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Connecting BIM and GIS: The New Reality of Environmental Projects

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Learning Objectives

- Learn how to close the gap between GIS and BIM.
- Discover the advantages of using mixed tools.
- Discover the benefits of looking beyond.
- Learn how to apply a BIM approach for a map-based industry.

Description

While talking about BIM (Building Information Modeling) and geographic information system (GIS) integration, it is clear that these are two systems with their specific purposes and use cases: GIS, with its mapping features and geographical database, and BIM as an object-based information model, tailored for built assets. The connection between the two platforms is advancing and gaining credibility, especially in large complex projects. Architectural and civil projects tend to use BIM technologies, while environmental projects are traditionally carried out using GIS systems. In this class, we will look beyond the standard use of 2D maps, GIS layers, and shapefile sets. We will go through all the benefits, challenges, and differences between using GIS and BIM technologies. The adoption of 3D and BIM processes and technologies will largely benefit the environment and remediation industries. It will open the door for more-inclusive stakeholder engagement, better design quality, and data-driven decision making.

Speaker

Pal Porkolab is a qualified civil engineer M.Sc. with more than 10 years of professional experience. His field of expertise is in applying BIM technologies for infrastructure projects, especially for roads and rail linear assets.

He is currently working as a BIM Manager for Arcadis North America and he was employed by the same company in the past several years in Germany and India.

Pal is a second time speaker at the Autodesk University this year. The topic of his previous class from 2018 at AU Germany was about implementing 3D and BIM technologies in the rail design.

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Introduction

As BIM and general 3D design technologies are advancing in the AEC industry, the application in the infrastructure sector is getting broader and broader. There are pretty extensive pilots and proof of concepts already out there and lot of buzzing is happening around digital twins and connected city models and smart cities. The advancement is happening even in the large-scale infrastructure projects, where complete corridors and networks of infrastructure assets are getting virtualized and connected.

Considering that the environmental discipline is an organic part of almost every project, especially in the infrastructure industry, the question is getting more and more relevant:
What about implementing BIM workflows in the environmental industry? Or in other words, how can we integrate environmental information into BIM projects?

The benefits and needs are in fact not different in the environmental industry. Large scale, long lasting projects, numerous stakeholders, different aspects, and area of interests. Benefits of BIM and digital twin workflows, connected and centralized data management systems, interactive and cloud based delivery, eliminating data loss during handover and lifecycle management, digital twins for the entire asset lifecycle are valid and key requirements for all kinds of projects regardless of the discipline and scope.

In this class we will talk about how the BIM approach can be implemented in such projects, what are the main differences in the most used technologies (BIM and GIS) of the AEC and environmental industry. We will cover some challenges and use cases in bringing together the different platforms.

What is BIM?

BIM is having many different definitions, regarding to the field of deployment, understanding of users and stakeholders, use cases and so on. I used to say BIM is nothing but a new way of communication, where we are using virtual representations of design objects as media, connected preferably in the cloud.

According to this Wikipedia page a simple and straightforward definition given by the American Institute of Architects is:

“The American Institute of Architects has defined BIM as "**a model-based technology linked with a database of project information**", and this reflects the general reliance on database technology as the foundation. In the future, structured text documents such as specifications may be able to be searched and linked to regional, national, and international standards.”

