



AUTODESK UNIVERSITY 2015

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Workflows for BIM Infrastructure projects

Fernando Oliveira - Autodesk

Lucy Kuhns – Autodesk, Nathan Moore – Reginald De Visscher - Autodesk

Learning Objectives

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

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

During this Industry talk we will supply information about global adoption of BIM Infrastructures, some best practices, customer's samples and technical information about how to use our tools to obtain the best results.

Used applications:

Autodesk® Infracore

AutoCAD® Civil 3D®

Autodesk® Revit® / Revit Extensions / Dynamo

Autodesk® Navisworks® Manage

Used formats:

Infracore modelbuilder

IMX (Infracore export)

DWG (Civil 3D project and Infracore base models)

RVT (Revit project)

RFA (Revit content)

CSV (cogo data)

NWC (NavisWorks models)

IFC (export format)

XML (civil data files)

RCS (point cloud)



Handout not finished, work in progress

About the Speakers

Since 1999 Fernando Oliveira has been involved in sales and consulting, and training 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/>. fernando.oliveira@autodesk.com

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.

*After completing his master's degree of Architecture, **Réginald de Visscher** began working for several construction companies before joining Autodesk Partner as BIM Manager Consultant. Working with Autodesk solutions since 10 years sharing his knowledge to the industry and helping customer adopting BIM solutions. Now as Premium Support Specialist part of Autodesk WWSS-GS, he is working with enterprise priority customers worldwide in order to help them adopting Autodesk solutions to be compliant with Building Information Modeling BIM. That means helping customers: taking advantage of the most efficient workflows and using the latest new features, avoiding issues before they occur, staying ahead of the technology curve and increasing productivity.*



Table of Contents

Learning Objectives.....	1
About the Speakers.....	2
Introduction	4
Infraworks for conceptual design	7
Deliver to Engineers and Architects.....	8
Building the Civil 3D model from InfraWorks Proposal	9
Revit Model, import data from InfraWorks to generate site model.	14
Import alignment and surface from C3D.	16
From Civil 3D data to Revit Using Dynamo	20
Bringing it all together in Navisworks	21
Conclusion.....	22
Workflow definition diagram:.....	23



Introduction

BIM is an intelligent model-based process that provides insight to help you plan, design, construct, and manage buildings and infrastructure.

Funding and public support for civil projects is critical to success. BIM solutions help turn information into insight to optimize designs and help accelerate approvals, resulting in more effective and resilient infrastructure.

BIM for infrastructures is a great topic, actually is probably the hottest on our Industry. More and more projects around the world are under this spotlight as owners are looking for better ways to do the old things. Roads and bridges basically are made the same way in the last 30 years.

So why changes in the industry?

Here are some statements from Industry professionals:

“Model used for various analyses including sun reflection and driver sight lines, and is linked to the project’s scheduling system to simulate construction phasing to help more predictably plan field activities. BIM processes supported by the following Autodesk software:

AutoCAD® Map 3D
Autodesk® InfraWorks
AutoCAD® Civil 3D®
Autodesk® 3ds Max® Design
Autodesk® Navisworks® Manage
Autodesk® Design Review
Autodesk® Revit® Structure

A4ALL Consortium - Boskalis, Heijmans, and VolkerWessels”

“AF Consult uses AutoCAD®, AutoCAD® Civil 3D®, and Autodesk® Revit® software available in the Autodesk® Building Design Suite to develop a dynamic digital model to establish alignments and longitudinal profiles of the tunneling system allowing the team to quickly adapt and correct tunnel alignments and profiles as their design progressed, and coordinate reviews.

AF Consult”

“Given the breadth and complexities of the work required and the very high traffic flows on the M4 above and A4 below, detailed planning is essential to minimize the impact on this strategic highways network. Atkins is using Autodesk® AutoCAD® and Autodesk® Navisworks® software to develop an intelligent 3D model—incorporating record information, current works, and long-term asset management data in a single common data environment.

Atkins, part Connect Plus - a DBFO consortium “



"Autodesk BIM solutions give us a more accurate engineering representation of the highway and a deeper understanding of the project during construction.

David Owens, Engineer Skanska Balfour Beatty Joint Venture"

"Given the enormous need for infrastructure improvements and demonstrated benefits of BIM for complex projects, it makes sense that organizations should increasingly be using modeling and analysis tools to design and build infrastructure projects—it improves efficiency and costs," says Harvey Bernstein, Vice President of Industry Insights and Alliances at McGraw-Hill Construction.

And what are the biggest difficulties to adopt BIM for Infrastructures?

