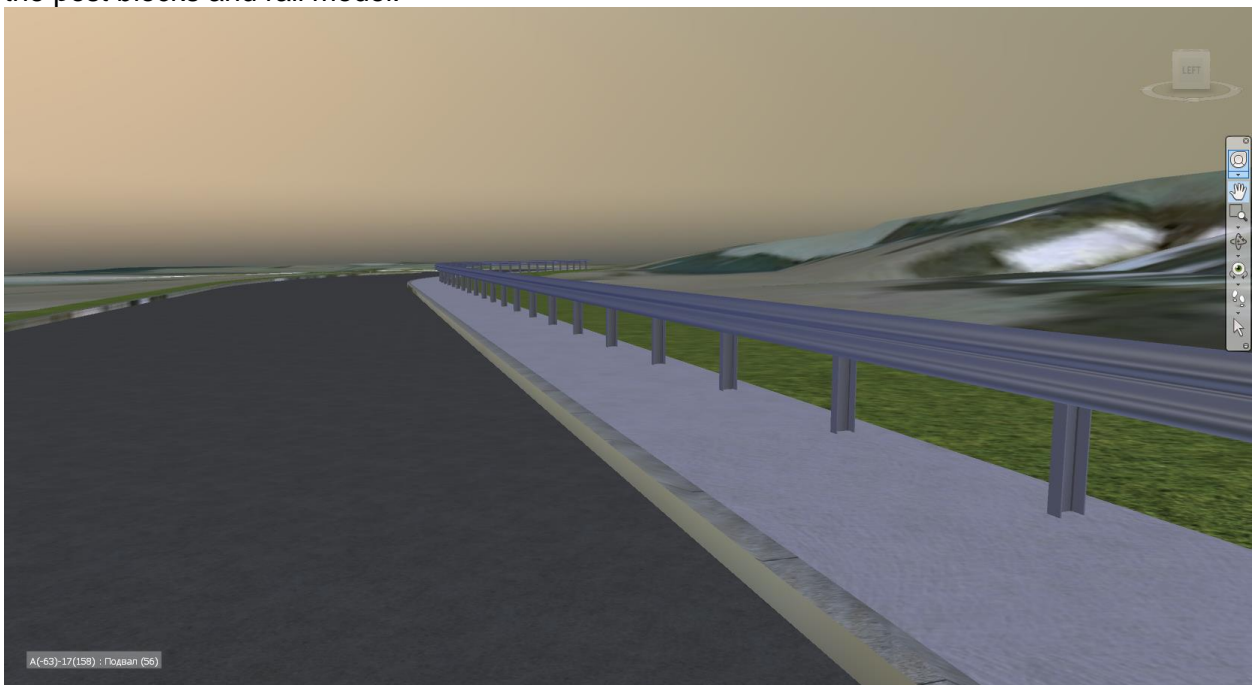
- Select objects to sweep or – select the profile of the rail;
- Select sweep path or – select 3D polyline of the rail.

As a result, we get a BIM model of a guardrail in Civil 3D.



Guardrail in Civil 3D

Add this DWG file to Navisworks. In Navisworks, you can see all the properties and attributes of the post blocks and rail model.



