AUTODESK UNIVERSITY 2014

From Infraworks to Civil 3D for Rail Projects

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CV5765_P From Infraworks to Civil 3D for Rail Projects

Learning Objectives

At the end of this class, you will be able to:

- Learn how to use Infraworks software for conceptual design
- Learn how to export Infraworks software data to AutoCAD Civil 3D software
- Learn how to create Revit software content to use in Infraworks software
- Learn how to use this data to create an advanced model in Revit Software

About the Speakers

Since 1999 Fernando Oliveira has been involved in sales and consulting, and he has trained users in Autodesk, Inc., software for the architecture, engineering, and construction market and Building Information Modeling (BIM) technology. He is a Premium Support Specialist in Autodesk WWSS-GS-Premium support, working with enterprise priority customers worldwide. Fernando is Autodesk Presales Certified in AutoCAD Architecture 2008/2010 software, AutoCAD Revit Architecture Suite 2008/2014 software, Revit Structure 2008/2014 software, and AutoCAD Revit MEP Suite 2009/2014 software. Fernando is also a Revit 2013 Certified Professional. In addition, he is moderator of the www.revitpt.com Portuguese language forum, international moderator in Autodesk User Group International (AUGI) at www.AUGI.com, and editor of http://Revit-pt.blogspot.com/.
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Lucy's experience has spanned many engineering realms from helicopters to mountainous highway interchanges to oil rigs. She began as a mechanical engineer, designing and testing helicopters for Hughes, off-road vehicles for Honda, and bi-modal rail equipment for a small start-up. After an off-road vehicle testing accident in the California desert she had some recovery time to study civil engineering. Later moving to New Mexico she joined a civil engineering firm and lead the company through the early and often painful process of implementing cutting-edge technologies – high accuracy GPS, scanning, 3D infrastructure modeling, and machine control. She states "We worked smarter with fewer people, and spent a fortune on new technology, and we competed with the big guys – and won!" It was a natural progression for her to move into software applications engineering and support after many years in industry. She now works with the Autodesk team of Product Support Specialists helping to provide solutions to Autodesk's global enterprise customers. Her focus is primarily on the products in the Infrastructure Design Suites. Her engineering degree is from the Ohio State University.

Nate is a Premium Support Spatial for Autodesk. His focus is the geospatial products, and his background is in GIS and remote sensing, with government, NGO, and software support/QA experience. From aerial photography in Borneo and Congo to GIS analysis and more, he's well versed in all aspects

of GIS. His educational background includes a B.A. in Geography and a master's degree in GIS. Formerly based out of the Manchester, NH office, he now works in Neuchâtel, Switzerland.

Infraworks for conceptual design

The first part of our project design will be done in Infraworks 360. As with any project the first phase includes defining the basic requirements, and for our purposes the location and extent of surrounding areas that should be taken into consideration are especially important. We can use Infraworks to help determine how big an area to work with.

With the Modelbuilder functionality, we can quickly extract the current conditions for an area up to 150 sq km (58 sq mi), including terrain, roads, rail, aerial imagery and some buildings. After defining the boundaries, the data is extracted in the cloud, and is then available for download – from start to finish takes about 30 minutes. With this in hand, we can start to experiment with different scenarios and iterate quickly through options.
Use Modelbuilder to define the area of interest

- Select area and a complete package of available data is downloadable shortly thereafter
- Quick no-GIS route for anyone to easily get contextual information for projects at any scale

Basic railroads as currently defined in Infraworks are limited. Since this rail project is light rail, we know that we can use AASHTO road standards as a very good proxy for light rail turn radius when placing the alignment. To compare multiple options, create a separate proposal for each.

- Visually determine a good route for the rail line, and place a *design* road accordingly.
- After placing the first point, you have the option to pick the design speed, which is used to determine curve radius.
- Using the Bridge design module, you can also insert and adjust bridges as part of the alignment for visual fidelity
- Use a new proposal for each option so that you can quickly switch to compare without extra intersections or unrealistic segment overlap. Each new proposal will contain everything in the proposal you have open when you create it – go back to the master for a clean start, or use a simple option to start from and create different versions. Edits will only apply to the active proposal.



TIP – Style the road to look like a simple railway to better visualize proposals

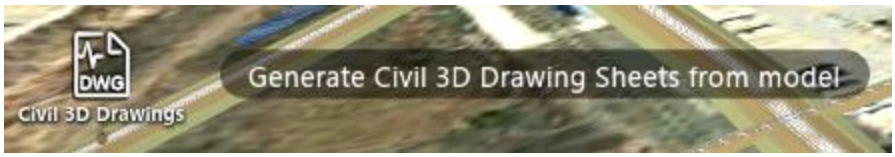
Now you have some good candidate designs.

- Work with stakeholders to determine which design will work best
- Use the Vertical Optimization tool to get an idea of cut and fill requirements and set maximum grade and thus cost

- Bring in other relevant data, such as areas to avoid (parks, schools, historic sites) to avoid surprises in the engineering phase.
- Use the profile view to confirm that all automatic designs were rational

Deliver to Engineers and Architects

- Under the Design Roads Analyze menu, you have the Civil 3D Drawings option



- This creates both a DWG and an IMX (see below)
- Note carefully the sheet set options and the export coordinate format. In this case, we used State Plane as that is the standard for the Civil Engineers.

Building the Civil 3D model from InfraWorks Proposal

We have just received the proposed light rail design. It is delivered in three file types which we can leverage in AutoCAD Civil 3D to build a robust base map and proceed with some detailed engineering and analysis.

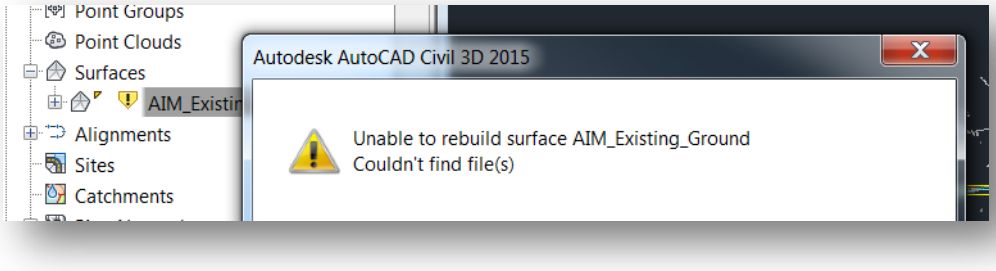
To prepare our infrastructure objects for extended value in BIM process, we will create accurate, 3D models of infrastructure objects, according to the appropriate level of detail, and begin to assign logical names to them.

The three file types received from InfraWorks preliminary design stage are DWG, IMX and SQLite, the brief descriptions are as follows:

DWG and IMX - (approx. size for 7km alignment 12MB .DWG file 24MB .IMX file) contains:

- Path of our design as horizontal (alignment) and vertical (profile) geometry.
- Swath of terrain surface used in the proposal
- Coordinate system

Drawings exported from bounded regions in InfraWorks are accompanied with an IMX file that contains surface data. If the IMX file is not closely linked to the drawing file warnings will occur. To eliminate the errors in the surface properties definitions browse to the location of the IMX file – or if the IMX is not available make a snapshot of the surface.

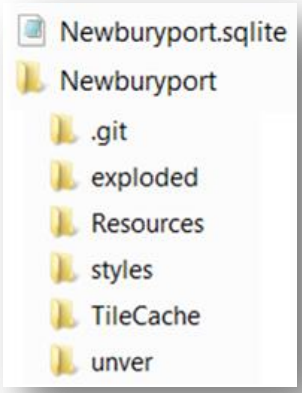


Using a drawing or the IMX from a bounded region in IW has several advantages, size is much smaller; horizontal and vertical optimization may have been done in IW; and rough drafts of sheets for plan and profile have been created.



TIP – To avoid having to re-style everything in the drawing you receive from InfraWorks, use the IMX file and import it into your preferred Civil 3D template.

SQLite - contains the relational pointer file and the accompanying data folders. These file sets can be very large - approx. size for 7km alignment project area can be greater than 200MB. The data includes not only the surface and user added design information but all of the accessory information from model builder and all other data sources. The SQLite file for this project includes:



- Surface
- Design Roads
- Existing Road and railway centerlines and names
- Building footprints

The tasks that need to be performed in Civil 3D are engineering design and analysis based. These tasks range from simple to complex and often require the input of additional data and the collaboration with experts.

Our demonstration will include the following examples of simple and complex tasks that are done in the Civil 3D application.

Simple tasks we will demonstrate and that can be achieved directly from the preliminary design from InfraWorks include:

- Preparation of work orders for detailed surveys,
- Assigning horizontal and vertical design criteria (rules), and rail cant
- Inserting the critical location and elevation points of the new station structures
- Adjusting the vertical design to match critical design points and delivering this information to experts

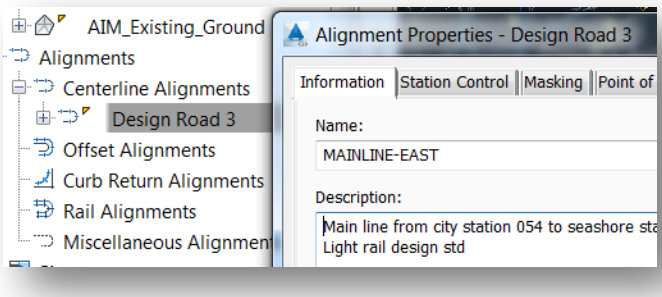
Complex tasks that we will demonstrate and that are done later in the design include:

- Refine the existing surface data with detailed topographic information
- Import of bridge deck and clash analysis with existing structures

Overview of Procedure:

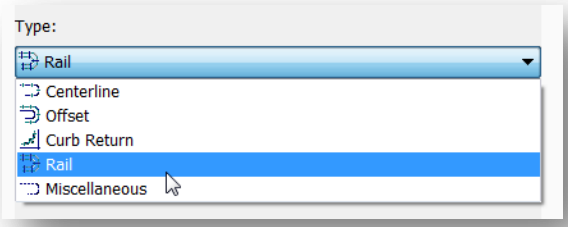
Import the IMX file into desired Civil 3D template created drawing. The coordinate system will be established based on the value in the IMX, if the coordinate system is different then the data will be transformed.