"The Industry has been pushing BIM adoption and application, yet this has been mainly in 'vertical BIM' (buildings,) whereas horizontal or 'linear BIM' (infrastructure,) for the most part, has been reluctant to adopt.

For infrastructure projects (and, inherently, the majority of its client base) one of the reasons for this reluctance is quite often the time to raise funds and procure via public bodies - local, state or federal. There are also hang-ups due to the current required contractual frameworks and the protracted delivery times of large infrastructure projects. Other challenges include a perceived lack of technical expertise; soft and hard implementation costs; a lack of industry standards." Suibhne Cullen, MWH Global

We saw companies struggling with new processes, looking for trained users; invest in consulting for better implementations.

One of big bottlenecks is the change of processes from traditional drafting processes to advanced model and data information ones.

The delivery of data models, using an independent format like IFC is still inadequate in Infrastructures.

Most tools and processes are too much building oriented.



BIM for Infrastructure Summary

Late in 2012, Autodesk was honored to be the premier corporate partner for McGraw-Hill Construction's "The Business Value of BIM for Infrastructure SmartMarket Report," which detailed the rapid rise in Business Information Modeling (BIM) in North America. As a supplement to the report, Autodesk was given special permission to highlight the report's most important findings and formulate them into an infographic we titled "The Business Case for BIM for Infrastructure. The infographic provides easily digested snapshots of key findings not readily accessible in the report.

While 89% of users see value in BIM, 67% of survey respondents reported a positive ROI on infrastructure projects considering most A/E firms are not very experienced in calculating ROI on infrastructure projects.

The infographic highlights three top means for improving ROI:

- Improved project process outcomes
- Better multi-party communication
- Improved productivity

Additionally, AEC firms reported internal benefits that included:

- Marketing New Business
- Better Project Outcomes
- Reduction in Construction Document Errors

The infographic also features three infrastructure projects that benefited from BIM:

- \$8 million saved by the San Diego International Airport
- 260-360 work hours cut from the Des Moines Sewer Systems Project
- Larkin Plaza in Yonkers was saved from flooding by the Saw Mill River after Hurricane Irene

Finally, the Business Value for BIM for Infrastructure infographic demonstrates the high rate of adoption of BIM compared to the last study in 2009:

- High/Very High usage comprises 52% of firms vs. 16%
- Medium usage peaked at 27% vs. 11%
- Low/No usage has dropped to 21% vs. 73%



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 200 sq km (77 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 15 minutes depending on your internet connection. 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

For this road project, we'll test out a few different road and bridge options in Infraworks.

- We'll visually determine a good route for the road, 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 according to the standard in use for the model.
- 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 options. Each new proposal will contain everything in the proposal you have open when you create it – go back to the master or original for a clean start, or use a simple option to start from and create different versions. Edits will only apply to the active proposal.
- Try very different proposals – maybe no bridge, but connecting into nearby roads instead.



TIP – Style the road with a basic two lane road style to match the aerial images.

Now you have some good candidate designs.

- Work with stakeholders to determine which design will work best
- Adjust the details of the bridge, such as number of piers and the clearance envelope
- 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



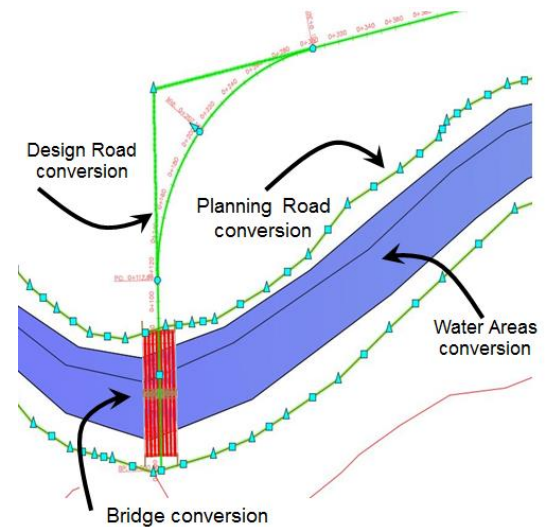
- This creates both a DWG and an IMX. Using the above option will automatically open the drawing in Civil, but you can also import the IMX to a DWG manually if you want to use a particular template.
- If you are only sending out a single road, you can automatically include an appropriate buffer zone around it.
- Note carefully the sheet set options and the export coordinate format. In this case, we used BritishNatGrid as that is the standard for the Civil Engineers.

Building the Civil 3D model from InfraWorks Proposal

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.