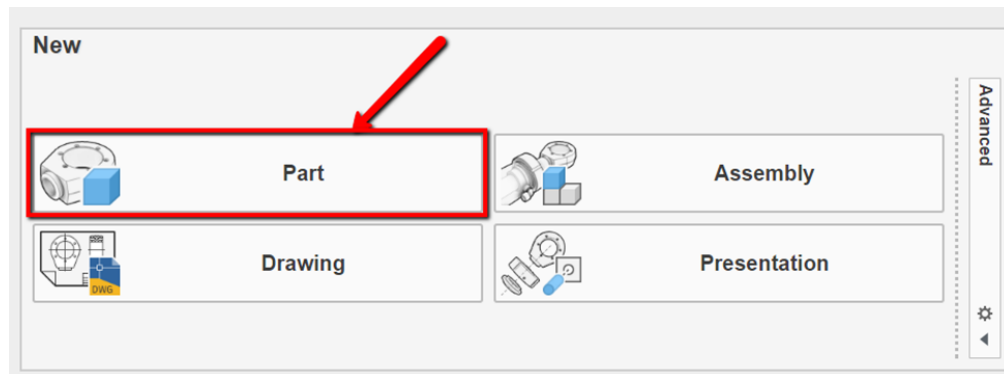
Guardrail in Navisworks

Creation of parametric barriers in Inventor and applying them to component roads in InfraWorks

InfraWorks has powerful conceptual design tools. The program features are impressive. But the standard library of parametric components is very limited. To create accurate road models, the standard library of components and design elements need to be improved. We will consider creating a parametric model for a component road in this chapter. For these purposes, we will use Autodesk Inventor. This combination allows you to get elements whose parameters can be changed in the InfraWorks model.

We will consider the creation of a parametric element - a Noise Barrier.

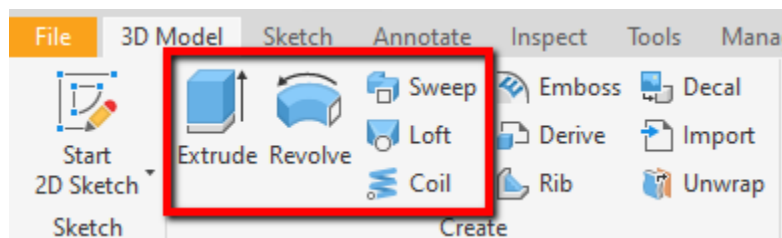
To create a Noise Barrier model in Autodesk Inventor, you have to use the "Part" template.



Using of Part template

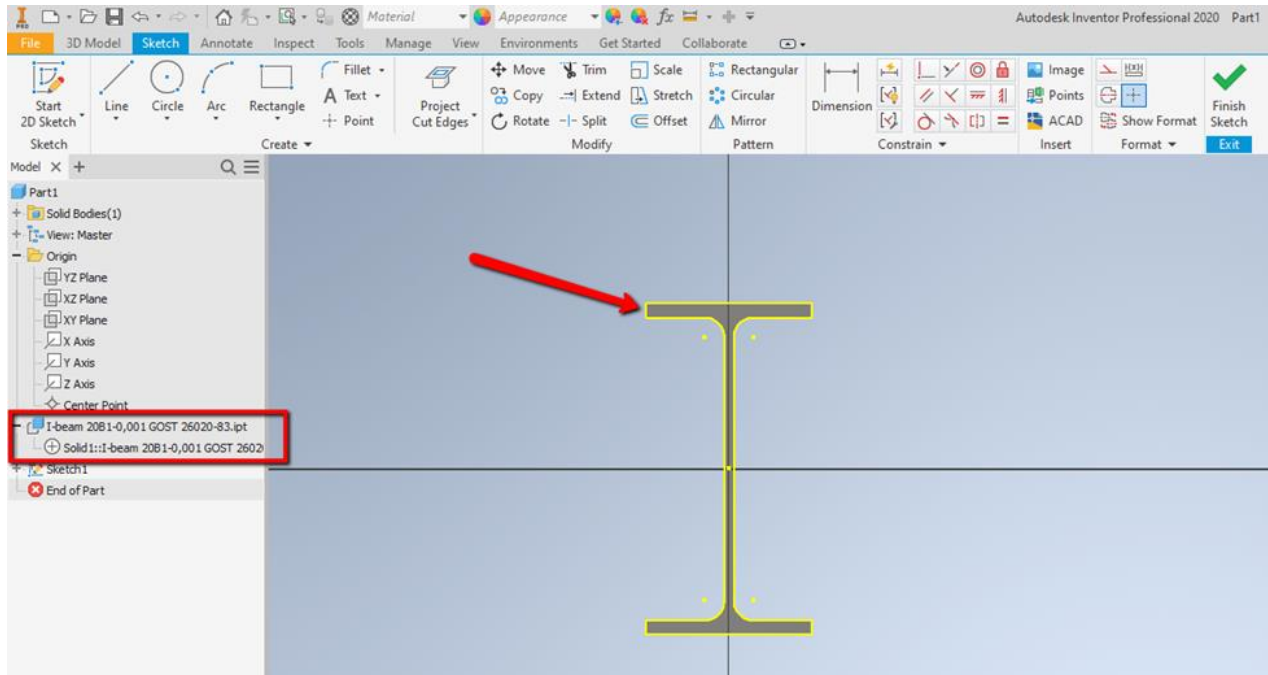
Next, we create a model consisting of elements in this template. In the case of a Noise Barrier, we need to create beam support columns, screen shields, a support plate, a pressure bracket, etc.