Verify the import of Civil 3D objects in the Prospector tab of the Toolspace.

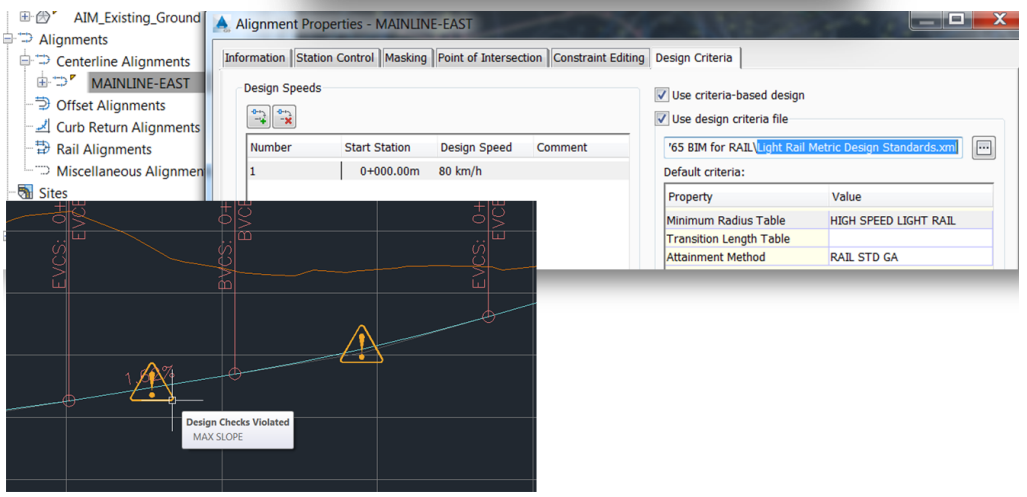


Assign logical names to the alignment, do not change the surface name as it is linked to the name value stored in the IMX file.

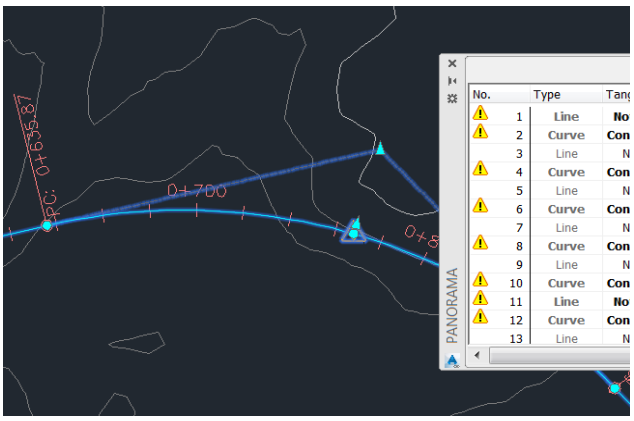
Change the type of alignment to Rail.

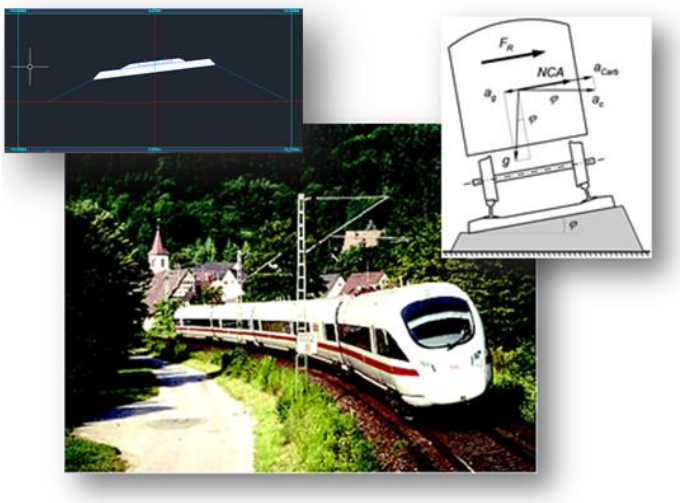


Assign the desired design criteria and design criteria file to both horizontal and vertical. Assigning design criteria assures that when adjustments are made to the horizontal and vertical path violations will be instantly reported and can be remedied instantly.



Make alignment geometry adjustments as needed. Geometry can be adjusted in both tabular form by manually entering in values, or in graphical mode by manipulating grips and glyphs.





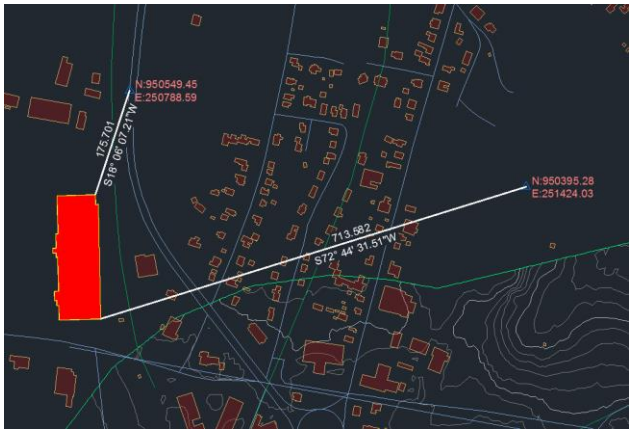
Apply proper rail cant.

The speed of high-speed trains is limited by curvature more than by grade. Most high-speed train sets are lightweight having a high power-to-weight ratio, enabling them to run on steeper grades.

Grades on high-speed light rail lines can be 5 percent or more which is typically much higher than those found on traditional railroads, where most grades are less than 2 percent.

Insert the detailed structure models or identify the critical location and elevation points where structures must meet the deign path. Lock cirtical design points in the profile design geometry.

Need to work with stakeholders responsible for the station design. Elevation and connection points need to be defined. Once determined theses points need to remain locked as other segments of the design are changed.



To identify the alignment “connection” locations. The exact location and height of the railhead alignment must be established. The stakeholder in charge of the station design has several ways to provide this crucial information. Often just a survey coordinate is given, a much better way to share this information is from the actual station model. The station design professionals should be asked to provide a .dwg. Remember a benchmark location and tie to the real world coordinates will be required if an assumed Cartesian coordinate system is used by the station designers.

Civil 3D projects are based on “real world” coordinate systems that are agency established, such as the State Planes Coordinate Zones used in the U.S. Often these coordinate systems are not used in the design of individual buildings and structures. This requires that “ties” are used to relate the local buildings with the large civil based coordinate systems, more than one tie is required to obtain rotational orientation.

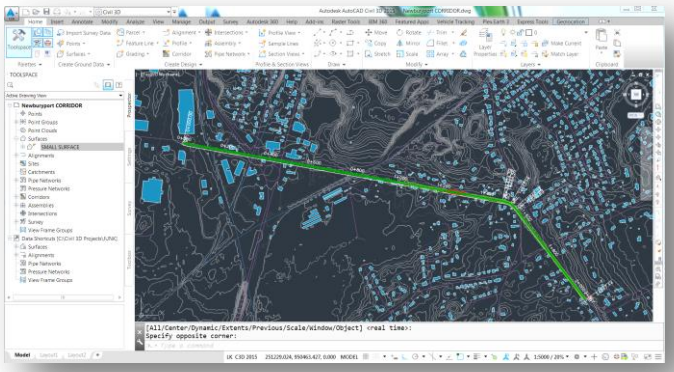
After critical connection locations have been determined adjust the vertical finished grade.

Export the finished grade design in XML format for use by the structural team. We will receive their final design later in the design process, however we can keep working without waiting.

Adjustments to the finished grade alignment and profile are made either graphically or in tabular form so that finalized location meets the station specifications and complies with the design criteria rules.

The finished grade alignment and profile is exported to the structural team to design the bridge deck and the supporting piers. Once this design is complete it is returned to Civil 3D.

Create a detailed base map of existing conditions. Using Map 3D FDO functionality attach the SQLite file exported from InfraWorks and any other pertinent data including flood plain zones and elevation limits. This GIS connection creates GIS data layers that can be stylized and toggled on and off as needed.



Add BING aerial for entire project and .DXF of underground structures in crucial areas. Add additional base map existing conditions. This includes information from a variety of disparate sources such as .shp files, .dxf files, and even underlays such as .pdf files

Prepare an example work order for detailed site and topographic survey. Again one of the advantages of using dynamic design objects is that work can proceed without delay and the fine-tuned adjustments can be added later with no need to start from scratch.

The analyses we find important at this stage in the project are:

Determine focused project area – alignment swath and station sites so that necessary detailed data can be gathered. Because our project is geo-referenced orders for detailed topographic surveys, geo-technical borings, and environmental studies are quick to define and prepare.

Prepare location specification for detailed data acquisition

- Add Bing Map, local coordinates, ties to control benchmarks
- Extract limits of survey shp fileset, dxf, and COGO point list

Now a Fast Forward to later in the design cycle:

Import the detailed surface topography that has been delivered as a result of the work order prepared earlier. Because the surface object is dynamic the refinement will be reflected throughout the model – such as in the profile view. Because we are working in software applications that support dynamic object modeling we can start detail design without waiting for these results. Principal design can proceed with details “swapped” in after they are delivered.

Updating model with detailed topographic survey.

- Balloon notification
- Instant update modeling data

Import the structural design and convert design elements to 3D solid objects.

Prepare cross section views.

Perform a clash detection between the bridge foundation piers and footings and any existing underground objects.

Final alignment is accepted and corridor is built. The corridor will represent two conditions – one where the alignment is above the grade and will be a bridge deck supported by columns and the second where the alignment is at grade and will connect to the surrounding terrain. Two different cross-sections will be used to represent these two conditions.

At this stage of the design the constraints for the detail bridge design are delivered to the bridge experts.

The design constraints will include horizontal and vertical critical points, and the required curve cant (superelevation).

Sharing the design at this stage of the design process with other stakeholders is dependent on the intent of the stakeholders needs. Some stakeholders will only require “flat” files and others will want robust 3D models. We can keep our model as a “single source of truth” and generate the deliverables as requested.