We have just received the proposed park design. It is delivered in 3 file types IMX, SQLite, and Civil 3D DWG, which we can leverage in AutoCAD Civil 3D to build a robust base map and proceed with some detailed engineering and analysis. The brief descriptions are as follows:

IMX - conversion from Infraworks objects to Civil 3D objects:



Infraworks Object	Civil 3D Object
Coordinate System	Dwg coordinate zone should be the same as UCS set in Infraworks. If no coordinate system is defined, the base system in Infraworks is LL WGS 84 and will be automatically converted to a UTM system most closely matching the position on Earth
Terrain	TIN surface
Planning Roads	Alignments with no curve data or labeling
Design Roads	Alignments with curve and tangent and labeling
Intersections	Intersection object as point marker and horizontal geometry only
Drainage Networks	Pipe Network named: Drainage Network with junction objects and pipes following under terrain
Planning Pipelines/Utilities	Pipe Network named: Infraworks Network with no junction connections or reference to surface
Coverages	3D Polyline – note often must be weeded after import because of spline fit conversions
Water Areas	3D Polyline – note often must be weeded after import because of spline fit conversions
Bridges	3D AutoCAD Solids



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
- Planning and 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)
- Inserting the critical location and elevation points of the new bridge
- 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

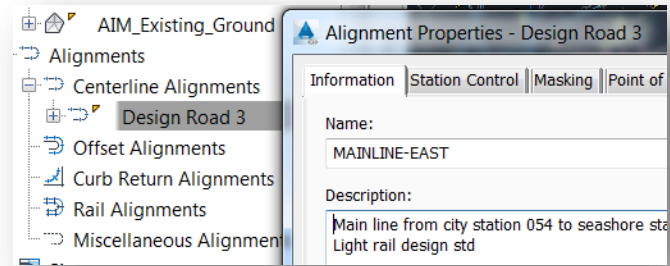
Overview of Procedure:

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 than the data will be transformed.

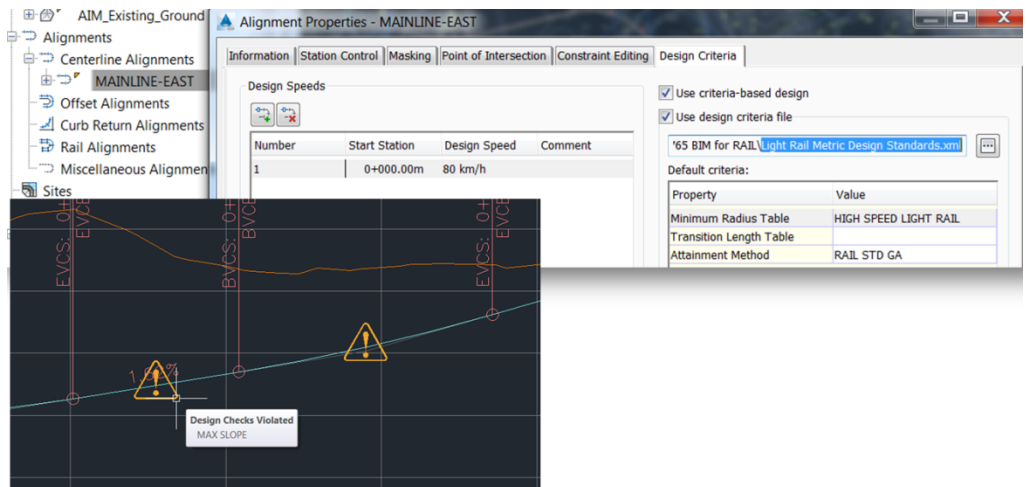


Verify the import of Civil 3D objects in the Prospector tab of the Toolspace.

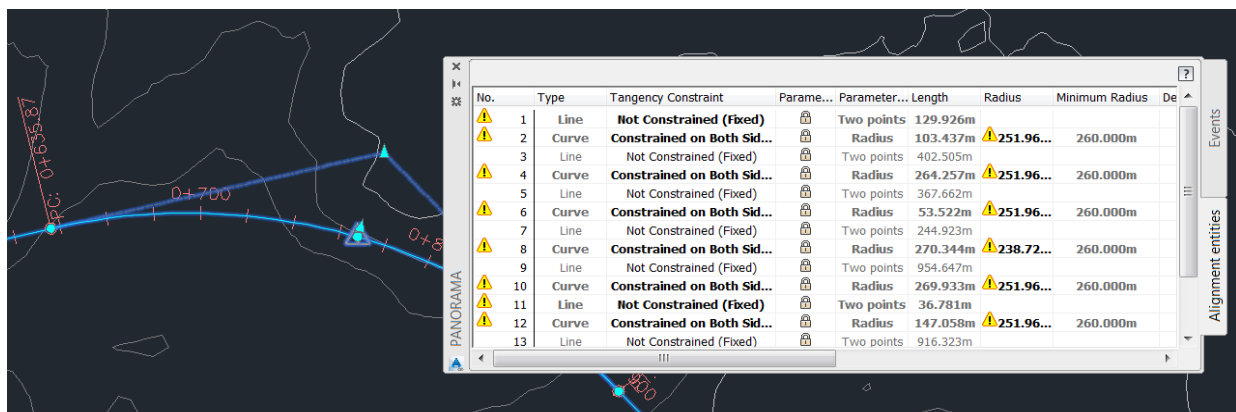
Assign logical names to the alignment, do not change the surface name as it is linked to the name value stored in the IMX file.