We create model details from a 2D sketch using modeling tools. You can use profile drawings in DWG format to create sketches.



Modeling tools

For example, here is an I-beam based on a standard item from the Autodesk Inventor library.



I-beam from Autodesk Inventor library

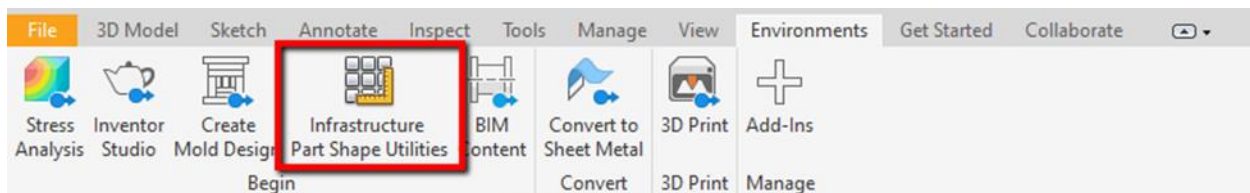
We create all elements based on a parametric sketch. Therefore, we can create dependencies between the parameters, and thus make the entire structure parametric for InfraWorks. To do this, name the parameters transferred to InfraWorks in English and tick the box for the key parameter.

d55	Work Plane3	mm	-35,200 mm	-35,200000		-35,200000	<input type="checkbox"/>	<input type="checkbox"/>
PanelLength	Extrusion6	mm	3000 mm	3000,000000		3000,000000	<input checked="" type="checkbox"/>	<input type="checkbox"/>
d66	Work Plane4	mm	20 mm	20,000000		20,000000	<input type="checkbox"/>	<input type="checkbox"/>
d93	Sketch16	mm	65 mm	65,000000		65,000000	<input type="checkbox"/>	<input type="checkbox"/>

Parameters transferred to InfraWorks

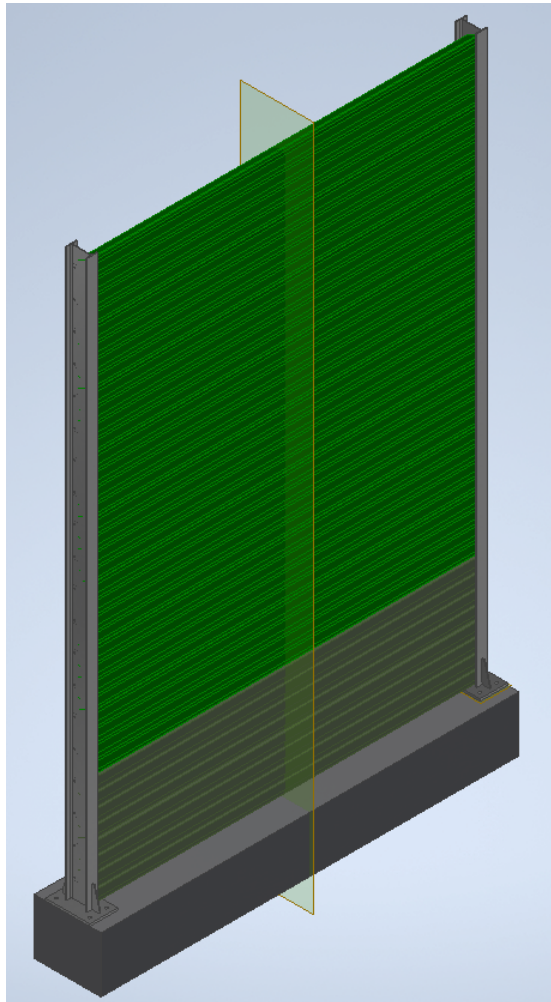
After creating the Noise Barrier model, you need to go to the Environments tab and use the Infrastructure Part Shape Utilities tool. This tool allows you to import not only geometry, but also parameters