Planning agencies may only need basic CAD drawings of the project

Plans Production

- Importance of Object Enablers
- Importance of Export to ACAD

BIM and construction coordinators will want 3D models with extra attributes

3D model to NAVIS WORKS

- Importance of logical naming

Architectural and structural experts will most likely need all of the modeling and base map information

3D model to REVIT

ML, and eTransmit with added extra content

Non-technical stakeholders will benefit from simple animation

3D model to IW

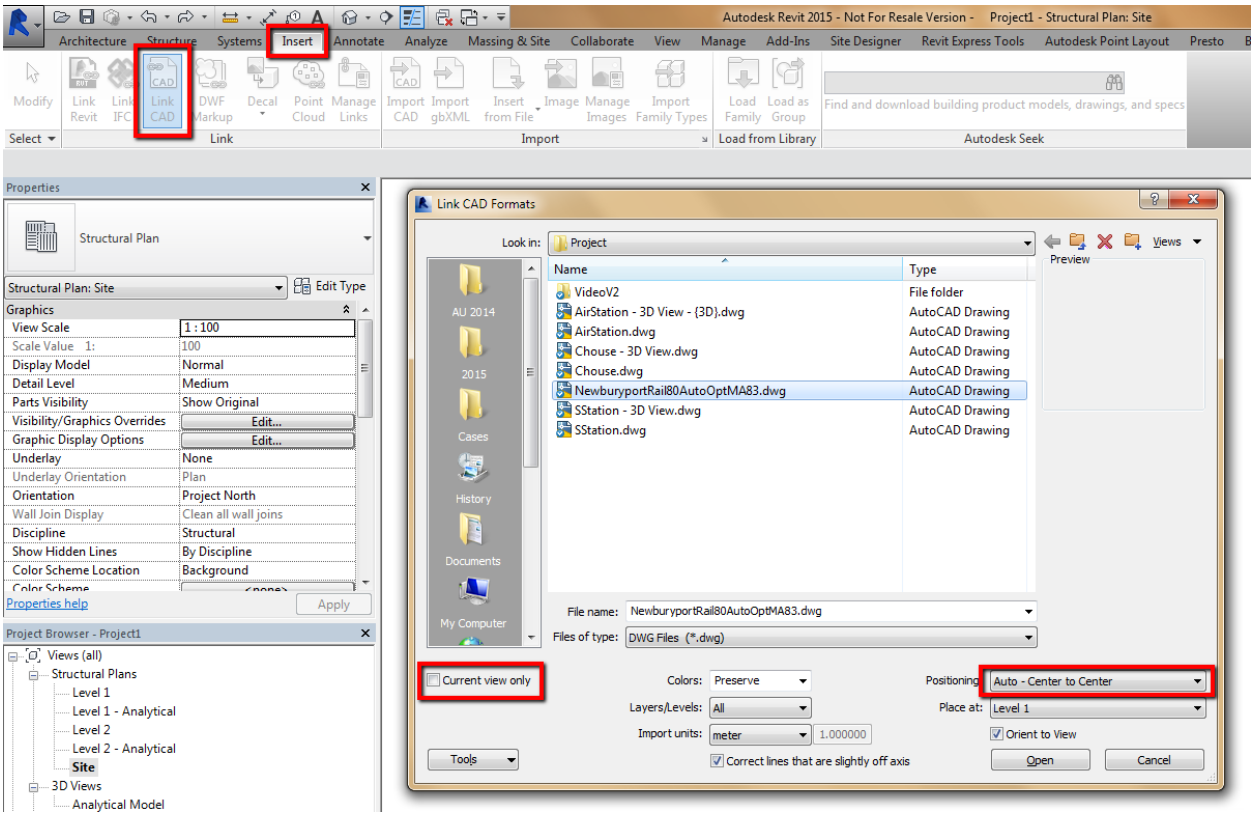
 TIP – Avoid the creation of .MMS files! Clearly define your export bounding box when exporting IMX from InfraWorks – don't get more than you need!

 TIP – The  in the upper left corner of the viewport indicates that the level of detail view is active. When the level of detail view is active, some editing options are not available as indicated by 

Revit Model, import data from InfraWorks to generate site model.

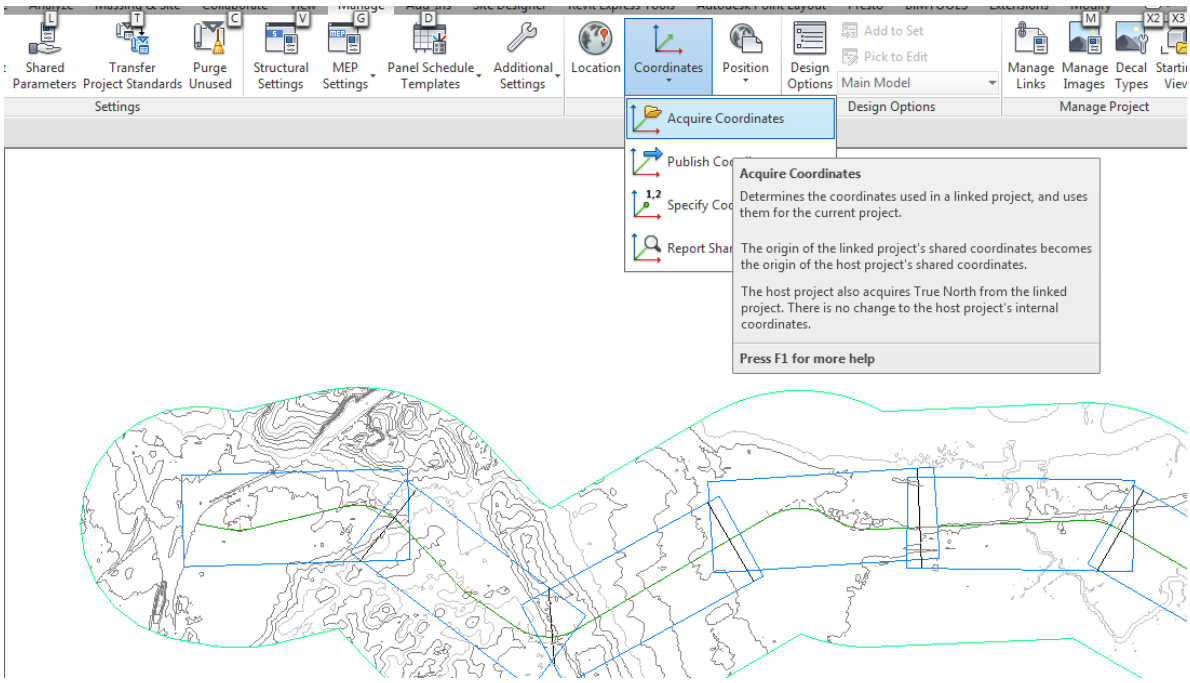
On the Revit starting point our first task is to create a file coordinated to Infraworks and Civil 3D that will serve as the main project file. For this we create a new file, using our preferred template. Once ready we link the DWG generated in Infraworks.

TIP- Check if the Proxiserver variable is set to 1, if not we won't see Civil objects in Revit as it doesn't use any object enabler.

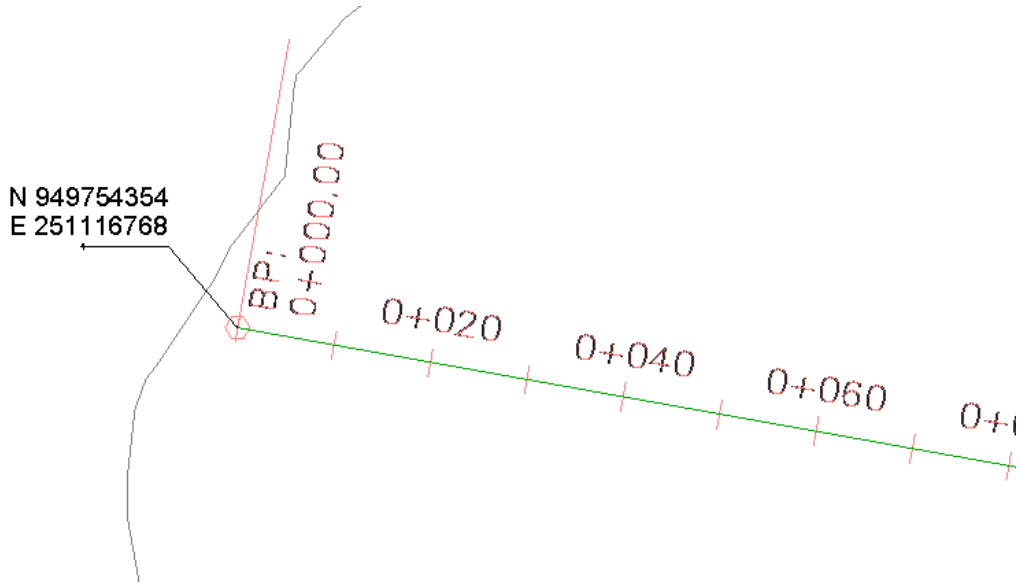


TIP- We link center to center to avoid the usual warnings about entities far away from our project center.

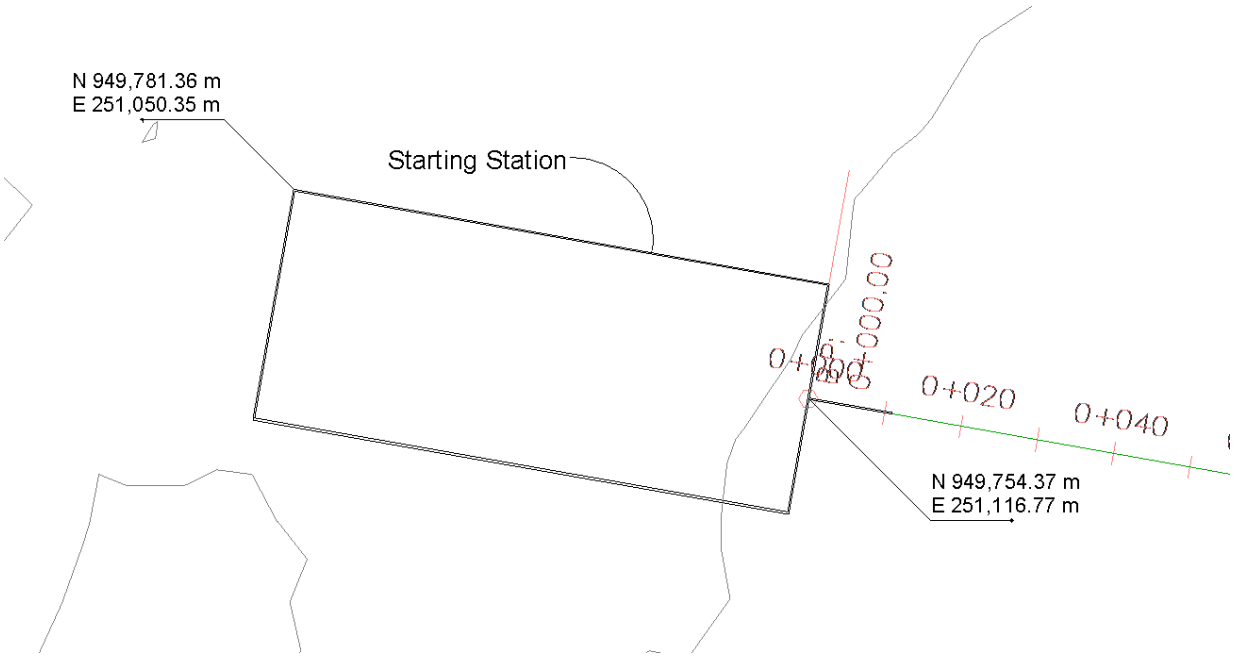
Next step is to acquire coordinates from the linked DWG.



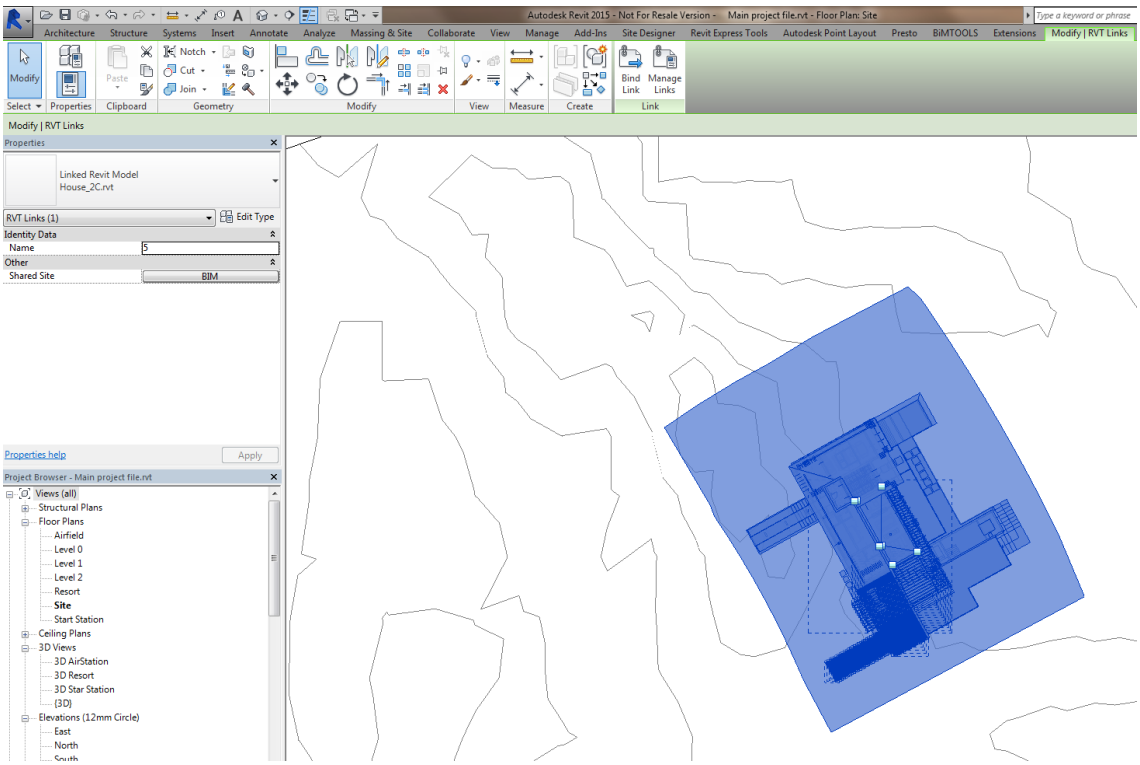
Now we have a main project file correctly coordinated to Civil 3D and Infraworks.



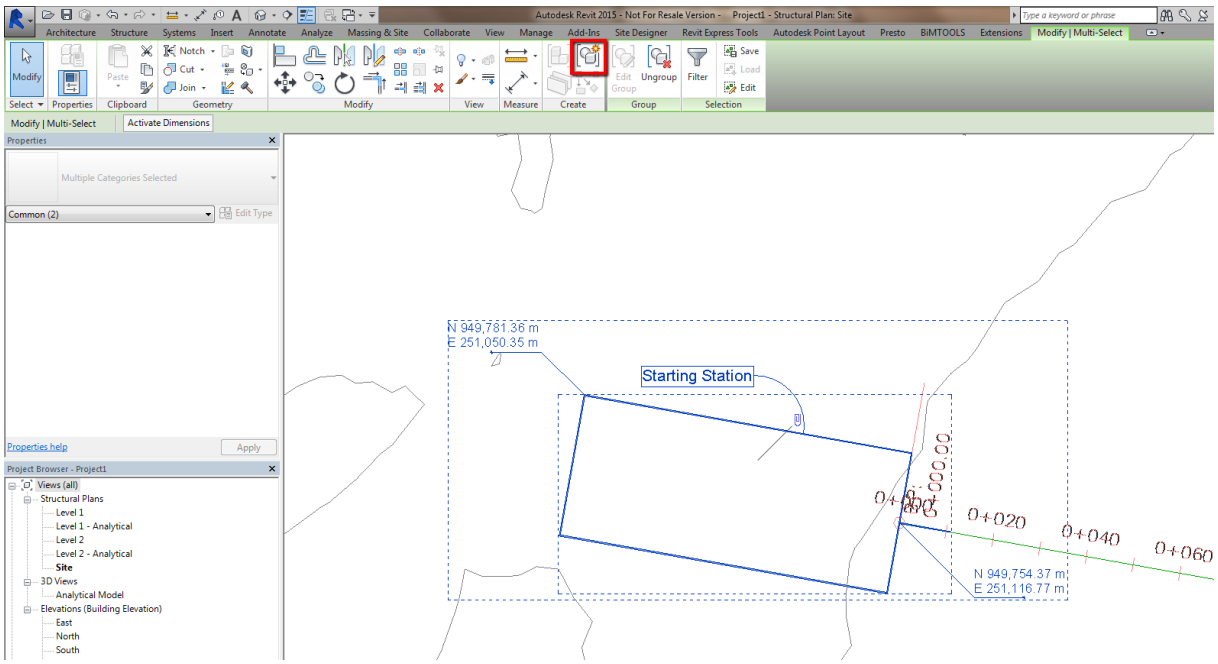
Working on this file will allow us to develop reserve zones for future buildings or infrastructures, we can do this by modeling mass objects, or as I prefer, draw some wall to define limits and alignments with the rail corridor from the Infraworks file.

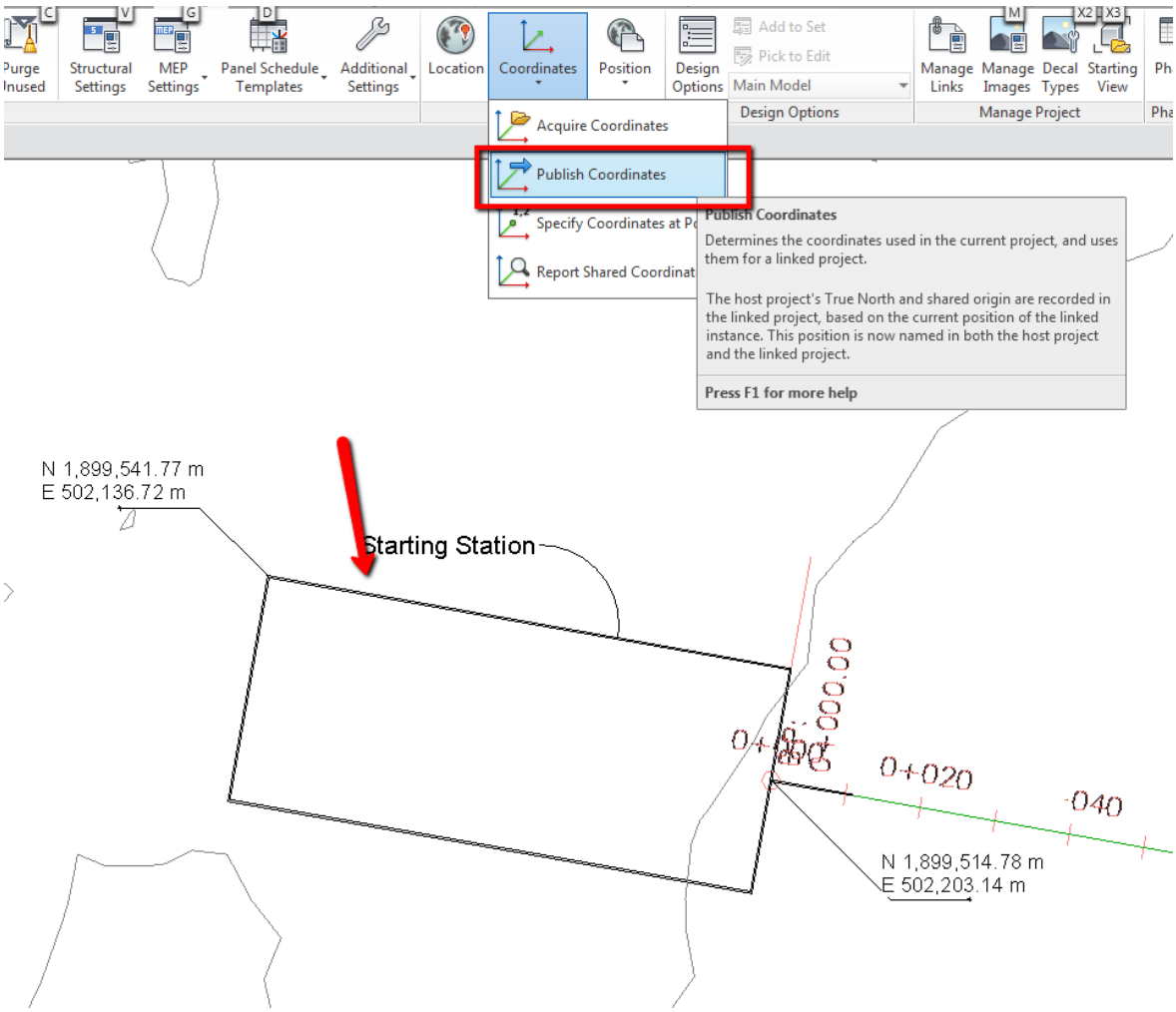


We can also link other models already done as long as we know where to put them. Or as free study to future development of our project.