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.



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

To identify the alignment “connection” locations. The exact location and height of the road alignment must be established. The stakeholder in charge of the bridge 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 bridge model. The bridge 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 bridge 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.



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 Infracore 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 Infracore.



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 Infracore.

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 road corridor from the Infracore 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 Infracore we use a trick to generate a quick conceptual design of our road and bridge system.

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

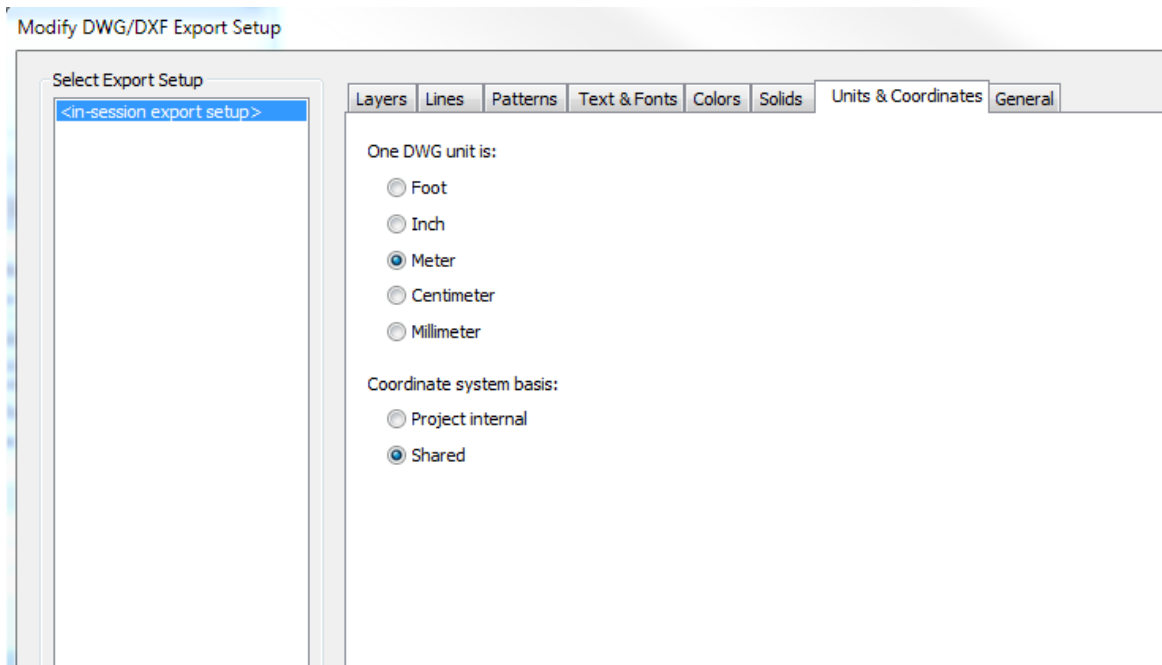
With the models placed on the right positions we can start to work on them individually and develop each project on its own.

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

Infracore will read the Revit files directly through 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.