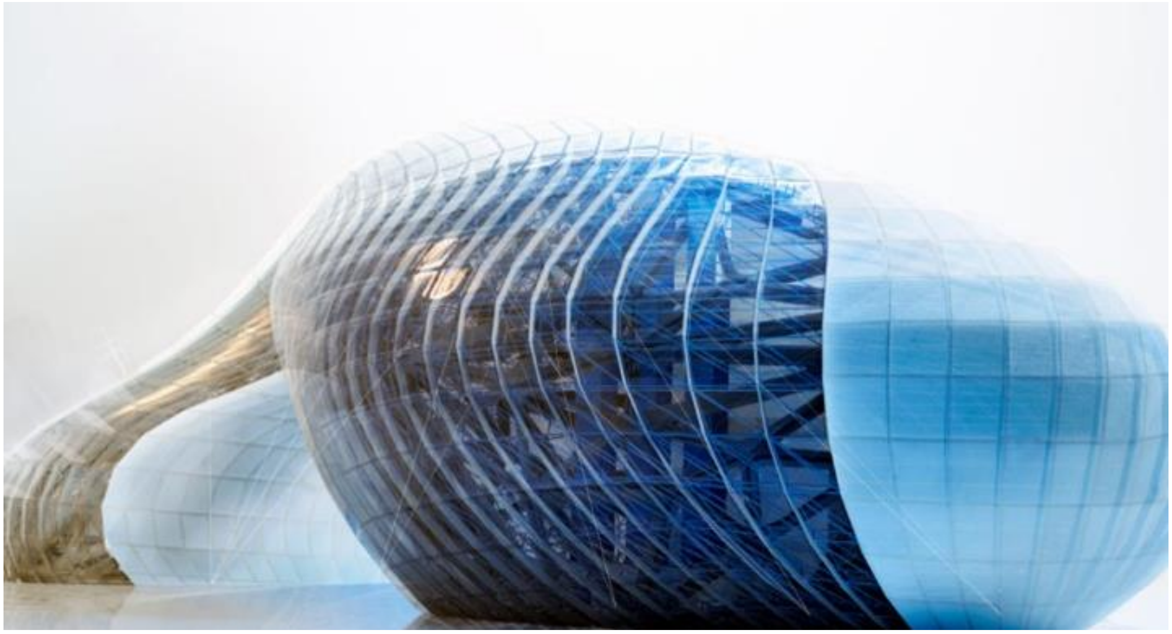
What is GIS?

Just like BIM, GIS has also many different definitions, but probably because of its longer history, stating back its origins to 1968, it is already a well-known technology in the industry. The professionals in the industry are mostly aware of the GIS applications, capabilities, features and available software. By the advancing technology working with 3D features inside of GIS systems and being able to produce and manage 3D objects is getting more and more popular.

Referring back to its main purpose a definition from [Wikipedia] can be found below:

"A geographic information system (GIS) is a conceptualized framework that provides the ability to **capture and analyze spatial and geographic data**. GIS applications (or GIS apps) are computer-based tools that allow the user to create interactive queries (user-created searches), store and edit spatial and non-spatial data, analyze spatial information output, and visually share the results of these operations by **presenting them as maps**."

BIM and GIS



BIM

- 3D representation of assets using complex geometries
- Rich database of attribute information
- Structured platform
- Analytics and evaluation

GIS

- 2D representation of large-scale geospatial shapes
- Rich database of attribute information
- Structured platform
- Analytics and evaluation

BIM and GIS similarities and differences

So what is truly common in both platform? As we have seen BIM is 3D representation of complex geometries connected with property data. GIS is doing more or less the same, it is about representing 2D large scale geospatial shapes connected with property data.

The key here is the data and the way of representation of this data. Property Data is an overarching theme in both BIM and GIS systems. As both platform's focus is on the data, the question is how these databases can be connected. Integrating the database of both platforms is going to be crucial in the new age of data regardless of its representation methods (2D or 3D). Once the data (including geometry data) is available in a structured and connected way the evaluation, analysis, representation of this data can happen in various and automated ways in 2D or 3D. This means, we are moving from application and output driven workflows towards the data driven workflow.

Does GIS always require 3D representation? Probably not, it is more important to have a proper data repository in place.

What is missing in GIS from a BIM perspective?

As we have discussed above the approach is the same in GIS and BIM, where we have object-based representation of information. Data, database, and objects, to represent them in the GIS works, are available. Here we need to consider the building blocks of the standard GIS representation. Not talking about the raster data, we are going to briefly cover the vector data.

Points

Zero-dimensional points are used for geographical features that can best be expressed by a single point reference

Lines

One-dimensional lines or polylines are used for linear features such as rivers, roads, railroads, trails, and topographic lines.

