L1.2 BIM-GIS Integration Workflow

Lecture Notes

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Summary

The lecture starts by comparison of different integration approaches, their advantages and disadvantages. Then, it describes how the integration proceeds, takes up the steps in the workflow and explains what parts of the models are to be integrated. The lecture discusses even data quality and possible issues to care of in the process.

Learning outcomes

At the end of this lecture, the learner is expected to be able to:

Name different integration approaches

Know the steps in the integration workflow

Understand importance of data quality and possible issues of the conversion

Expected competences when entering the lecture

Knowledge of BIM and 3D GIS corresponding BIRGIT courses Introduction to BIM and 3D GIS, City Models and Digital Twins and completed L1.1

Expected workload

9 slides with information and accompanying text, approximately 1 hour

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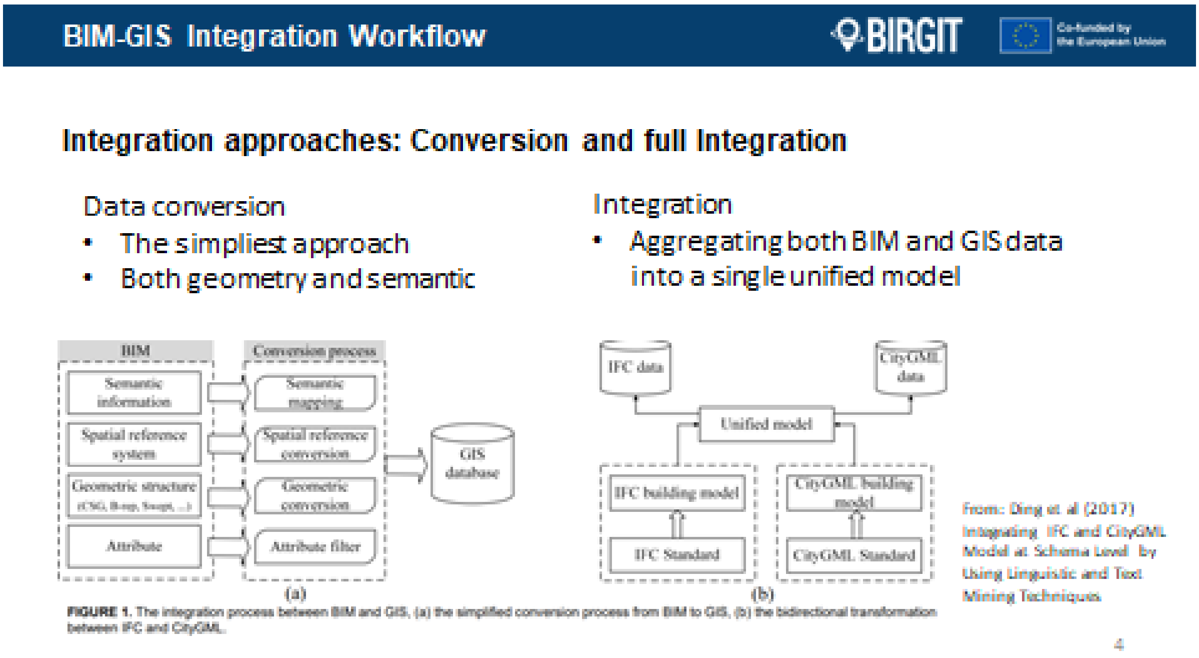


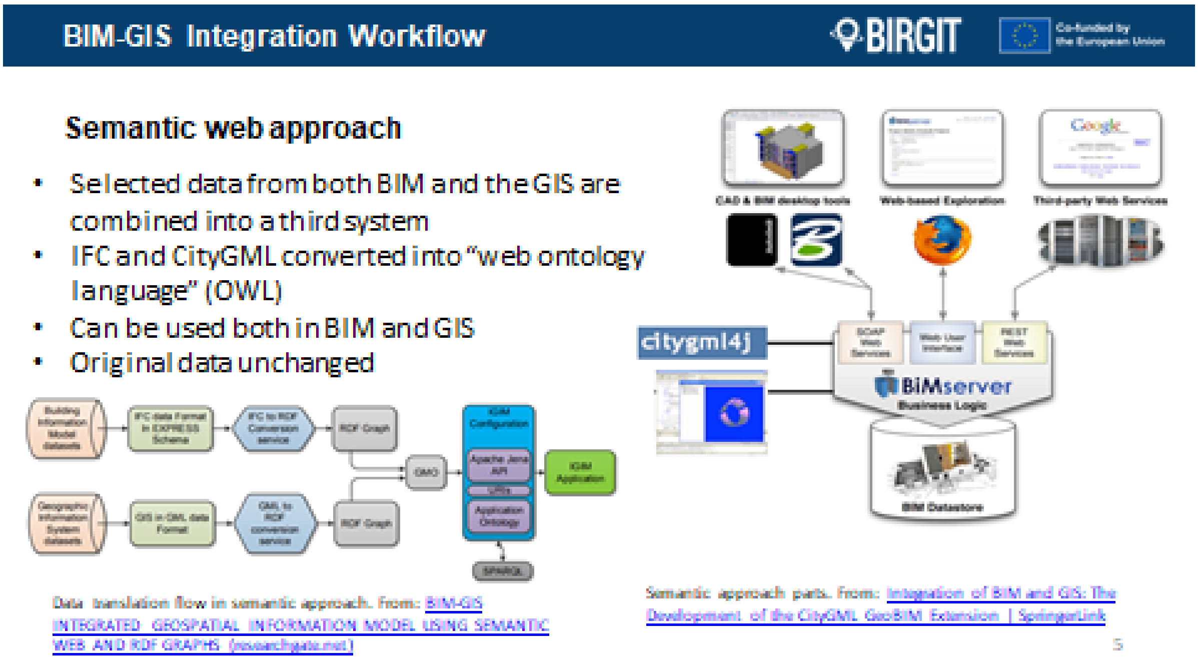
Integration approaches – conversion and full integration