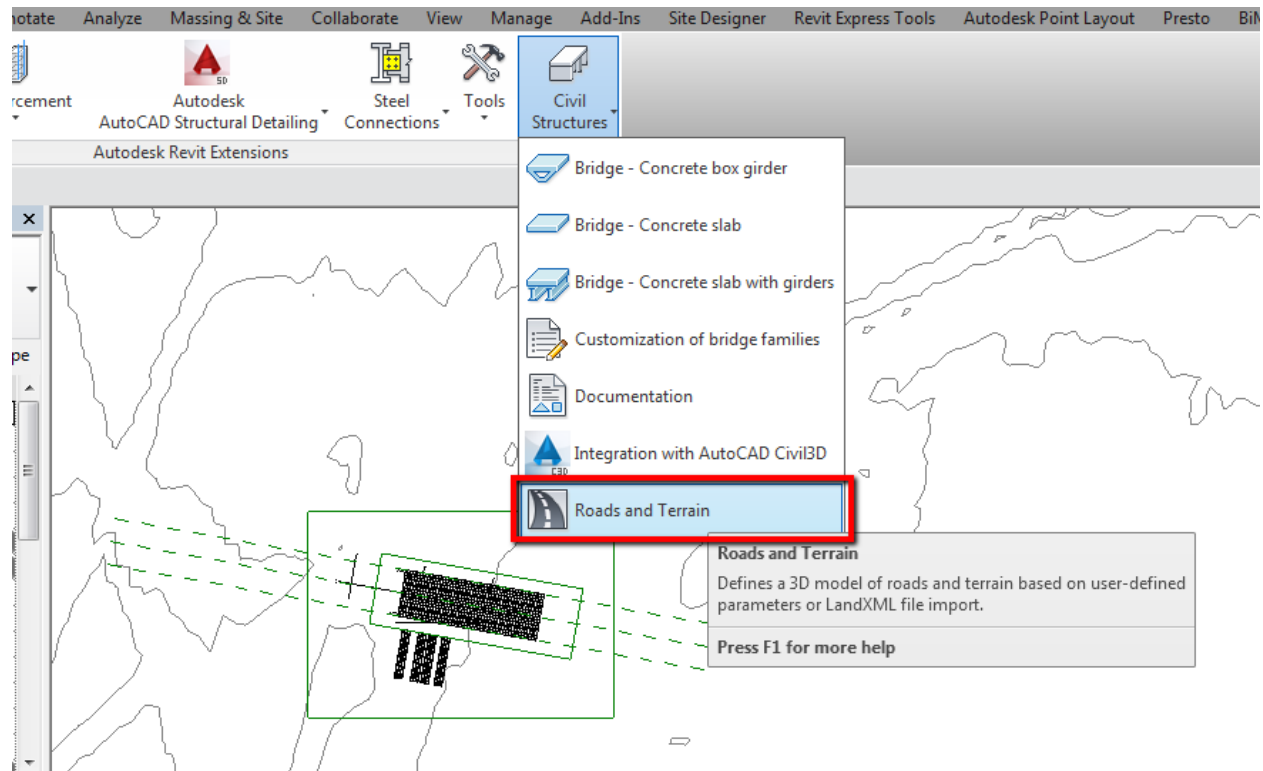


For now our task is finished, we have send our Revit models to Infracore to complete the model and also export relevant information to Civil to allow the engineer to define their corridors properly interacting with our model in place. Also our models are ready to be appended to a Navisworks aggregation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



Import alignment and surface from C3D.

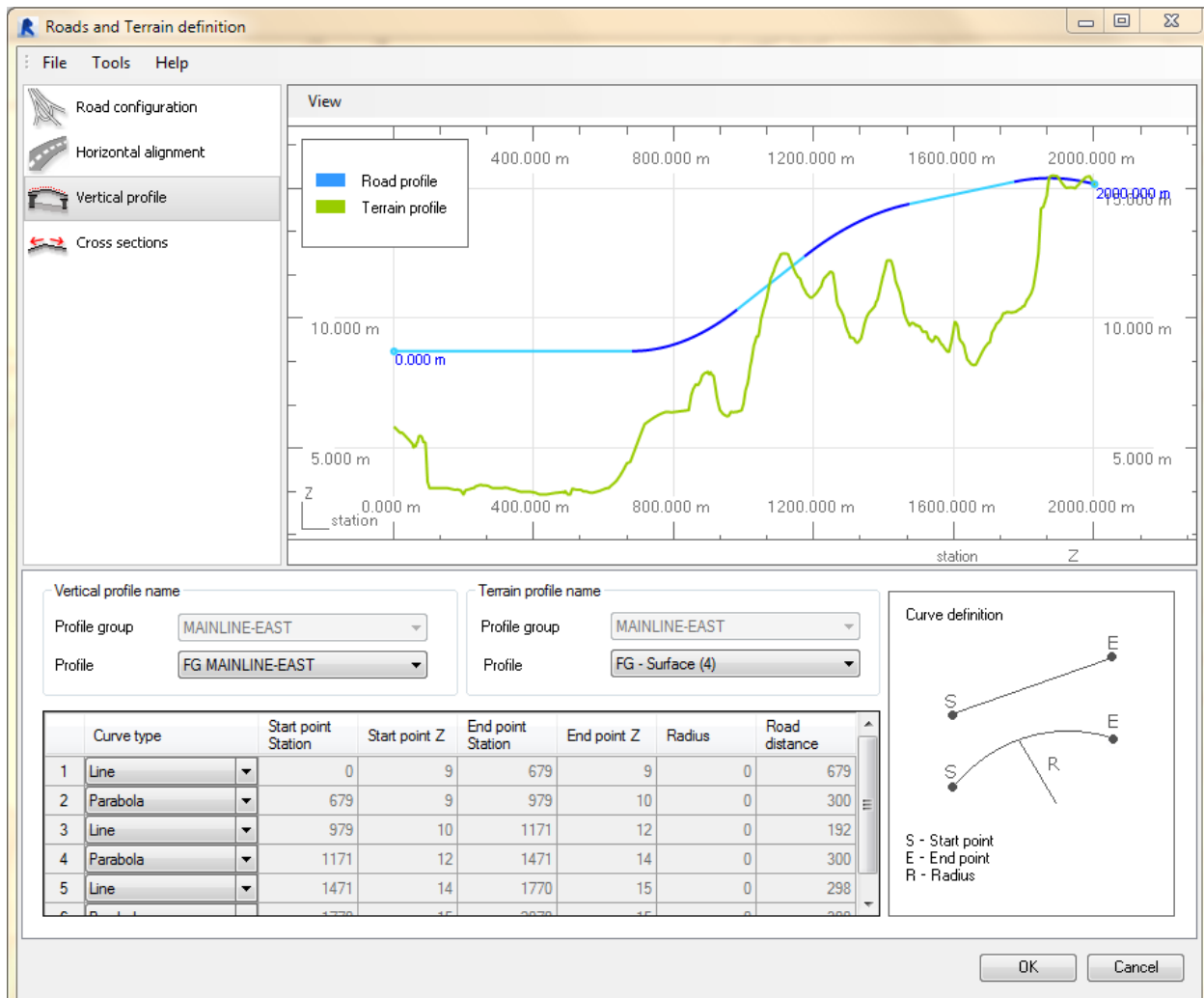
Meanwhile as our engineer adjusts the alignment of the road we can use it to develop a more advanced model not only using the final corridor as also checking the clearance and interference with the existing terrain. For this purpose we are going to use the extensions for Revit, in this case “Civil Structures”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