Infrastructure Part Shape Utilities export the model to IPT format and create a sketch in *.jpg format, which we will import into InfraWorks.



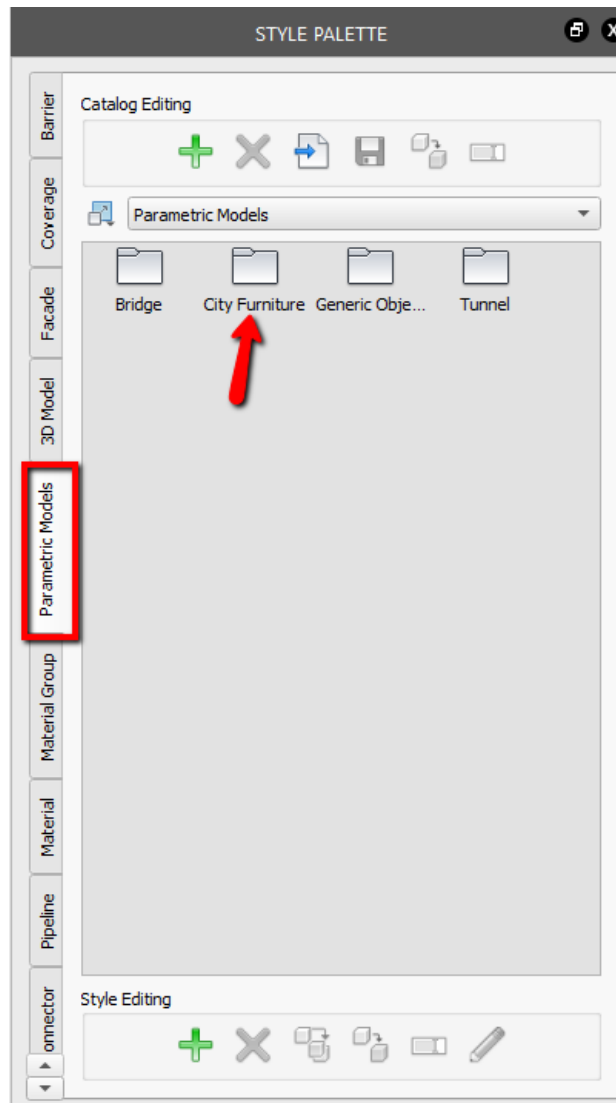
Infrastructure Part Shape Utilities

As a result, we obtain a parametric model of the Noise Barrier, which we can use in InfraWorks.