Polygons

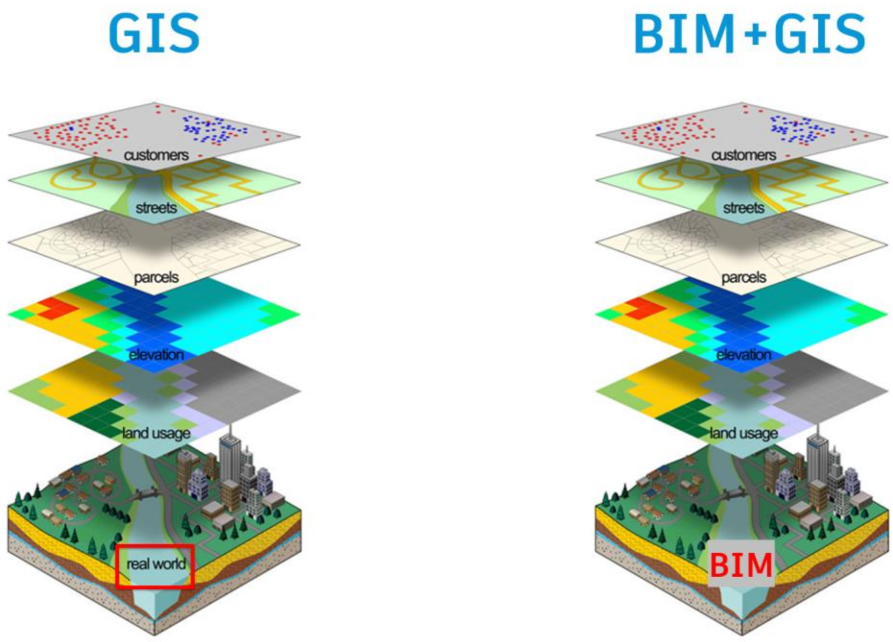
Two-dimensional polygons are used for geographical features that cover a particular area of the earth's surface.

https://en.wikipedia.org/wiki/GIS_file_formats

We can clearly see the complexity of the above geometries are low and we are not able to talk about fully developed Revit families or standard object libraries in case of GIS contents. And this makes the integration of both platforms challenging besides the connected database.

Connecting BIM and GIS

After integrated or connected database the question is how to put GIS data into the 3D BIM environment.



Content structure of GIS and BIM

On the left side we can see the regular GIS content structure. At the very bottom the real world, which is usually not represented in the GIS system, on throughout using a base map. On the top of this real world base map different thematic layers are displayed and being used to spatial evaluation and generation of further contents. The layers tend to be as 2D geometries or shapes with elevation data.

On the right side instead of using a base map for representing the real world, let's consider the BIM model and a connected/integrated database for both BIM and GIS platforms.

If we put the 2D layers on top of a BIM model, let us say by draping thematic maps and layer on a terrain surface would we achieve with this to connect both systems? By only plotting, adding 2D reference GIS layers into an existing BIM model will not solve the dysconnectivity issue and won't necessarily bring closer the different applications. How would be possible with this to run complex spatial conflict checks or do quantity extractions and 3D model coordinations?

With this experiment we can say ideally it is not enough to integrate data bases and reference together GIS and BIM contents into a same model space only, but some kind of conversion of GIS contents needs to be done in order to bring all the BIM and GIS contents into the same level.

Workflows

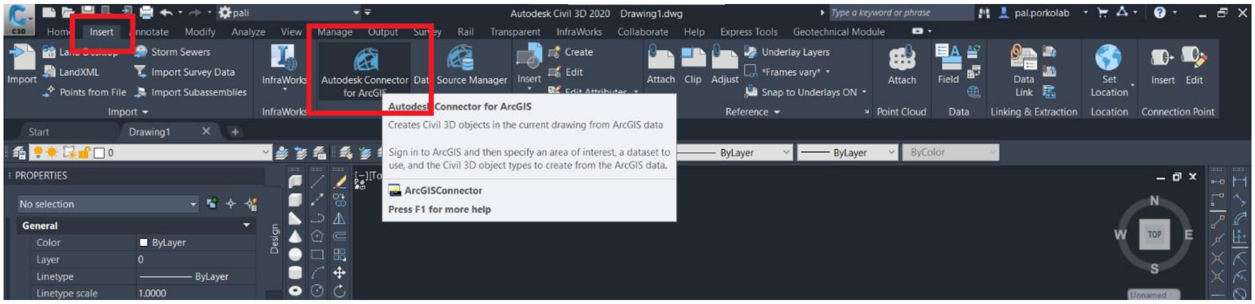
In this chapter we are going to show and discuss some potential workflows how to load and convert GIS data into BIM environment. We are going to show standard and customized workflows with their advantages and disadvantages. In the workflows we are going to briefly mention different software applications and features, not focusing on a single one only.
The dataset we are going to use to demonstrate is either publicly available online or created only for the demonstration purposes and not having any real live references or meanings. Still we were trying to establish a workflow which can reflect to a potential real-life use case in the environment industry.