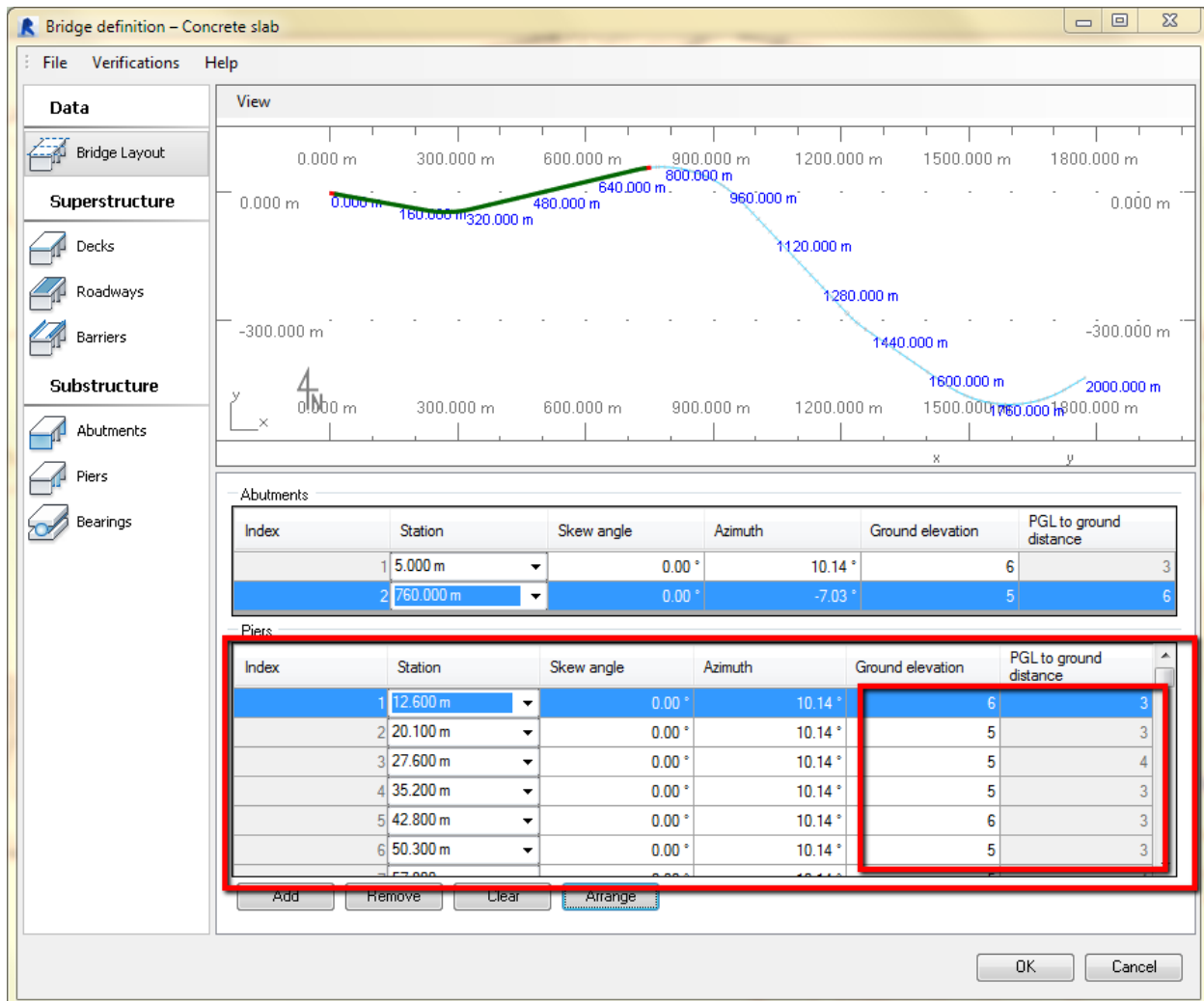
We can customize some parameters of the corridor to be generated in Revit; especially the cross sections, or if we want, only to generate parts of the profile. It is possible to change the horizontal and vertical profile, but this should be used only if the original xml data is not satisfying some parameters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