Noise Barrier model

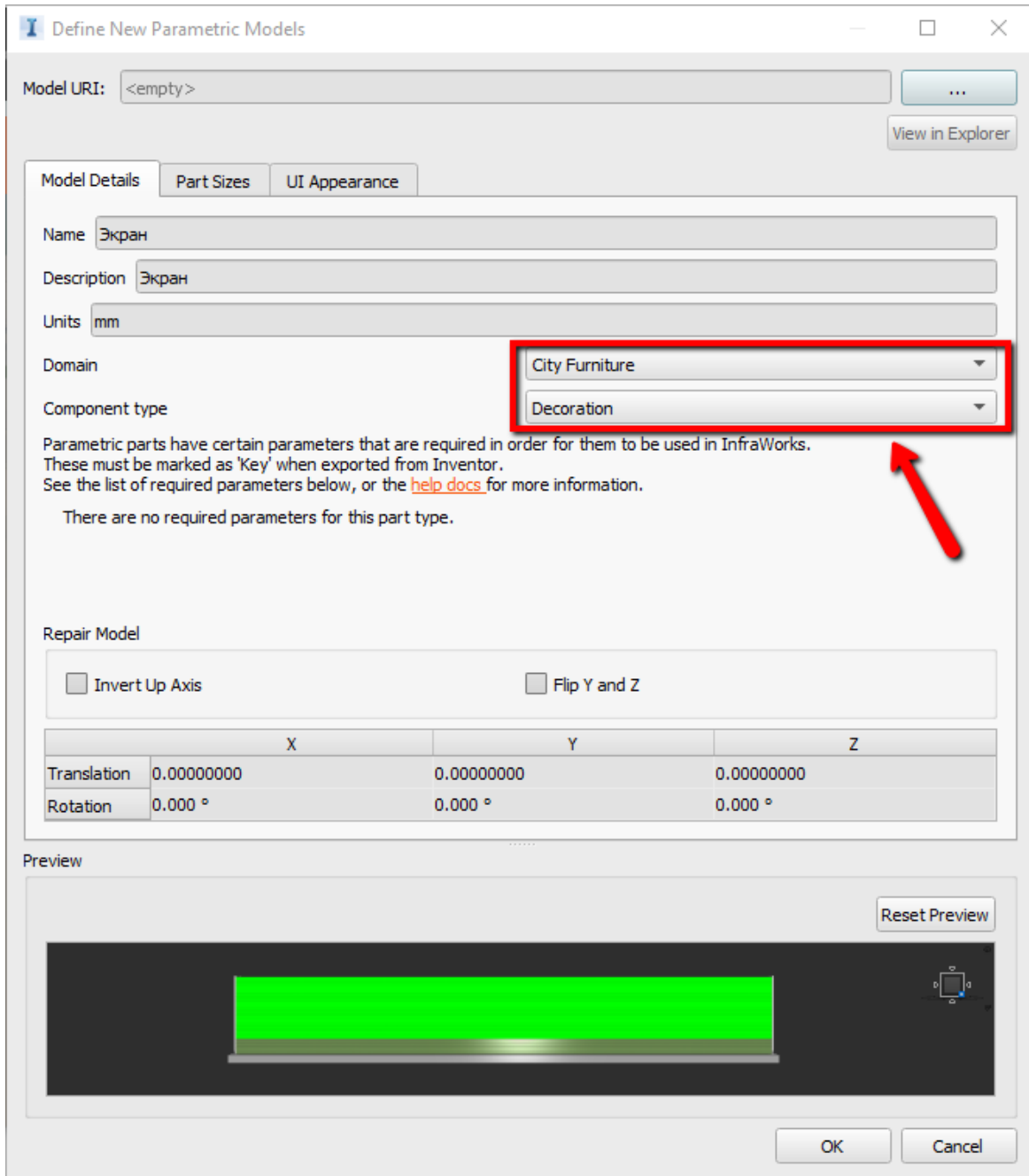
We import this parametric component through the style palette – **Parametric Models** tab – **City Furniture – Decorations folder** in InfraWorks;



Import of Parametric models

Set the **Model Details** as following:

- **Domain** - City Furniture
- **Component type** – Decoration:



Define New Parametric Models

Model URI:

View in Explorer

Model Details | Part Sizes | UI Appearance

Name:

Description:

Units:

Domain:

Component type:

Parametric parts have certain parameters that are required in order for them to be used in InfraWorks. These must be marked as 'Key' when exported from Inventor. See the list of required parameters below, or the [help docs](#) for more information.