The following applications are in use, focusing on their capabilities to deal with standard environmental and GIS natured data:

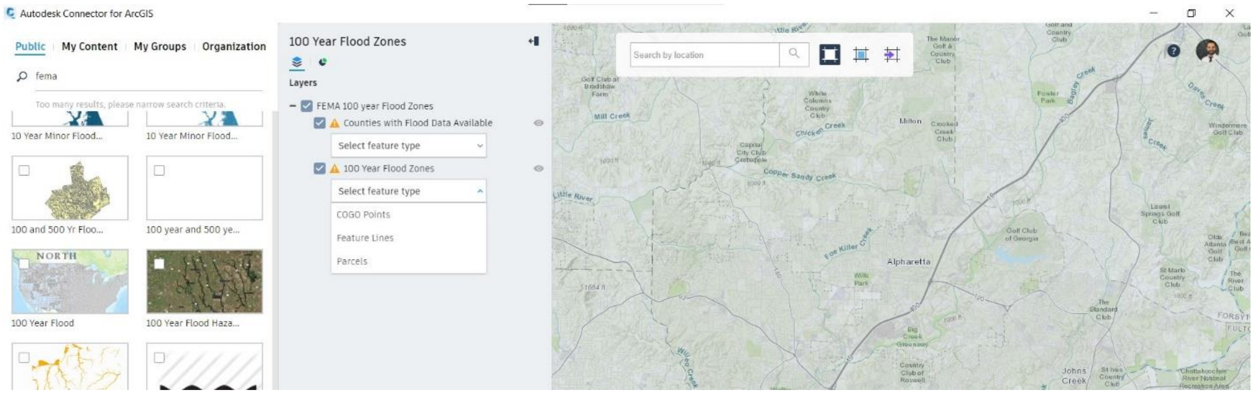
AutoCAD Civil3D,
Infraworks,
Autodesk Connector for ArcGIS,
Dynamo,
Python,
ArcGIS API,
Navisworks,
ArcGIS Online / ArcGIS Enterprise

Autodesk Connector for ArcGIS with Civil3D (and Infraworks)

With the ArcGIS connector we can establish a live link in between GIS contents hosted in ArcGIS Online or Enterprise and Civil3D. This link can work both ways by loading in and converting predominantly shape files or any other GIS contents into the Civil3D environment while converting it into CAD objects. The associated property data is going to be loaded along with the content conversion.



After selecting the tool, a login window appears where the ArcGIS credentials need to be used to login into the ArcGIS Online account.