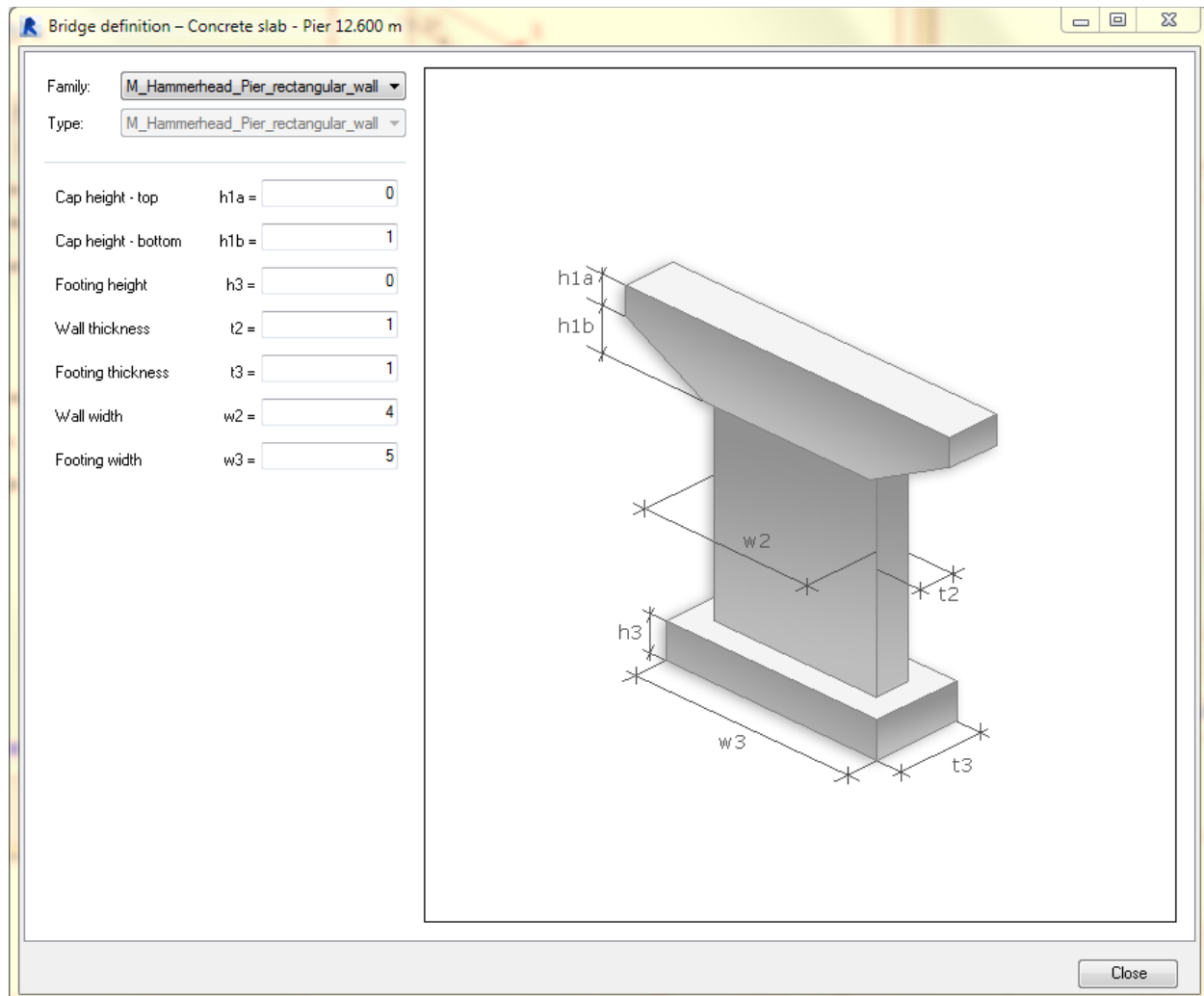
In the end we get a Revit mass, that we can use to generate a bridge using the Extensions, or as a 3D path for a sweep.