We can recognize several levels of BIM-GIS Integration. These go from simple data conversion to full integration in a single model. Let us look at them closer.

The simplest approach is data conversion from IFC to CityJSON or vice versa. The converted file is then uploaded and used in an existing BIM or GIS model. Both geometry and semantics can be transferred in this way.

Next level of integration is aggregating both BIM and GIS data into a single unified model in a common database. This model then allows BIM and GIS tools to share information by sending and retrieving data to and from the database. This is theoretically easier to reach in GIS tools, as BIM applications usually do not have advanced mechanisms to work with data stored in database format.

An alternative to that is to link to full original BIM files from a GIS interface or Business-Intelligence tool, available via web.

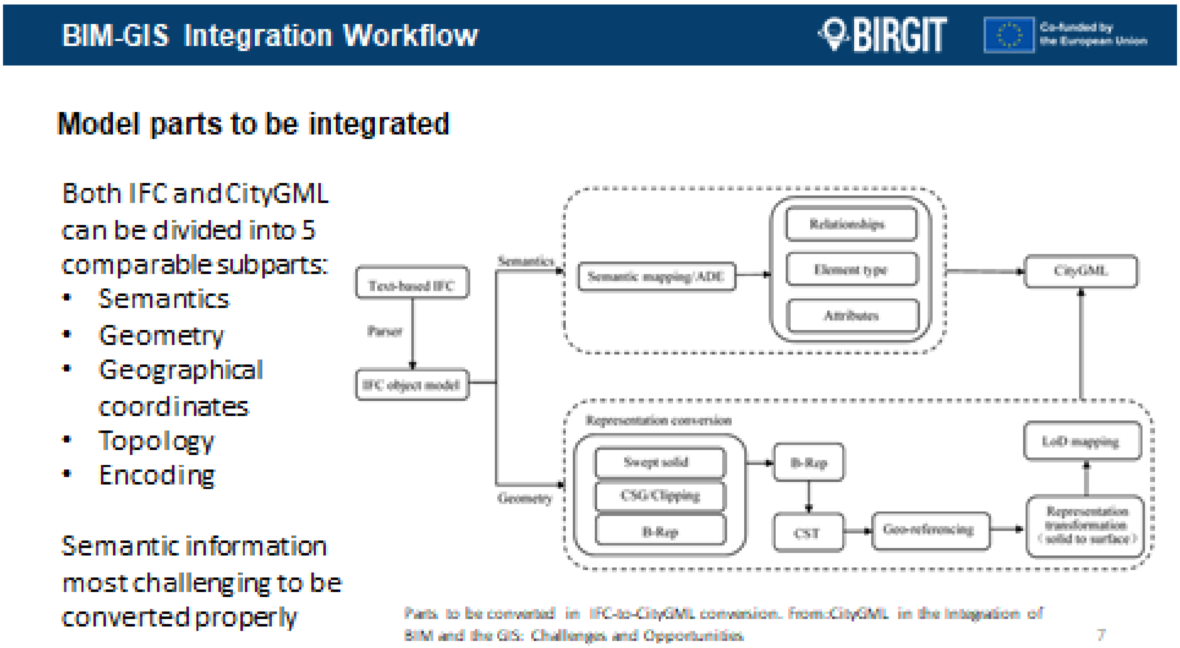


Integration approaches – Semantic web approach

Another way is called "linked data approach" or "semantic web approach". In this case, selected data from both BIM and the GIS are combined into a third system. IFC and CityGML are converted into "web ontology language" (OWL) representation which includes all the concepts and relationships within both the BIM and GIS models. The original data remain unchanged, while OWL formats of the converted results can be used both in BIM and GIS. Though its high potential, this approach is use-case specific and explored so far in research only, not in practice.