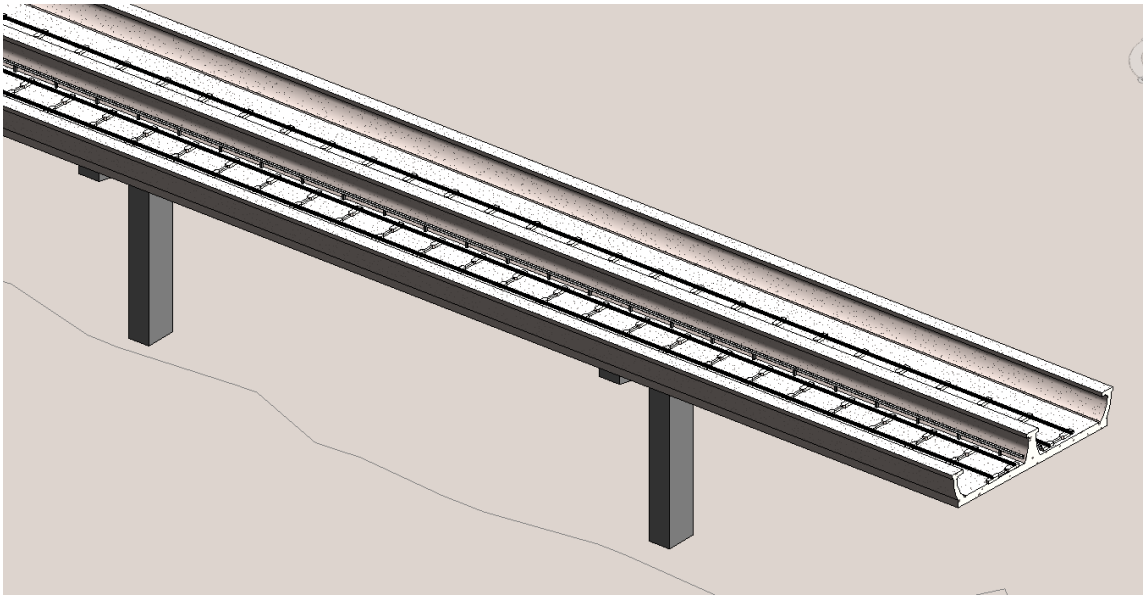


Using the objects modeled in the reserve zones, we go group the entities on it, save as a link and publish the shared coordinates to it, so we have a new file ready to work with the proper coordinate system enabled on it.





Following the base corridor exported from Infraworks we use a trick to generate a quick conceptual design of our rail system. For this purpose we customize a railing profile that simulates our platforms and piers, and quickly picking the corridor line we have a leveled 3D model of our project.



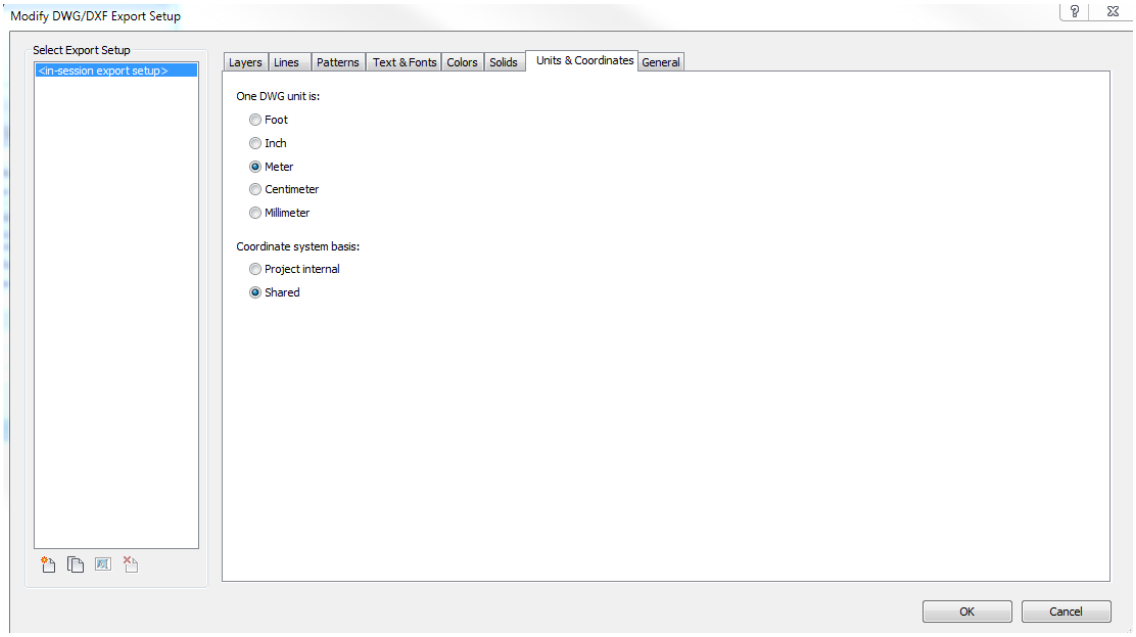
Again we group these entities and save the individual parts of our system.

With the models placed on the right positions we can start to work on them individually and develop each project on its own.

Now we would like to return data to our team, for that we can export the Revit models directly to Infraworks or as 3D DWG to Civil 3D.

Infraworks will read the Revit files directly trough the Naviswork engine, so the best option is to create a named 3D view, like we used to do for Navisworks. Basically we create a clean 3D view showing only relevant components for this project.

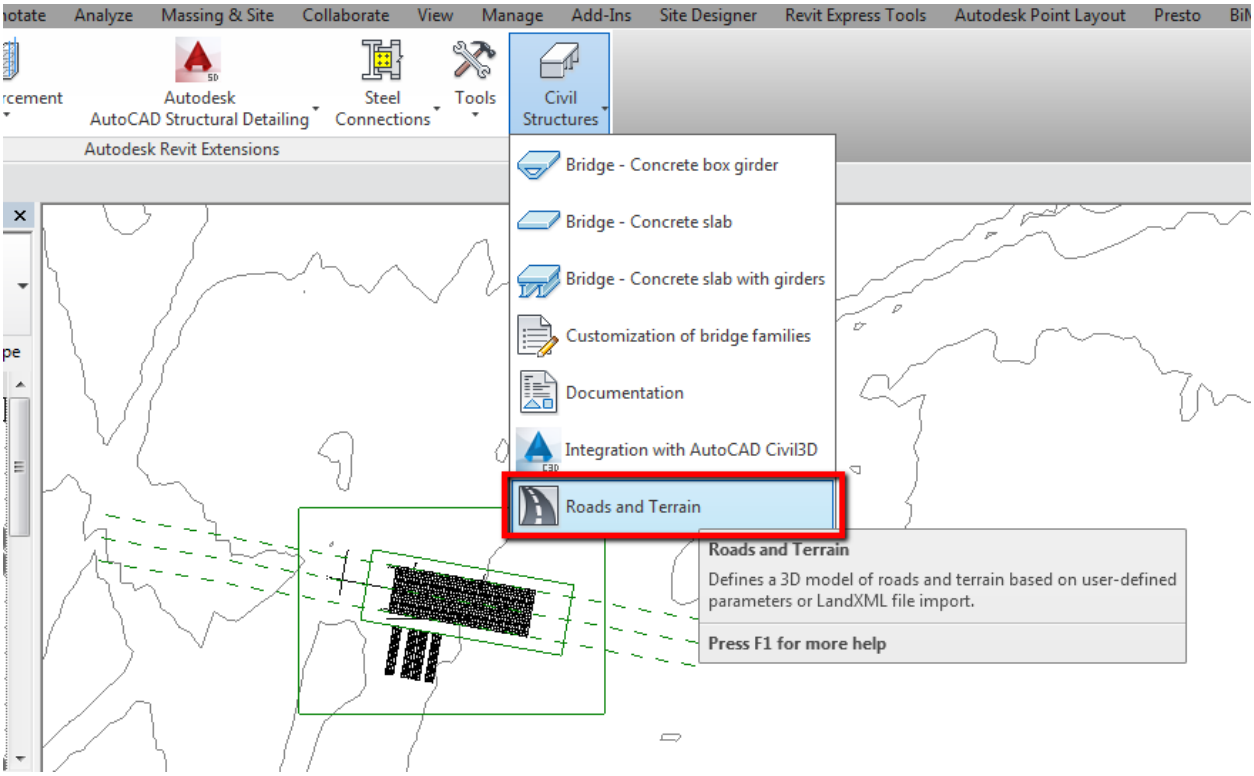
To export the Revit model to Civil 3D we export as a DWG, if needed map the layers properly our use one of the standards styles. Don’t forget to select the export model to solids and choose meters as the exporting units using shared coordinates.

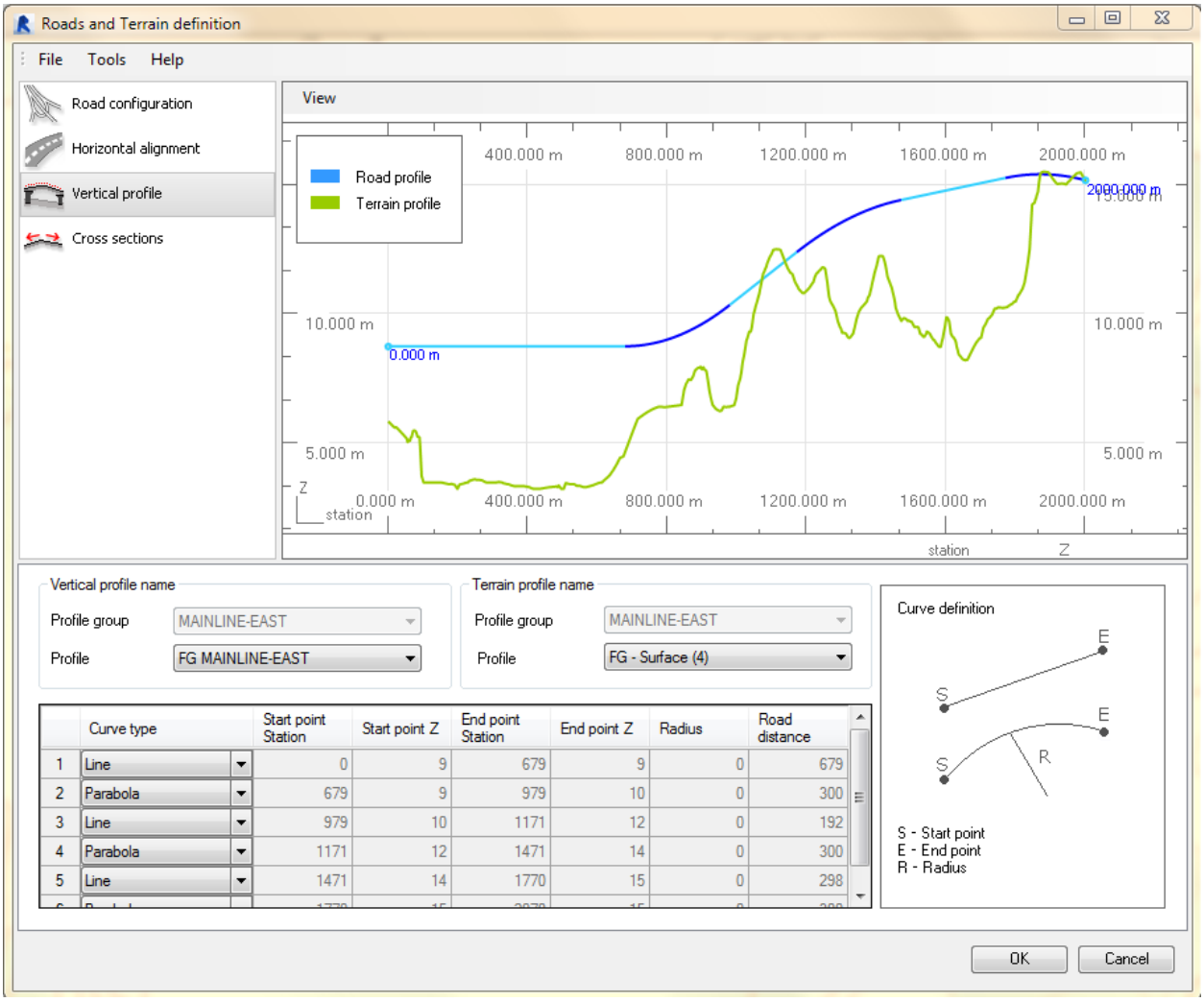


For now our task is finished, we have send our Revit models to Infraworks to complete the model and also export relevant information to Civil to allow the engineer to define their corridors properly interacting with our model in place. Also our models are ready to be appended to a Navisworks aggregation model for future use.

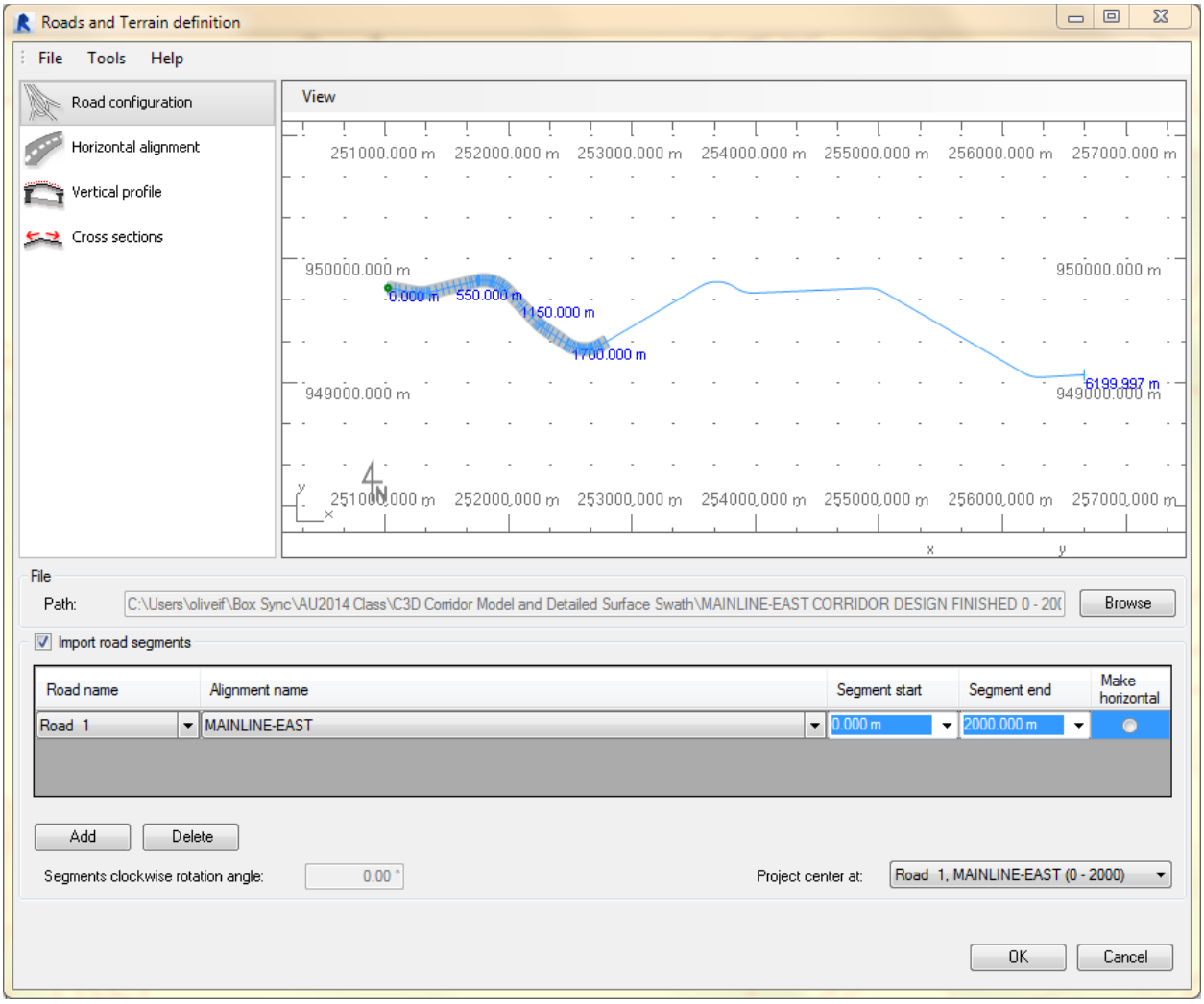
Import alignment and surface from C3D.

Meanwhile as our engineer adjusts the alignment of the rail line we can use it to develop a more advanced model not only using the final corridor as also checking the clearance and interference with the existing terrain. For this purpose we are going to use the extensions for Revit, in this case “Civil Structures” and then Roads and Terrain option.

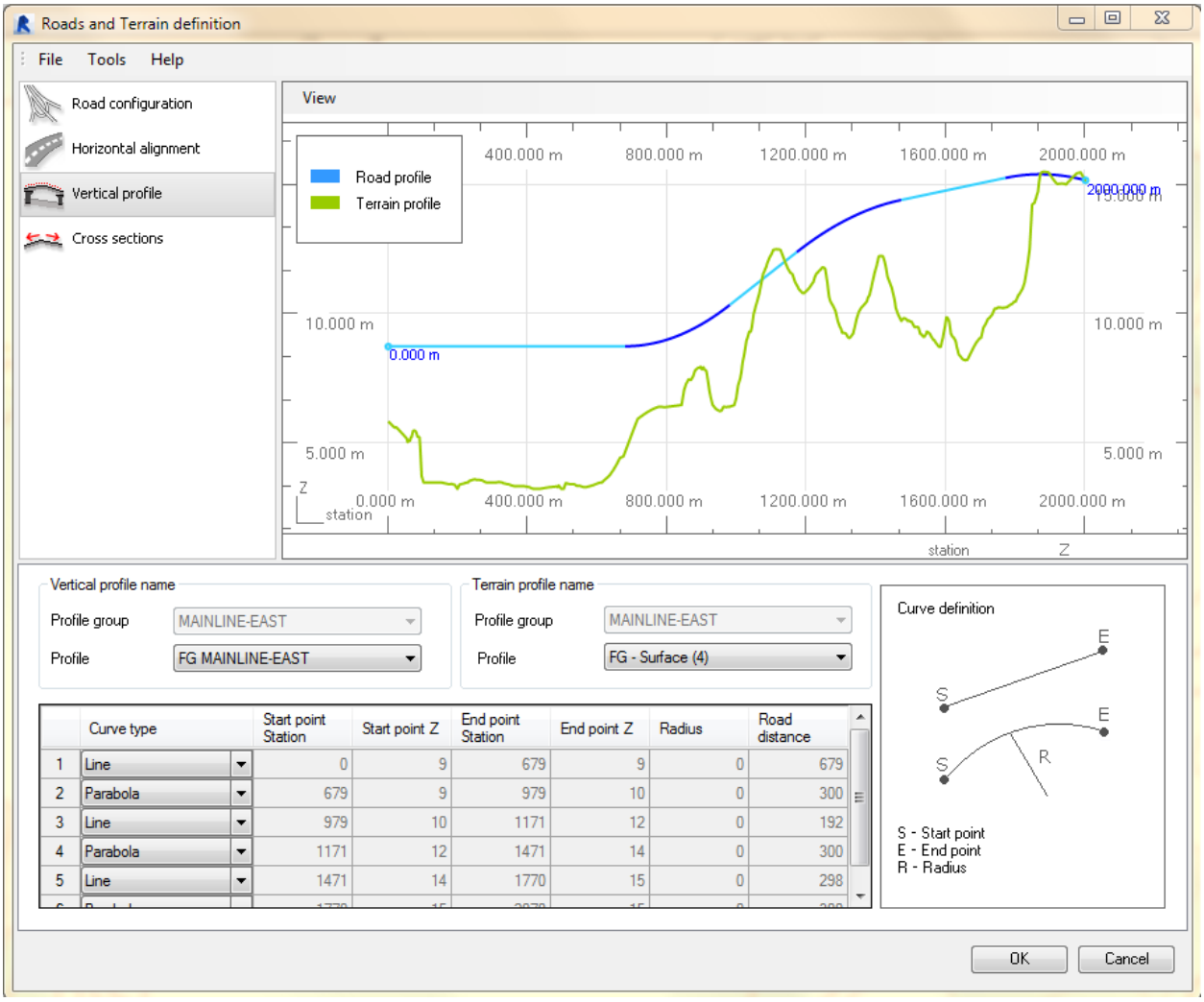




This option allows us to choose a XML file as long it contains a corridor and if possible the surface related. To avoid complex processing times the profile can't be bigger than 2km, Also we recommend splitting the corridors if they are not on the same typology along the alignment, for example if at some places we need to cut terrain and other to fill, or create a viaduct for the corridor, it is better to split it at the transition stations.

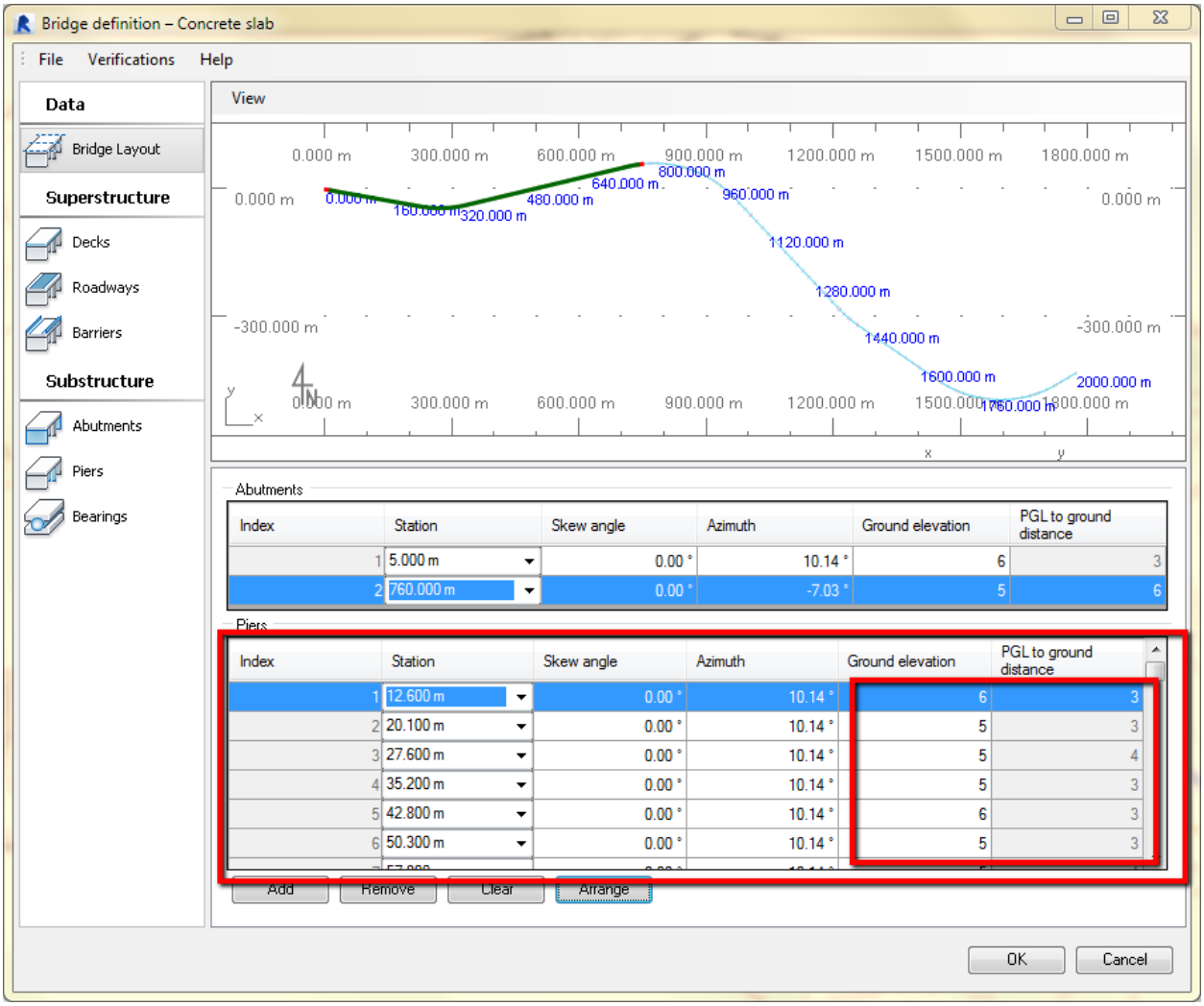


We can customize some parameters of the corridor to be generated in Revit; especially the cross sections, or if we want, only to generate parts of the profile. It is possible to change the horizontal and vertical profile, but this should be used only if the original xml data is not satisfying some parameters of our project.



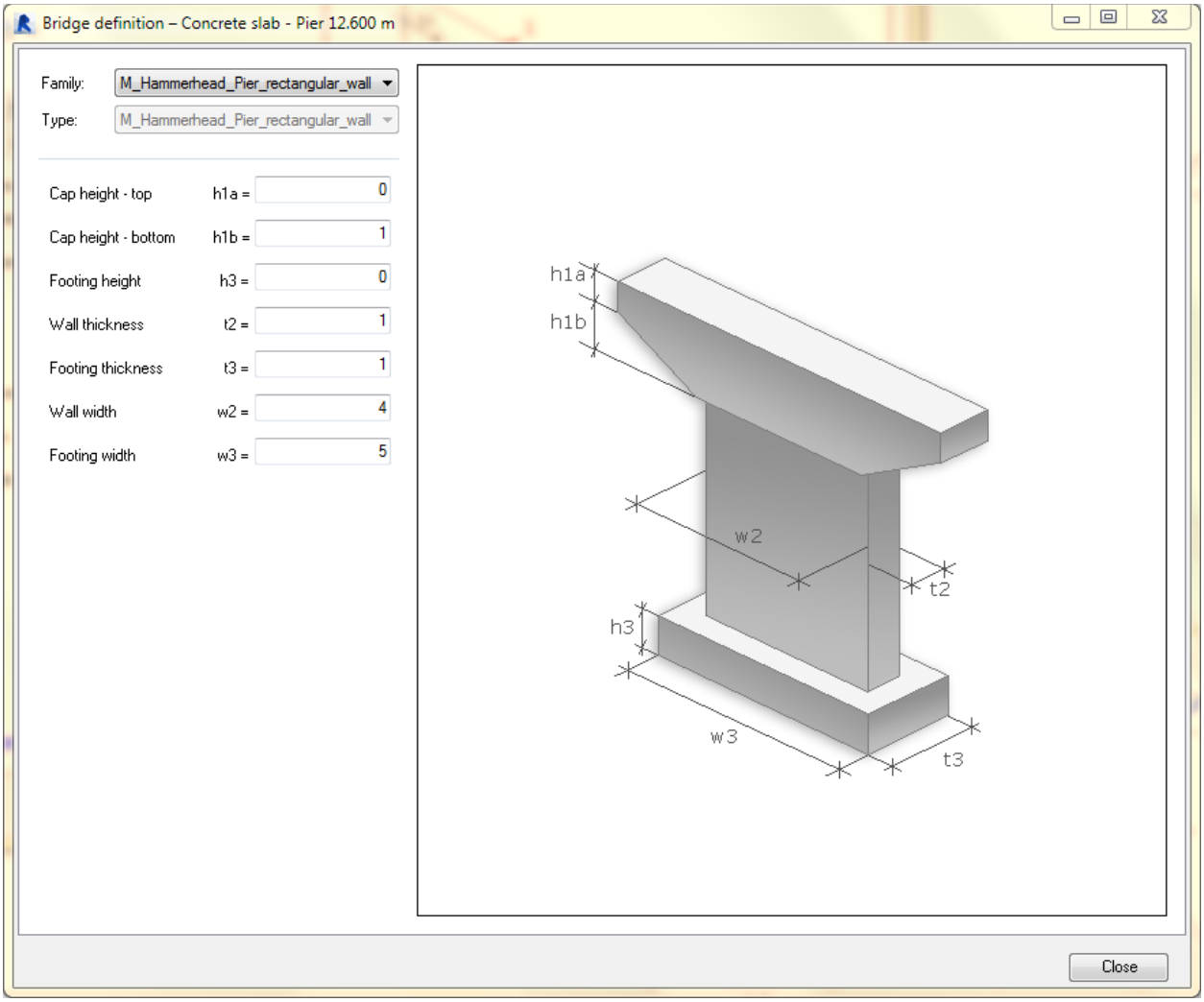
In the end we get a Revit mass, that we can use to generate a bridge using the Extensions, or as a 3D path for a sweep.

For elevated roads or rails this is a good tool to allow us the creation of a reasonable 3D model, for Tunnels we can use this option but instead create an in place family and extrude the tunnel along the road profile.



As we notice the bridge tool can calculate the height of the columns based on the corridor profile and the terrain definition, this is a very useful tool in terms of planning and preparing a construction model.

The bridge tools doesn't work well with columns with a height less than 1meter which is another reason to split the alignment in different corridors based on their offset from the base terrain, or the proposed terrain if the engineer decide to manipulate the terrain in Civil 3D to a better implantation of this project.



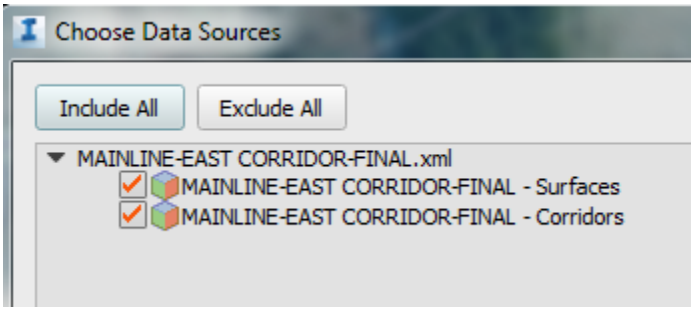
Again the generated model will be grouped and linked as a new project file, this way our project is lighter and easier to manipulate.

Now our Infraworks team can append the Revit models directly to the Infraworks model and we will export each Revit model as a separate dwg to deliver to civil 3D where the engineers can easily check the project definitions.

Bringing it all together in Infraworks

Once the Architects and Engineers have done their work, you can easily bring their deliverables back into Infraworks for managements, presentations, etc.

Start with the Civil data. Since they created an XML of the surface for Revit, we'll take advantage of that to refine the surface along the rail alignment using the LandXML import option. You'll have a few options, but only need the surface:



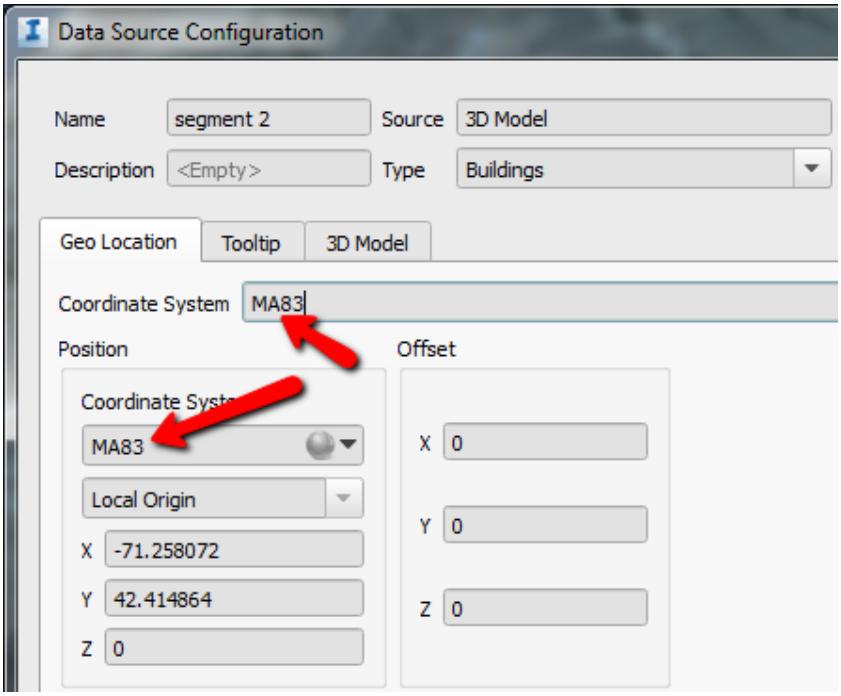
Since the rail is coming from Revit and that data handoff happened directly, that's the only import we have to do from Civil

There are a few different ways that the Revit data can be created. For a longer project like this, it is best if each entity is delivered in its own file.

Infraworks 360 can import locally, which requires Navisworks Manage to be installed on the same computer, or from the cloud, which requires an active internet connection and an Autodesk subscription. You can set your preferences in the Application Options

After importing the Revit files, they need to be configured in order to display. At this point we need to watch for two things:

Set the coordinate system in TWO places, lower first:

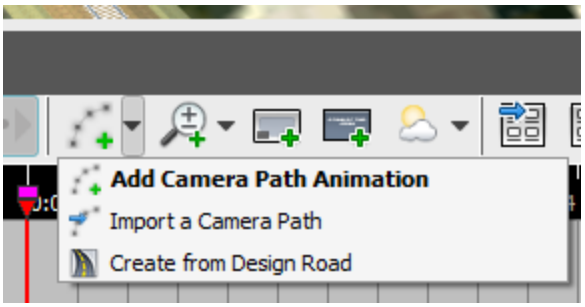


This will force it into the proper location, even if the XY values aren't correct for any coordinate system

On the 3D model tab, you can reduce the Simplification value greatly depending on your needs. For something close to just a shell, use 5%, for near full fidelity with quick display, try 50%.

Check the result. Didn't appear? Check in Revit that the Navisworks view is set to the right content for Infraworks for local imports. For cloud imports, check that the 3D view has what you need. In either case, after making any changes in Revit, removing the connection from Data Sources and completely reimporting generally gives better results than the built in Reimport option, and only takes a moment.

Storyboards allow a range of camera movements to create a compelling presentation. For a project like this, it can be hard to manually create a path that follows the road nicely. You have two options that will let you do this quite automatically:



The bottom option, Create from Design Road is slightly easier as it is all inside Infraworks. This will simply follow a road along a path just above the surface. This means that by default you will mostly see the road. To avoid this:

Go to the proposal with your final design road. Unless it was changed drastically in civil, then the proposal you used to export should work. Make a new proposal based on it.

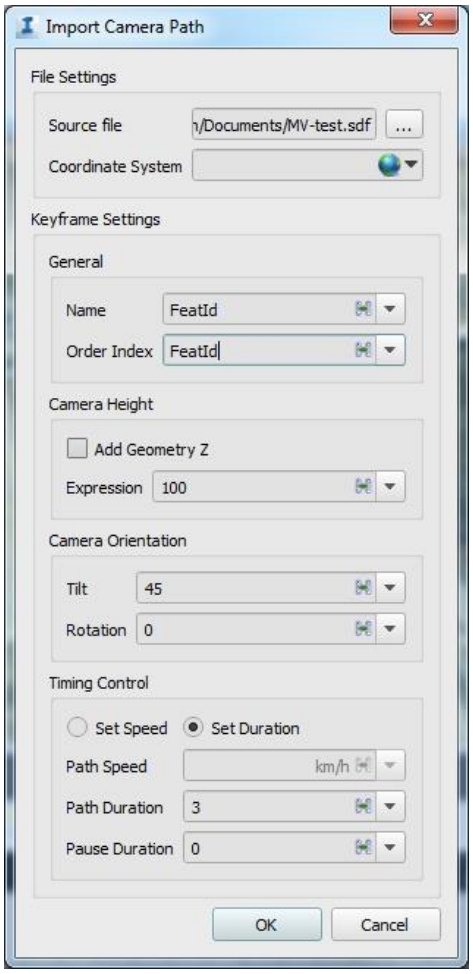
In the new proposal drag a Bridge style onto your entire Design Road. This will allow it to be separated from the terrain so that Z edits won't contort the surface

Go to the profile view and select each PVI and edit – you can type in values here, so you could create a completely flat surface to travel along for the presentation or you can set it to have a consistent offset. 25 meters is enough that you can see a good amount around you without too many distant and distracting components coming into view.

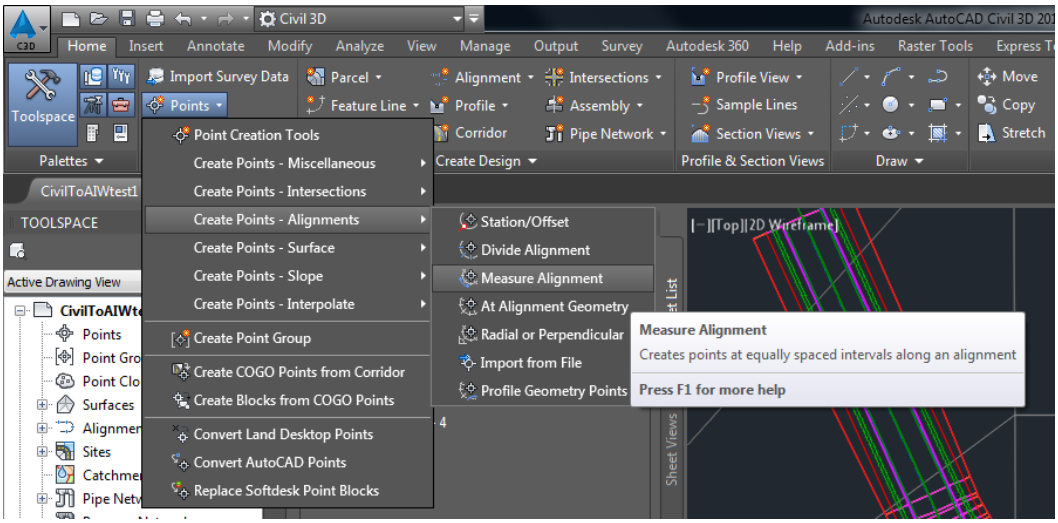
In the Storyboard creator, use that newly edited road to create a storyboard. Now switch to the finalized proposal with the Revit and Civil features – since the storyboard always shows content from the current proposal, you'll have a great view of the project.

The second option requires a little work in Civil 3D, but does give a little more view control.

In Civil, open the drawing that has the final alignment.



On the Home tab in the Create Ground Data section, pull down Points, and select either Divide Alignment or Measure alignment.



Once you have created points, on the Output tab, select Export Civil Objects to SDF.

Back in Infraworks, in the Storyboard creator, select Import a Camera Path and then navigate to the SDF from the previous step.

For the Order Index, do not use FeatID – instead, select the Number field that Civil created.

Set the elevation as needed – this won't be easily changeable, but it is easy to recreate the whole storyboard

Set the camera tile – this is the main reason to use this option. 20 or 25 degrees is usually good

Note that you can set the speed for the entire thing or how long each point will be the active keyframe. Setting speed to the design speed helps to give a realistic feel.

Once the road path is imported, you can create introductory or closing animations to complete the story, complete with captions, titles and changes to lighting.

At this point, the project work is done. You can even create a scenario publish to the web and make it public so that anyone with a browser can take a look at the project.