There are no required parameters for this part type.

Repair Model

☐ Invert Up Axis ☐ Flip Y and Z

	X	Y	Z
Translation	0.00000000	0.00000000	0.00000000
Rotation	0.000 °	0.000 °	0.000 °

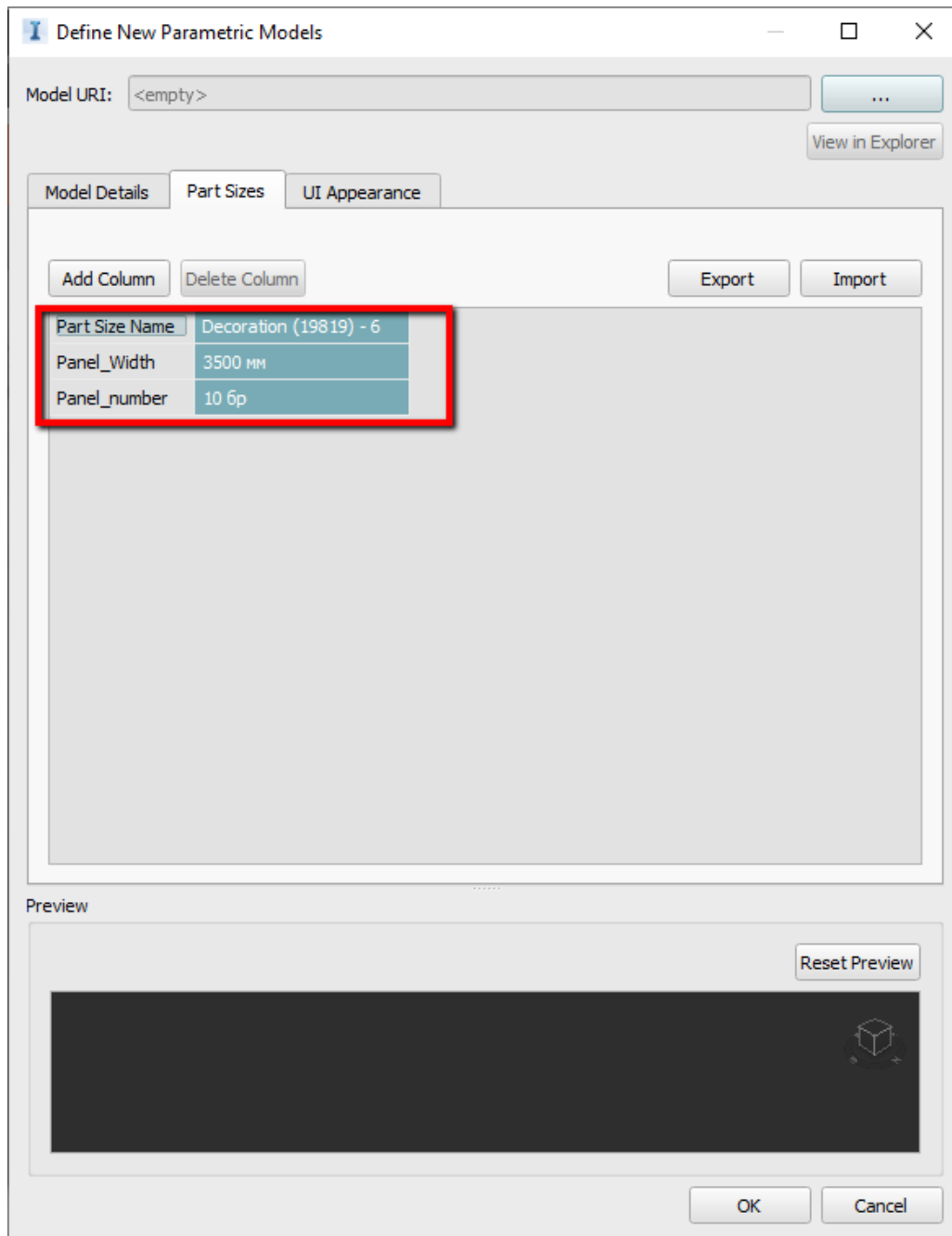
Preview

Reset Preview

OK Cancel

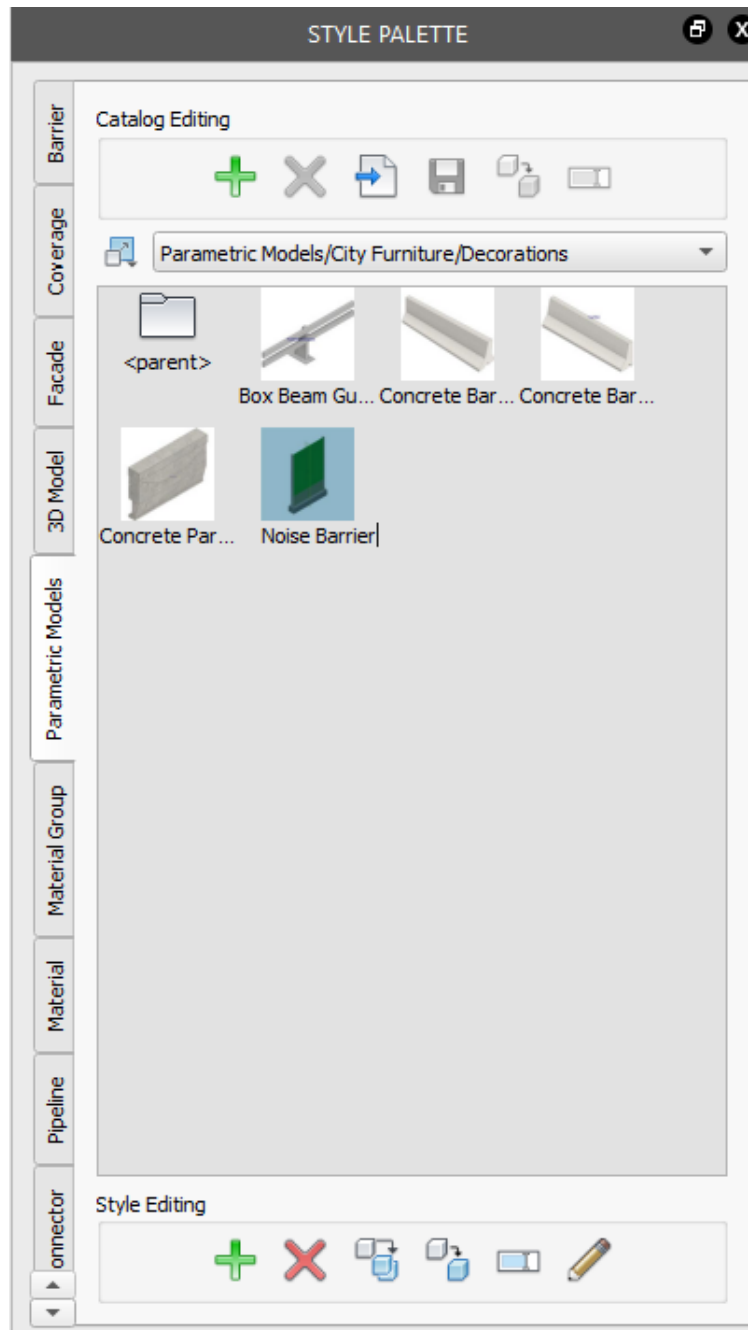
Import of Parametric models: Model details tab

We can see parametric properties from Inventor in the **Part sizes** tab. We can change these parametric properties in the InfraWorks model.



Import of Parametric models: Part sizes

Then you can use this parametric element from Inventor as a standard InfraWorks parametric element.



Parametric element from the Inventor in Style Palette

We create parametric Drain Rain Trays with Gratings, various fences, lighting poles, etc in the same way.