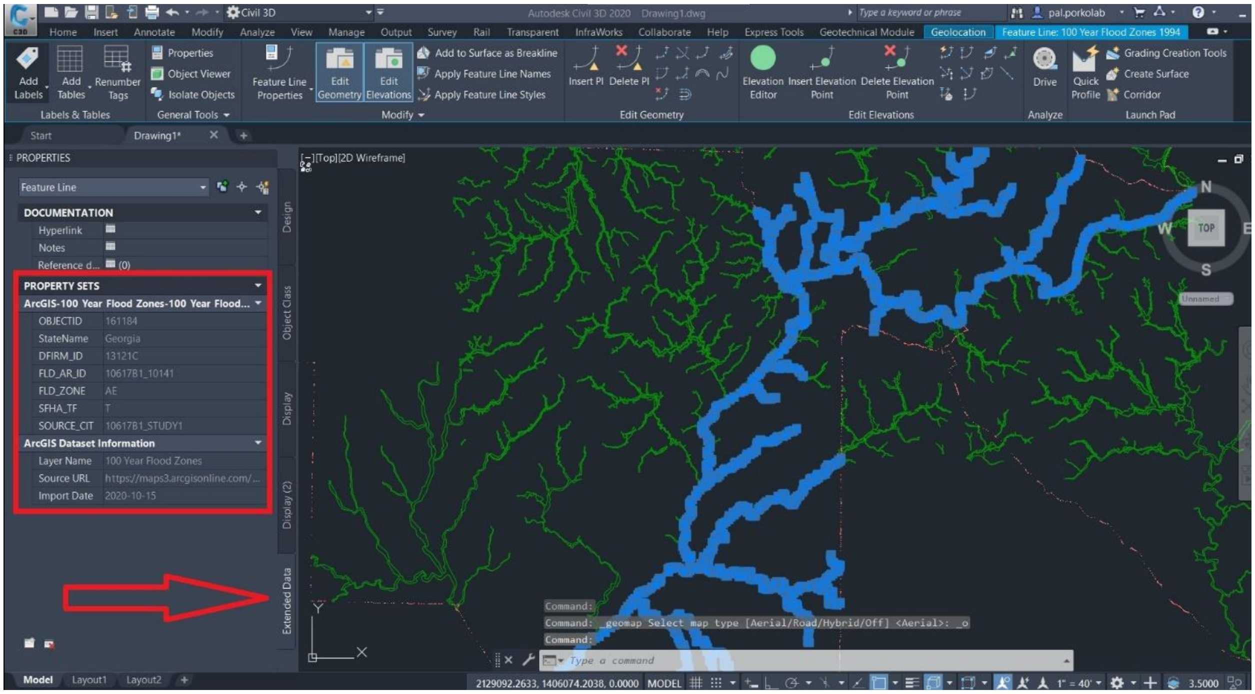
Selecting the area of interest and looking for the wanted content in the search bar the GIS layer can be loaded and converted into various ways into the Civil3D environment.

<u>Available feature types in Civil3D:</u>

COGO points
Feature lines
Structures
Parcels
Gravity pipes
Alignments

The available feature types providing only a limited use and options to be able to truly convert GIS data into BIM objects. The available feature types more serving the creation of CAD objects from the GIS content (COGO points, feature lines). With the option structures 3D BIM Civil3D objects can be generated, although only with some predefined object types such as manholes, and mostly drainage components.
The option Parcels can be also limited to convert shape area feature into BIM objects, since the loaded GIS content not always represents parcel information.
The tool is really useful when it comes to gravity pipes, especially when the hosted GIS layer has all the elevation and dimension information.
After referencing and editing the content in Civil3D, the changes can be saved back into ArcGIS Online, so that the hosted layer on ArcGIS Online will be updated.

The same tool is available for Infraworks too, where as feature types, there are more options available. Although editing or generating customized 3D objects is also limited in that application.



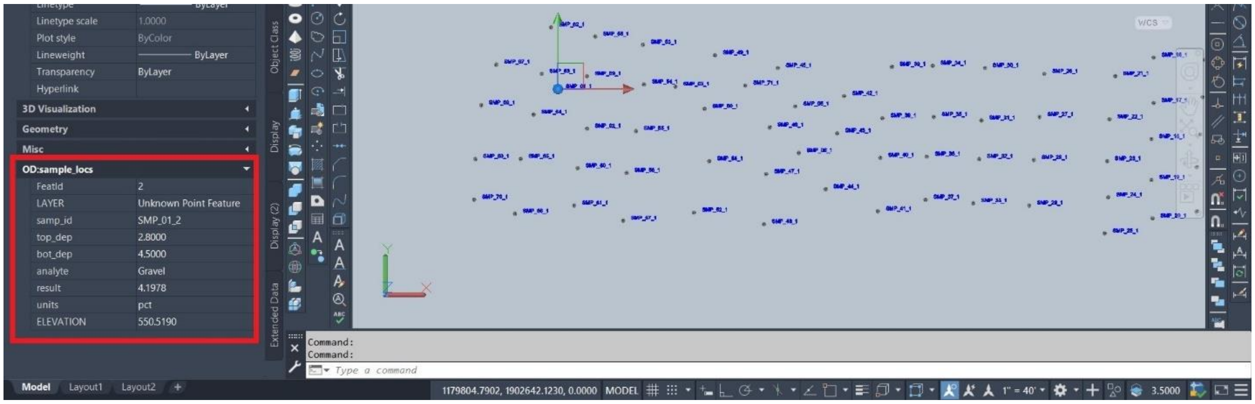
After loading the selected content, the CAD objects are getting available for edit in Civil3D. We have highlighted the loaded property sets coming from the GIS data base along with the geometry data. The tool is population the property sets under the Extended Data tab, which, after eventual editing, can be still accessed in Navisworks, where the final BIM model coordination can happen.

With this workflow we can reference in GIS content straight forward into Civil3D and Navisworks, although the content definitely needs to be converted from simple CAD into 3D objects to be able to make use of the GIS content in BIM environment. Otherwise we would have only loaded 3D polygons and points in the federated BIM model.

Mapimport command in Civil3D

This is the old-fashioned way to load shp or other GIS type of files into Civil3D workspaces. The result will be similar as we have seen this using the ArcGIS connector. Other limitations here are that the data needs to be downloaded and is therefore essentially offline, which makes the potential automation effort difficult and the connected database is not anymore considered.

While loading similar content into Civil3D using the mapimport command, the read property sets are appearing in the properties window under the section Object Data. This type of properties is not anymore recognizable in Navisworks where ideally the final model coordination should happen. This means we are losing information while transferring the data into the federated model.

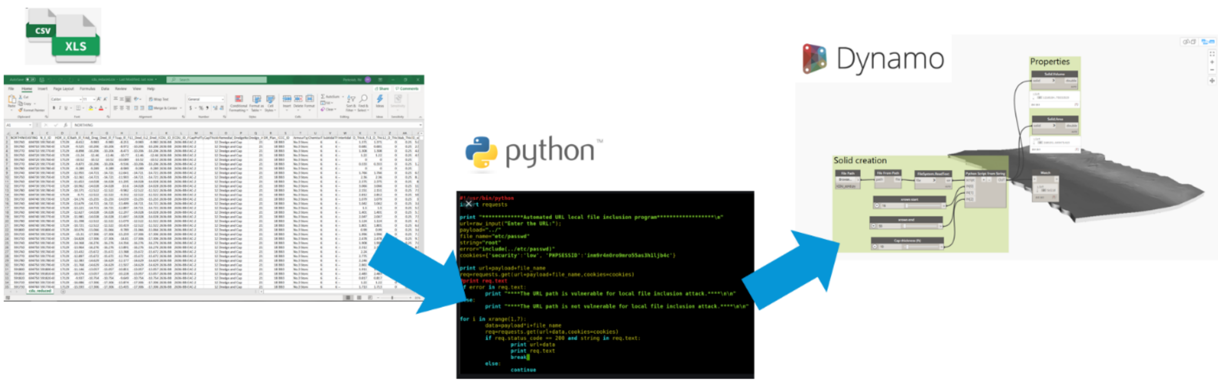


Customized workflow

In this chapter we are focusing on potential workflows where we can solve the challenges we have seen in the above standardized ways. Meaning creating flexible 3D objects based on the loaded geometry and solving the attribution while generating the objects to make sure the information is going to be still visible after adding the content into the federated model.

With the combination of the following applications we can ensure the flexibility of data conversion:

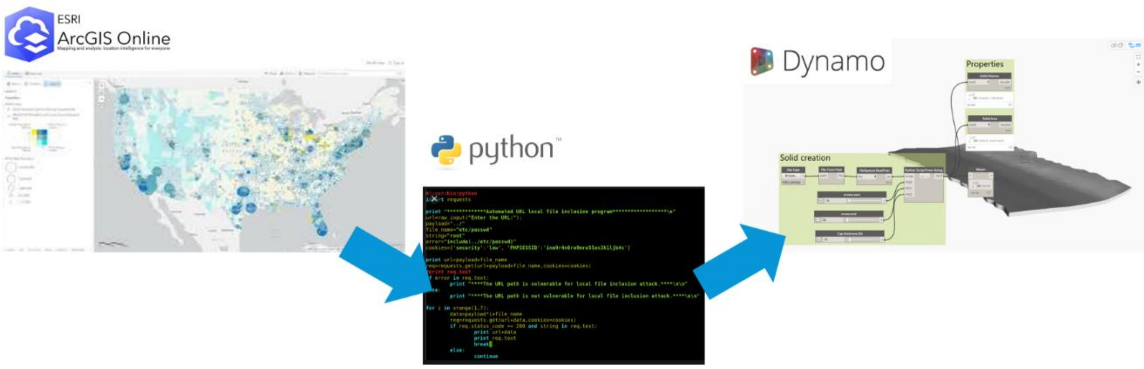
Data source (online/offline) → Python for data processing → Dynamo (C3D) for modeling → Civil3D/Navisworks for hosting



Obviously, this needs more technical knowledge and creating 3D models need to be solve programmatically. The workflow can be "downgraded" to use only Dynamo to read and convert source data in simpler cases where we do not need to deal with complex data structures.
In the above example we have a csv file containing information about a terrain model with coordinates, elevation data and other properties such as material, layer configuration, applied

thicknesses etc. The Python script is reading the dataset and restructuring it into the format to use them as input for the available Dynamo nodes. Once the data is structured and loaded to Dynamo the object is generated and additional attribute sets are assigned.
This workflow clearly enabling the flexibility to generate complex objects (terrain, earthworks, etc.).

The above-mentioned workflow can be eventually automated with using the ArcGIS API directly in the Python script.



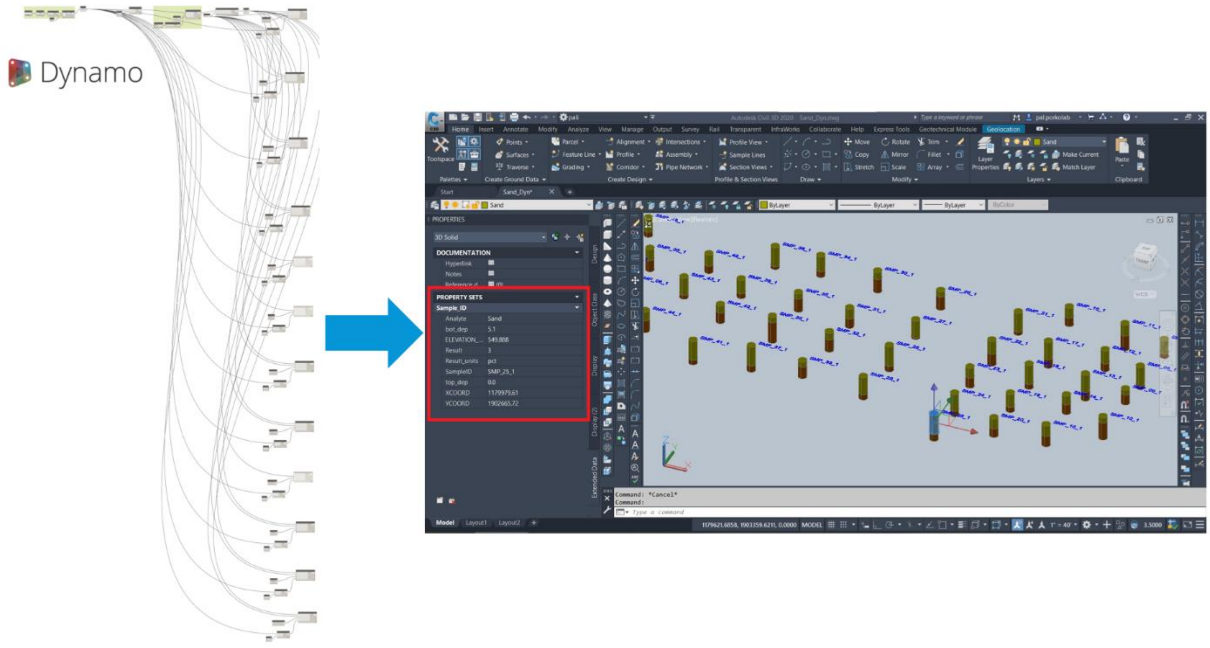
In this way we can eliminate the data connectivity issue and not anymore using offline sources, but directly from the GIS data repository.

The following Python library and class can be used to query and read data from ArcGIS online:

```
from arcgis.gis import GIS
search_results = gis.content.search(query=query, max_items=10)
```

More information about the API can be found in the ArcGIS API documentation:
https://developers.arcgis.com/python/guide/using-the-gis/

With this customized workflow the GIS data conversion is flexible and automatized. We can generate complex geometries and keep the attribute information. This workflow enables the automation in case of regular updates or change in the data set or attribution.


Dynamo