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.

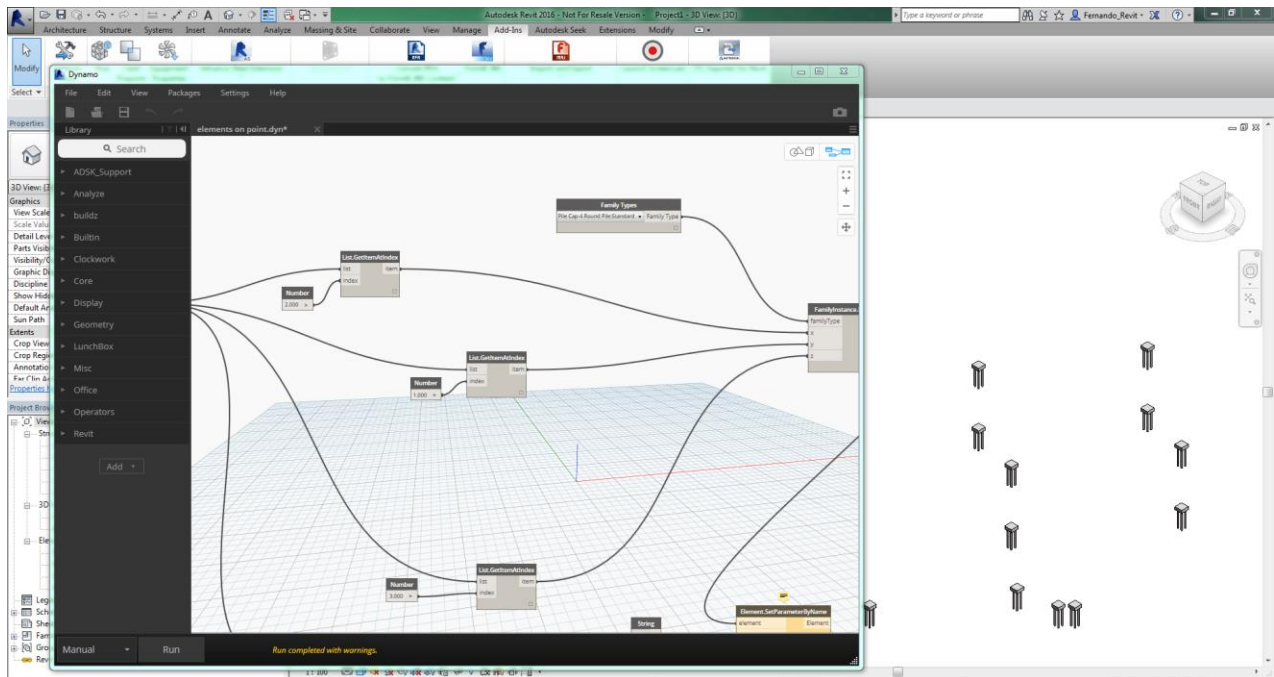


Again the generated model will be grouped and linked as a new project file, this way our project is lighter and easier to manipulate.

Now our Infracore team can append the Revit models directly to the Infracore 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.

From Civil 3D data to Revit Using Dynamo

Using Dynamo in Revit will allow us to import a list of points from Civil3D that represent the position of some bridge foundation piles, or other infrastructure components like pipes or manholes. This operation will be presented on the live section and a script will be delivered to the assistants of this class.



Bringing it all together in Navisworks

On Navisworks not only we can join the models from Infracore, Civil and Revit as we specially can perform operations of clash detections, prepare construction scheduling and mostly have a good 3D model with references to a wide variety of linked documentation in multiple formats.



Conclusion

As we see on this class, real cooperation between Autodesk applications can be used on our infrastructure projects, from conceptual design in InRoads, to infrastructure project in Civil 3D, also using Revit as a components modeler and as a tool to generate a BIM project capable of generate more information to be used during the project execution and lifecycle.



Workflow definition diagram:

