CES322405

A Case Study of BIM Design for a Smart City with the Architecture, Engineering & Construction Collection

Vincent Duloup
Ingerop

Vincent Fredon
Autodesk

Learning Objectives

- Learn how to construct the BIM implementation for an urban project
- Learn how to apply a BIM workflow with the AEC Collection on a complex urban project
- Learn how to create an InfraWorks model assembled from Civil 3D modelization
- Discover the benefits of BIM for building the future smart city

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Description

This session will cover a case study of BIM (Building Information Model) implementation for a complex urban project designed as a smart city. The 126-hectare project is called Garonne Eiffel, and sits in a large development area in Bordeaux, France. The heart of Garonne Eiffel is the Belvedere subdistrict, a 12-hectare (30 acre) area. BIM has been implemented on the Belvedere project, which is the first key step for a future smart city. We will present the project with its specific challenges (urban density, collaboration, technical complexity). We will discuss the BIM strategy applied, including good and not so good aspects. We will describe the workflows created with the Architecture, Engineering & Construction Collection to show how InfraWorks software, Civil 3D software, Revit software, and Navisworks software are key tools to urban design. We'll show how we used InfraWorks to assemble Civil 3D modelization for the Belvedere project: buildings, roads, trees, and street equipment. And, we'll show how Dynamo helped us improve our productivity.

Speaker(s)

Vincent DULOUP, Project Manager in the field of urban design. After obtaining his degree in engineering, he joined Ingérop Bordeaux, France in 2011. The city of Bordeaux has a large potential for urban development meaning he has worked on several large-scale urban infrastructure projects from the planning stages through to the construction stages. Since 2016, he has taken a keen interest in BIM in the urban field. During the last few years, he has implemented BIM on a large urban project in Bordeaux called Garonne Eiffel (https://www.youtube.com/watch?v=-hy44B-7R9M). His work on this project was even nominated for a French BIM d'Or Award in 2018 in the infrastructure category. He is also a member of technical and scientific direction group of Ingérop. In this role he helps with BIM implementation nationally within Ingérop through leading workshops, training or surveying technologies.

Vincent Fredon is an Autodesk Technical Sales Specialist in AEC for South Europe. He is an Infrastructure specialist working with all the Autodesk infra solutions and mainly Autodesk Civil 3D, InfraWorks and Navisworks. He is based in Paris. Vincent has worked 13 years for Engineering companies in the Infrastructure domain. He then moved to an Autodesk VAR GraphLand where he has been Trainer and Consultant for various enterprises and projects road, rail, energy… on different software and BIM processes implementation. During the last few years, he has developed a strong expertise in meeting the needs of French civil companies. Vincent also worked on the French Civil Country Kit and the Autodesk InfraWorks localization, as a contractor for Autodesk.

Why BIM for a urban project ?

Bordeaux in the 90's

The first urban project in Bordeaux in 1996 had three essential objectives:
- reduce the mobility gap thanks to the tramway
- develop the quays area of the city and create a new sustainable development area in northern / southern Bordeaux
- to return the luster of Bordeaux by promoting its heritage

In 2009, these three objectives were achieved. The next step was necessary, and a second urban project was started with the ambition of implementing the sustainable development area, from the lake in the North to the train station in the South.

Before 1996   After 2009

Before 1996

After 2009

A new European metropole for 2030

The Urban Community of Bordeaux is created, starting with its ambitious "Metropolitan Project". Objective: to lead the regeneration of the city and welcoming 250.000 additional inhabitants in the 27 municipalities of the agglomeration. The ambition is to reach in 2030 this "population 1 million city" which intends to play a leading role at European level.

Indeed, the ability to attract people to the city and its region does not decline and is among the strongest in France. We often criticize elected officials with responsibility for the living environment, but it is important to understand the undertaking of this Bordeaux 2030 project.

Even beyond the demographic trends, the need of this new metropolitan ambition is clear. The arrival of the Tours-Bordeaux TGV line in 2017 (making Bordeaux only two hours from Paris) along with the launch of the Euratlantique National Interest Operation will create a new Business Centre along with the urban remodelling of the station neighbourhood,

Bordeaux Euratlantique, a large contributor for 2030

Bordeaux Euratlantique is one of the largest development operations in France. Operation of National Interest, created in 2010, is led by the public establishment of development Bordeaux Euratlantique.

Bordeaux Euratlantique perimeter (orange area) within Bordeaux metropolis

Bordeaux Euratlantique, which is made up of a dozen different districts, aims to create 50 hectares of new green spaces on both sides of the river Garonne, and on both sides of the Saint-Jean train station. Its mixed programming (public facilities, housing, offices, shops, business premises, hotels, etc.) will enable it to create 30,000 jobs and meet the housing needs of 50,000 people by 2030.

The Bordeaux Euratlantique Board of Directors includes the Representatives of the State, the presidents of the Regional Council of New Aquitaine, the County Council of Gironde and Bordeaux Metropole, as well as the mayors three communes.

Belvedere subdistrict

The Garonne Eiffel project was created in 2016 and reconfigures 126 existing hectares, including 100 rezoned hectares, on the right bank of the Garonne River, in the Bordeaux Euratlantique National Interest Operation. A framework agreement for urban project management, dealing with urban studies and the development of public spaces throughout Garonne Eiffel, was won by the TVK consortium (architect and urban planner), INGEROP (engineering) and Patrick Ecoutin (landscape architect) in 2011.

Garonne Eiffel project - Bordeaux Euratlantique
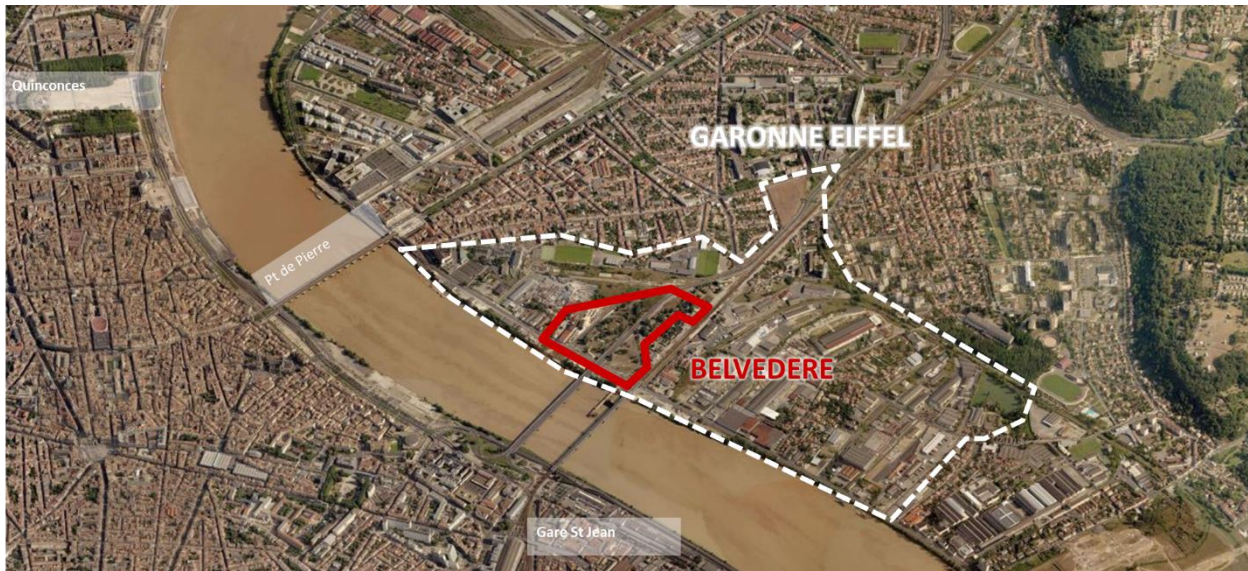
Belvedere district within Garonne Eiffel project

The Belvedere district is in the heart of the Garonne Eiffel project. It is located adjacent to the Saint-Jean bridge, facing the UNESCO-listed old stone city of Bordeaux. It includes 10 hectares and plans the construction of 141,000 m² of floor space on a complex site, currently occupied by typical metropolitan infrastructure. On this emblematic site Bordeaux Euratlantique launched a tender for project developer in 2015. The winner of the 14 lots is a consortium of real estate operators.

The successful project is characterized by a strong overlap between public spaces and private spaces. The development also includes certain constraints:
− In the long term, a high density in a territory currently occupied by road infrastructures
− The presence of existing underground services (electric transport, gas, drinking water, sanitation)
− The need to manage accessibility, pedestrian and cycle, taking into account existing structures such as the Saint-Jean bridge and roads, while also managing large level differences
− The creation of an underpass under the Bordeaux Paris train line

Existing road – boulevard Joliot Curie

Renovated road – boulevard Joliot Curie

Carrying out a project like Belvedere implies managing a "complex urban system" over a long period of time, involving many actors. In 2015, these issues led Bordeaux Euratlantique and INGEROP to explore an innovative approach, taking into account the operational realities of the urban project and aimed at:

- facilitating the understanding of the project and the risks by all the actors of the project
- fostering collaborative processes
- centralizing the project data and keep it always up to date
- having viable and sustainable digital data over time

BIM implementation for an urban project

What is City Information Model ?

Our approach, inspired by the Building Information Model (BIM) changes scale here to apply to a territory. This is a City Information Model (CIM) approach that involves:

- A spatial scale change of the models - territory of 10ha, 13 models of buildings, 1 model of 6ha of public spaces
- An operational approach over a long time
- Heterogeneous BIM maturity
- Taking into account the existing
- New thinking on urban BIM objects to model
- Management of several BIM environments: building and public space
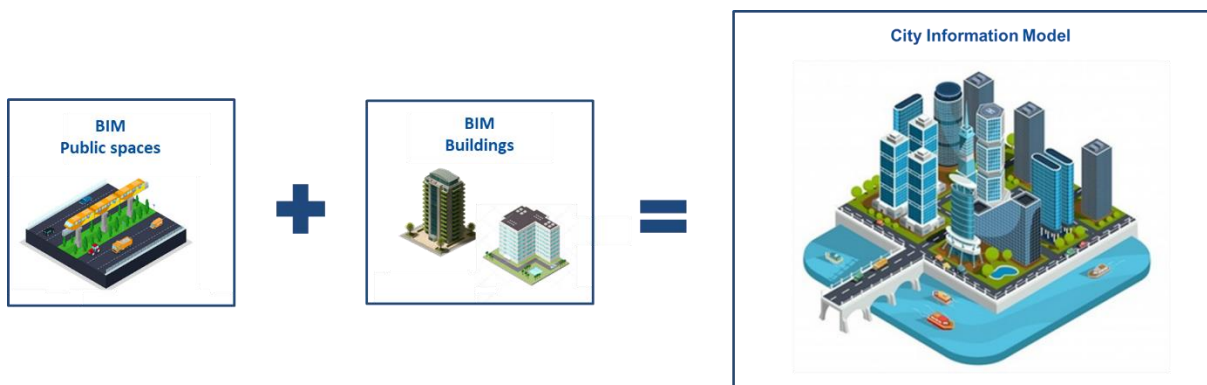
City Information Model conceptual schema

Overview of BIM implementation

The exploratory BIM approach implemented in the Belvedere district demands a CIM approach. The territory is vast (10ha) and the time of construction long (10ans). To meet this double challenge, the following actions are undertaken:

- Between 2015 and 2016, structuring of the approach: identification of areas of improvement and BIM objectives in the design, construction and management of new infrastructure,
- Starting in 2015, the developers of the project will be involved in the CIM process (registration of BIM objectives in the sales promises: follow-up of the developed floor surfaces, sent using textured envelopes),
- Since 2015, collaboration with the Bordeaux metropole on interoperability by data formats (IFC, FBX, SHP, ...) to feed into the various tools used,
- In 2016, agreement on the objects to be modelled and data to be implemented for the urban technical coordination in the design phase,

- Since 2017, design, technical coordination and urban visualization using BIM data in the design phase (public spaces and buildings),
- In 2018, realization of a VR model from the InfraWorks visualization model
- Since 2018, support to the BIM structuring of the regional civil companies by holding regular workshops with the regional civil federation (presentation of the work carried out, sharing of objectives, definition of experimental work areas, adaptation of the level of requirement to reality of the sector) to ensure the construction in BIM (speaking to contractors, completion of construction),
- End of 2019, taking into account the expectations of future operators for the specification of the as built information,
- End of 2019, consultation of the first public works contracts of the public spaces with the BIM model (help with the understanding of the model),
- In 2020, experimentation in the construction phase: coordination on site from BIM for construction models - buildings and public spaces,

Structuring of the process

The area design team is composed of:
- 1 developer
- The multidisciplinary team "public spaces" (urban planner, landscaper, engineer)
- 5 real estate operators
- 14 multidisciplinary teams for private lots (architects, design offices)

To ensure coordination of all actors, the following organization has been set up:
- a coordinator BIM for all lots, SXD (client = developers)
- a BIM coordinator of the public spaces and CIM Manager of the whole operation, INGEROP, (client = Bordeaux Euratlantique)

Each coordinator is responsible for collecting and publishing the BIM models. From the BIM models, two types of CIM models are produced by INGEROP:
- a model aiming at the technical coordination between public spaces and private lots
- a model with the objective of urban immersion

CIM organization
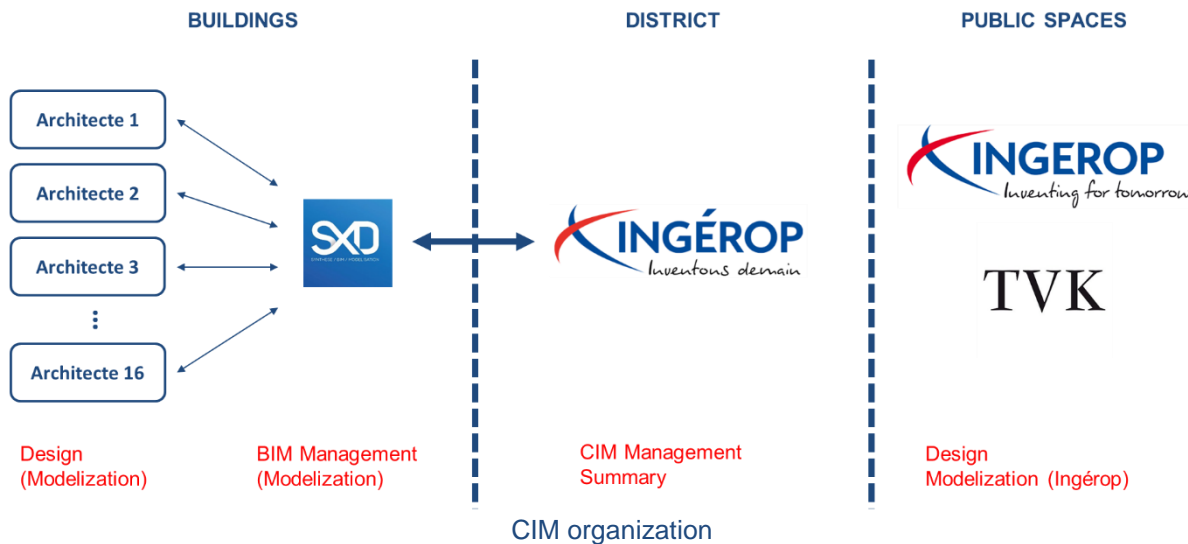
Use cases for design stage

Prior to the design, the structuring and the formalization of the process were necessary. Starting from scratch, we have drafted BIM conventions at the Belvedere level that define the objects and data to be modelled for public spaces and public / private interfaces.

Specifically, in the design phase, the following BIM uses were selected:

- At the urban scale (CIM)
- o Technical coordination at public / private spaces interfaces
- o Urban immersion

- At the scale of public spaces, in addition to the elements needed to meet CIM uses
- o Technical coordination of public spaces
- o Production of design deliverables

- At the scale of the buildings, in addition to the elements necessary to meet the CIM uses
- o Program monitoring

Decomposition of models

It is during the drafting of the BIM conventions that the data to be generated have been codified and configured to meet the identified BIM uses. These agreements include all the expected elements by phase including:
- Geometric Level of Detail (LOD)
- Geometry type
- Alphanumeric data
- Modeling tool (s)
- Contributor
- Identification code by object family

AEC Collection for a complex urban project

The Autodesk AEC tools were used to create the CIM approach. The main tools used are Revit, Civil 3D, InfraWorks and 3DsMax.

The diagram below summarizes the productions and interfaces between tools.

AEC collection workflow for city information model
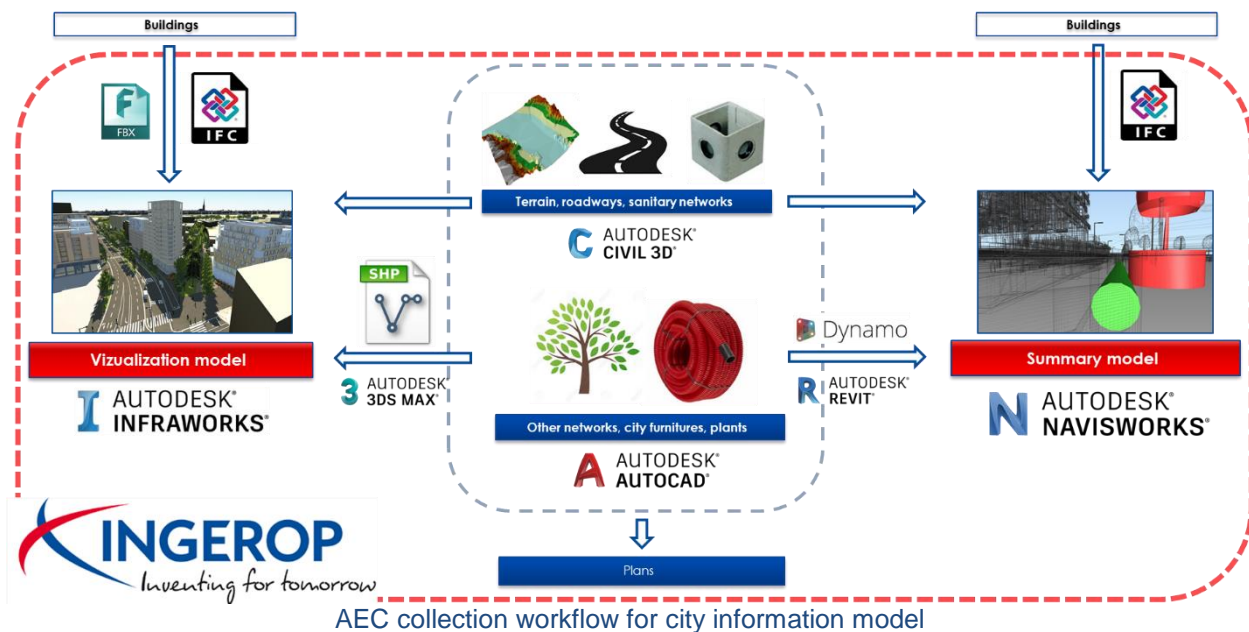
The following paragraphs will detail the workflow methodology of the following themes:
- Modelling public spaces
- Creation of the Navisworks summary model
- Creation of the InfraWorks visualization model

Civil 3D & Revit - Modeling public spaces

All components of the public spaces project are modeled in the coordination model:
- Existing surface
- Highways
- Squares
- Tracks/paths/footpaths
- Existing and projected services
- Green spaces
- Plants
- Urban street furniture

Uniqueness of the data in the production of design plans and models of public spaces has been one of our main objectives. Thus, from the same data, we were able to undertake the technical design plans of the public spaces, the coordination models and the urban immersion model.

Specifically, the plans produced with Civil 3D, whose modelization is common to the models are the following:
- Horizontal and vertical geometry
- Grading plan
- Drainage network plan
- Drainage network longsection
- Earthworks plan
- Cross sections

Given the BIM maturity of the other designers of public spaces, the rest of the plans (plantations, furniture, dry networks) were produced with AutoCAD. The modelling of these objects was carried out after their design.
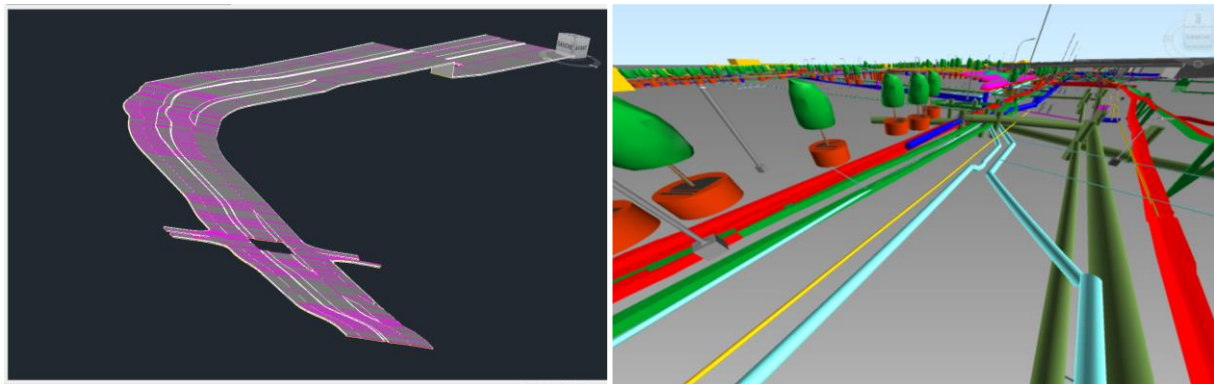
Public spaces models - Civil 3D & Navisworks

In the first phase of detailed design, we sought to create all objects as 3D solids from Civil 3D. This involved the following objects:
- Roadways: 3D Corridors
- Squares: Feature lines & Surfaces
- Drainage networks using the Gravity networks module
- Other networks: Feature Lines & 3D Corridor
- Street Furniture, plants: Multi-view blocks
- Signage: Multi-view blocks
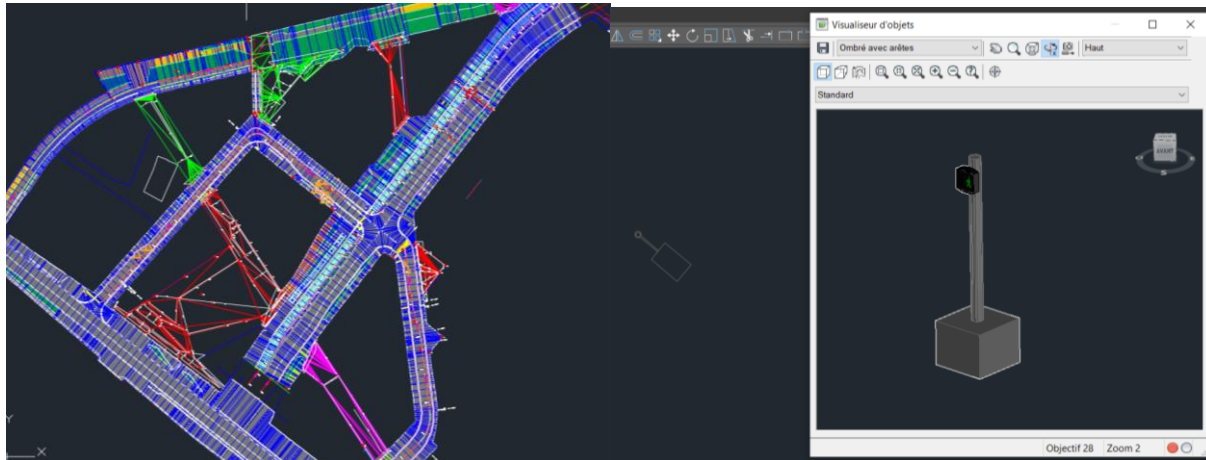
Public spaces models - Civil 3D – Roadways & squares & signage

Given the planned developments, especially on sidewalks and roadways, we sought to implement the following methodology in the production of corridor that allows us to follow design changes while remaining flexible:

- Construction of a corridor by homogeneous element - pavement, right sidewalk, left sidewalk
- Construction of the corridor centreline along the centreline of the roadway
- Extraction of the Feature Lines edges with dynamic links
- Use of extracted Feature Lines for sidewalk corridor construction
- Calculation of the roadway crossfall to the axis

An issue encountered was that the sidewalks change often with respect to the centreline. The corridor therefore must include many standard profiles. Although feasible, their construction is very time consuming especially as the project involves.
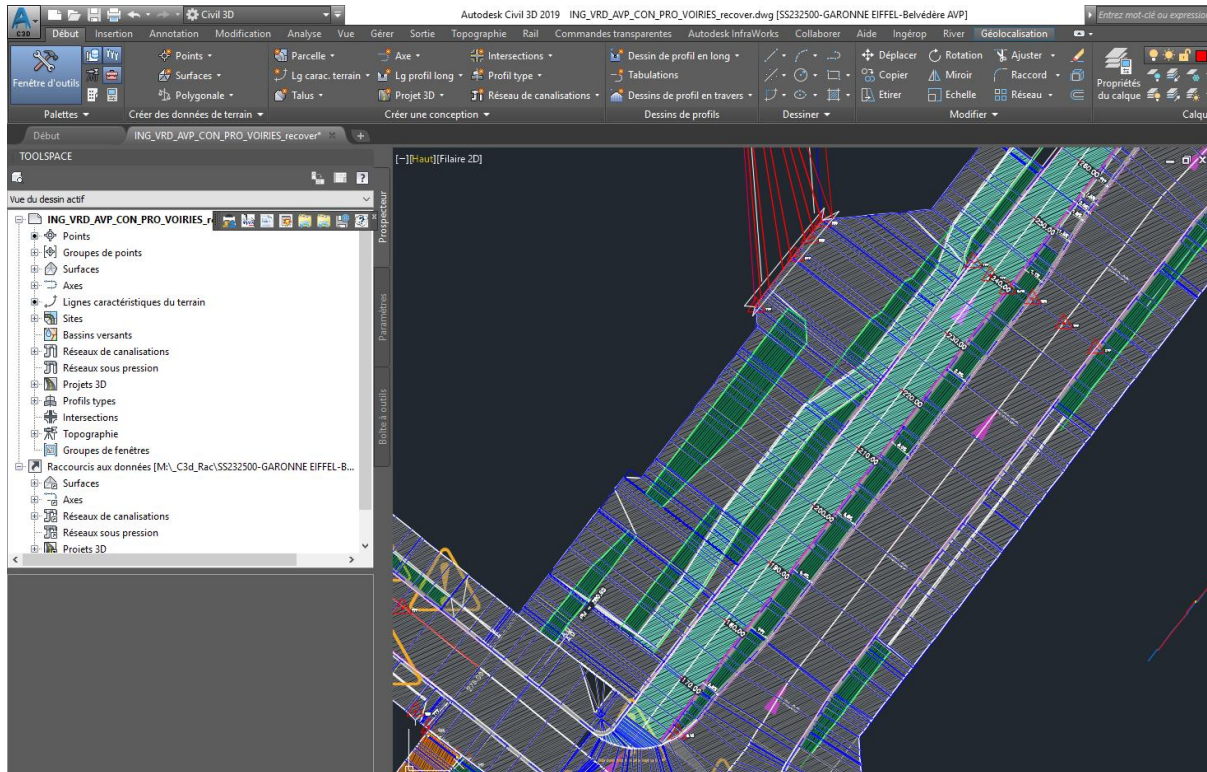
Public spaces models - Civil 3D – 3D corridors for sidewalks

In the second phase of design, we optimized the production of these elements by modifying our method. In this new method, we sought to model the surface of sidewalks without considering the nature of the existing surface. We then integrated the projected surface through:

- The integration of polylines defining the contours of each surface type
- Transformation of polylines in Feature Lines, attached to the surface output from the corridor of each sidewalk
- Surface modelling for each sidewalk pavement from created Feature Lines and the "fill" slope function

Finally, we applied this principle to all project surfaces. The grading of a project is a priority in the design since it is a vital input to other design elements (underground networks, street furniture, building thresholds ...). We therefore sought to create a global surface of the entire project, consisting of the copying all the individual surfaces to one overall surface. The use of Feature Lines plated on this surface and the filling function of the slope tool allowed us to integrate the nature of the soil on the entire project.

A second area of improvement was sought concerning the management of street furniture, plant and street lighting libraries along with the production of alphanumeric data associated with each object. For this undertaking, we decided to use Revit due to its ability in the creation of parametric families in place of the use of multi-view blocks in Civil 3D.

In addition, we also decided to model the non-drainage networks (ex. Electricity) via Revit because the Feature Lines & 3D Corridors method was considered too laborious.

For these 2 cases, we used Dynamo to achieve the following:
- Automatically insert infrastructure in Revit from an AutoCAD plan: an AutoCAD block corresponds to a Revit family.
- Automatically model networks in Revit from an AutoCAD plane: each network is drawn by a polyline in a layer and corresponds to a Revit family.

The topographic surface was then created by exports of the overall surface of the project produced with C3d contours at 2cm intervals.

Navisworks - Summary model

The creation of BIM models of all the project infrastructure allowed an easy technical summary of all these infrastructures. After analysis and aggregation of the BIM models (buildings, public spaces) by the CIM Manager, a federated CIM model is created under Navisworks to carry out this summary.
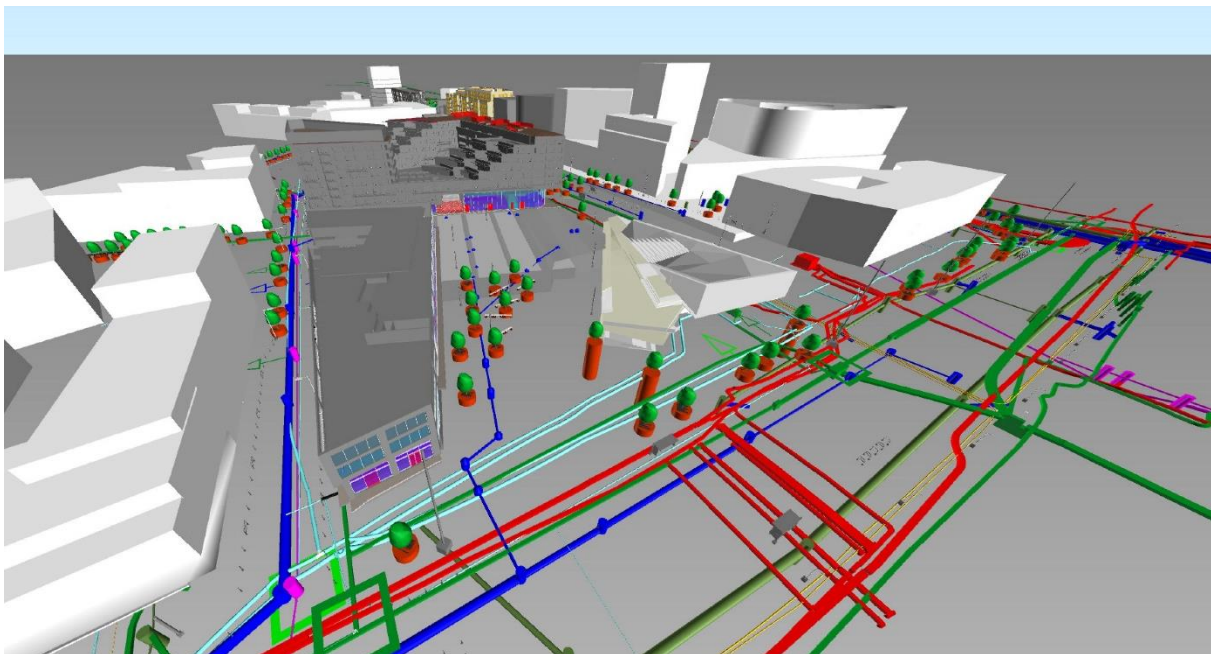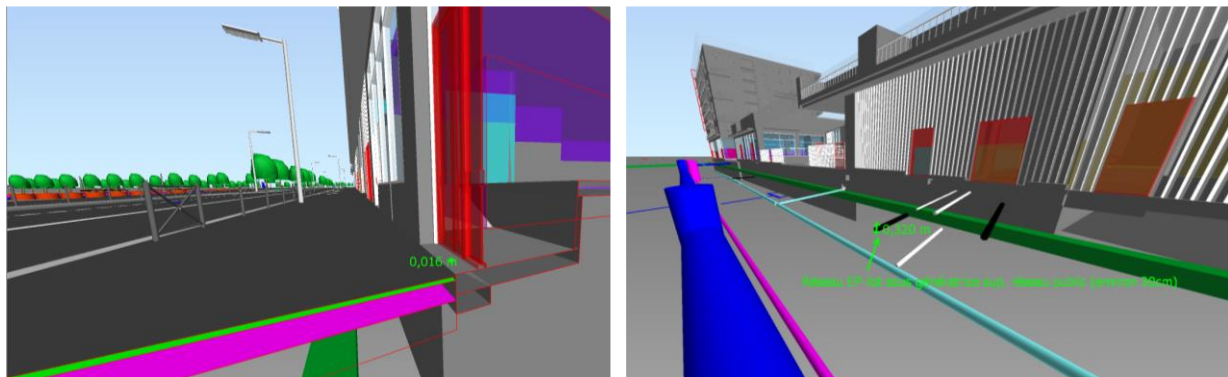

Summary model - Navisworks

On public spaces, the main clashes were carried out on underground structures, namely services (existing and planned), plants and street furniture.

The technical coordination, dealing with public / private spaces interfaces through the model, allowed us to deal with the whole area:
- Boundaries – public/private,

- Interfaces of accesses (position, levelling, function),
- Services connections,
- The location of accesses, plants and street furniture in the lots,

After analysis and aggregation of BIM models (buildings, public spaces) by the CIM Manager, a federated CIM model was created using Navisworks. This model serves as a basis for analysing the interfaces between public and private by the CIM Manager.

Summary model - Navisworks

The diagram below shows the interfaces between tools for the creation of the summary model.
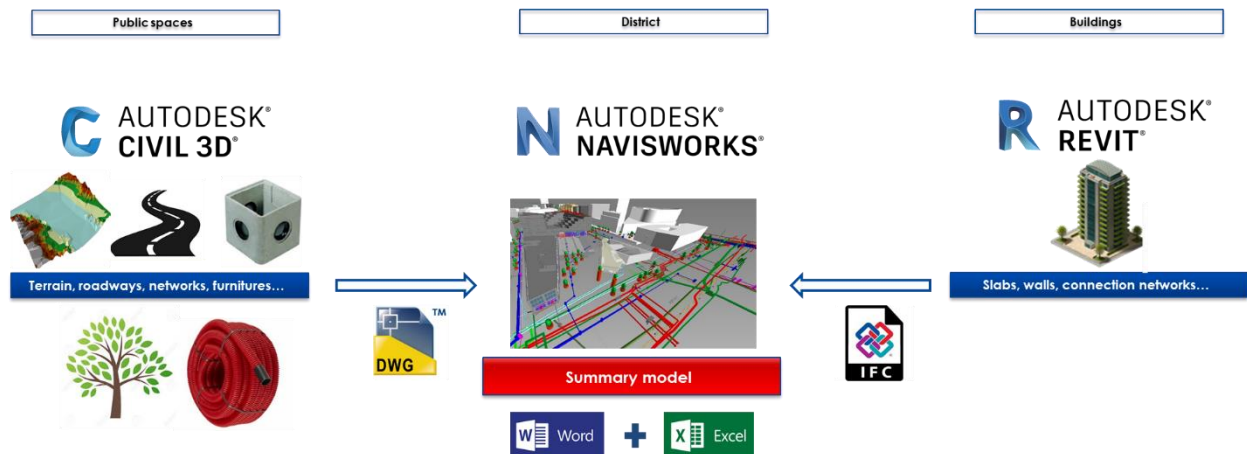
AEC collection workflow for urban summary

In Navisworks, the model is configured (selection games, codified views, clash detection) to help in the treatment of summary issues. A summary table, in connection with the codified views, supports the model and is a deliverable. This summary table is easy to use and allowed us to involve all stakeholders in the first phase of coordination. On the basis of the analyses carried out by the CIM manager, monthly coordination reviews are organized to share the adjustments to be made.

For technical coordination, raw data, federated CIM models and analysis reports are shared on a BIM web platform.

InfraWorks - Visualization model

In parallel with the coordination, an immersive urban model was created with InfraWorks.

Vizualization model - InfraWorks

This model aims to realistically represent the project area directly from the design modelization. The structure of this model is also by object, so it is an immersive CIM model. This model is a useful digital urban tool, demonstrating the neighbourhood of tomorrow.

The goal of this model is twofold:
- present the neighbourhood project at a given moment
- to allow the update of this urban base by the new project lots and the evolutions of project over time

This model is intended for a very wide audience:
- designers to validate their proposals during the design phase
- decision-makers to help understand a complex urban project

It can also be beneficial to citizens, allowing them to participate in the development of their neighbourhood.

Vizualization model - InfraWorks

The diagram below shows the interfaces between tools for the creation of the visualization model.
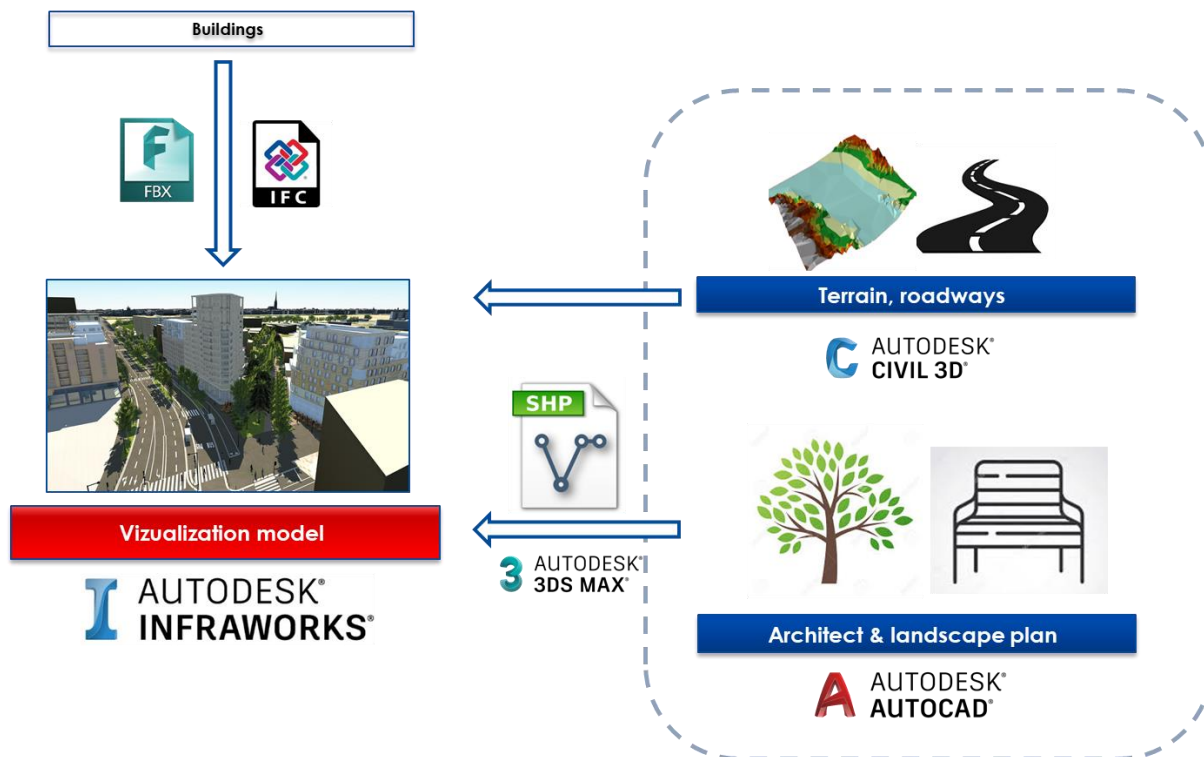
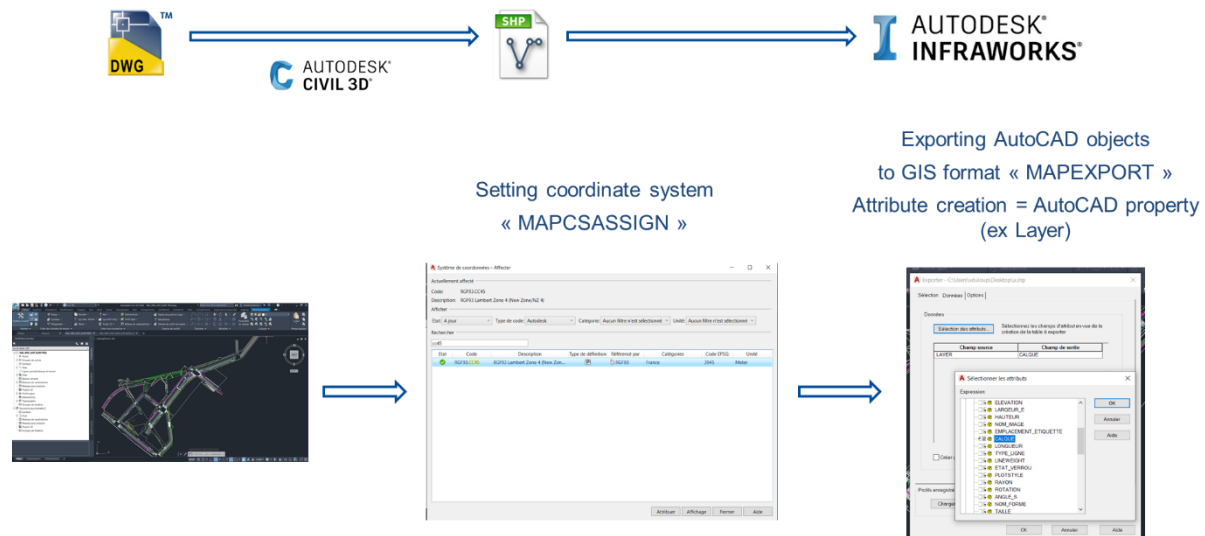AEC collection workflow for urban vizualization

We used InfraWorks as a visual aggregator of data. The data integrated are as follows:

- Urban context buildings: CityGML – Information obtained from the city of Bordeaux
- Urban context topography: dwg Civil 3d - Triangulated surface modelled on the basis of polyfaces. Information obtained from the city of Bordeaux
- Urban context images: Rasters - Information obtained from the city of Bordeaux
- Project topography: dwg Civil 3d - Triangulated surface modelled from survey
- Project grading: dwg Civil 3d - Triangulated surface resulting from the design project
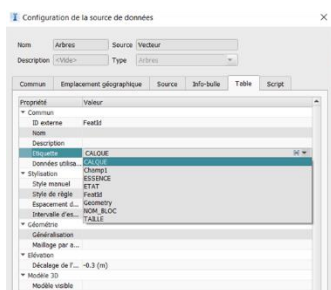
- Project buildings:
- Stage Sketch - SHP – Building footprints with height attributes
- Planning application / preliminary design information - Fbx or IFC - Made available by the different lots
- Pavement finishes - SHP - Polygons delimiting each zone from the project masterplan (AutoCAD). Each zone has an attribute that indicates the nature of the pavement finish
- Emergences (furniture, trees,) - SHP - Points correspond to each emergence from the AutoCAD project masterplan. Each point has an attribute that indicates the nature of the emergence
- Planted tree areas - SHP - Polygons delimiting each tree area from the projects AutoCAD masterplan. Each zone has an attribute that indicates the nature of each tree

It should be noted that the existing and proposed underground services are not represented in this model since they are not used for the visualization of the project.

The workflow below details the integration of AutoCAD generated elements into InfraWorks via the SHP format produced in Civil 3D.

Setting coordinate system
« MAPCSASSIGN »

Exporting AutoCAD objects
to GIS format « MAPEXPORT »
Attribute creation = AutoCAD property
(ex Layer)

Importing GIS datas in Infraworks
Assignment of the attribute to a
free field (ex Tag)

Creation of a rule style
Expression : Tag = 'attribute value'
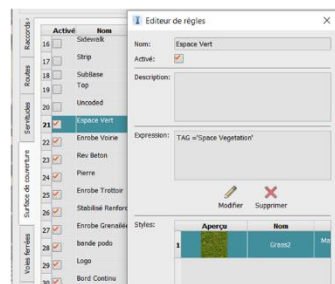
Workflow from AutoCAD to InfraWorks

The same method is used to integrate the planted tree areas. However, assigning multiple plants to one specific style leads to a uniform distribution in each zone, not the random distribution originally required. To overcome this problem, we superimposed each species making up the zone and modified the following parameters:

- **Object spacing:** define the distance between the features on a regular basis. For a polygon feature, this is a regular grid. For a polyline feature, this is the distance between two objects along the polyline.
- **Object spacing variance:** define how far the position can change on a random basis. Specify a value between 0.0 (fixed) and 1.0. The value represents the distance each 3D model can move (in meters or the user-defined unit of measurement) from its regular position.