Integration approaches – Vendor systems

Besides the project-specific approaches named above, there are vendor systems. The most relevant is Esri (ArcGIS)-Autodesk cooperation, which provides applications to seamlessly connect BIM and GIS in both directions. The system is easy-to-use, web-based, works smoothly and provides several applications based on the project scope. Disadvantage is the high price for the software licences.



Model parts to be integrated

Whatever the approach used, it is important to understand how the integration works and what to be aware of when integrating the BIM and GIS data.

The two standards, IFC and CityGML, can be divided into 5 comparable subparts; Semantics, Geometry, Geographical coordinates, Topology, and Encoding.

Of course, it is possible to convert e.g. the geometry only, usually including also the appearance. It allows visualisation of the model in the other system and it may be enough for the purpose. However, the semantic part can add important information and allow numerous analyses and should be often considered with the integration.

And it is the semantic information which is the most challenging to be converted properly, given the differences of IFC and CityGML.

1. Data requirements

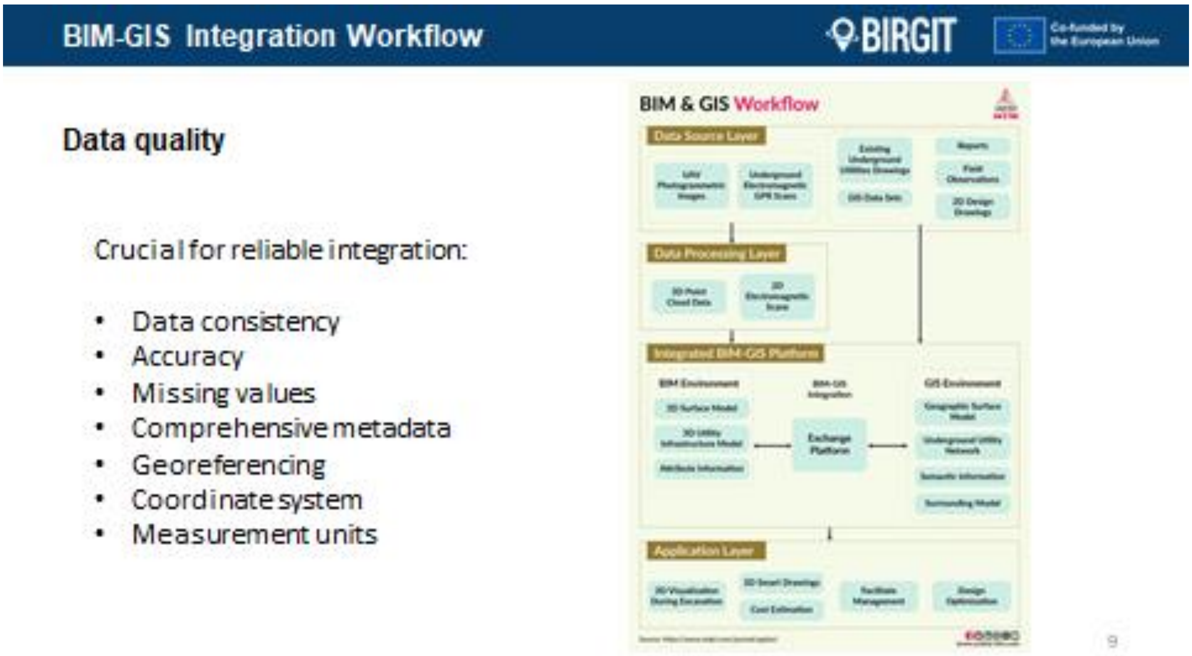
BIM models tend to be large and complex, particularly for large-scale facility or infrastructure projects. Space usage of a single BIM model is often not much less than a whole 3D city model. Processing such massive datasets within GIS environments can strain resources and slow down workflows.

Hence, not everything from IFC should be translated to 3D GIS, and it is not necessary either. Solution to it is to keep info that is really needed, and discard all other info, when converting to CityJSON.

Such removing of details results at suitable level of abstraction/generalisation, when 3D GIS still provides detailed geometric and semantic information of the objects.

It is definitely beneficial to well understanding scope of the work. It allows choosing those relevant parts of the model and an optimal level of details to be converted. It helps to keep the integrated model of reasonable size as well as to prevent long downloads and software lagging.

So the first step of the integration is to determine the specific data requirements – what do we need to integrate?

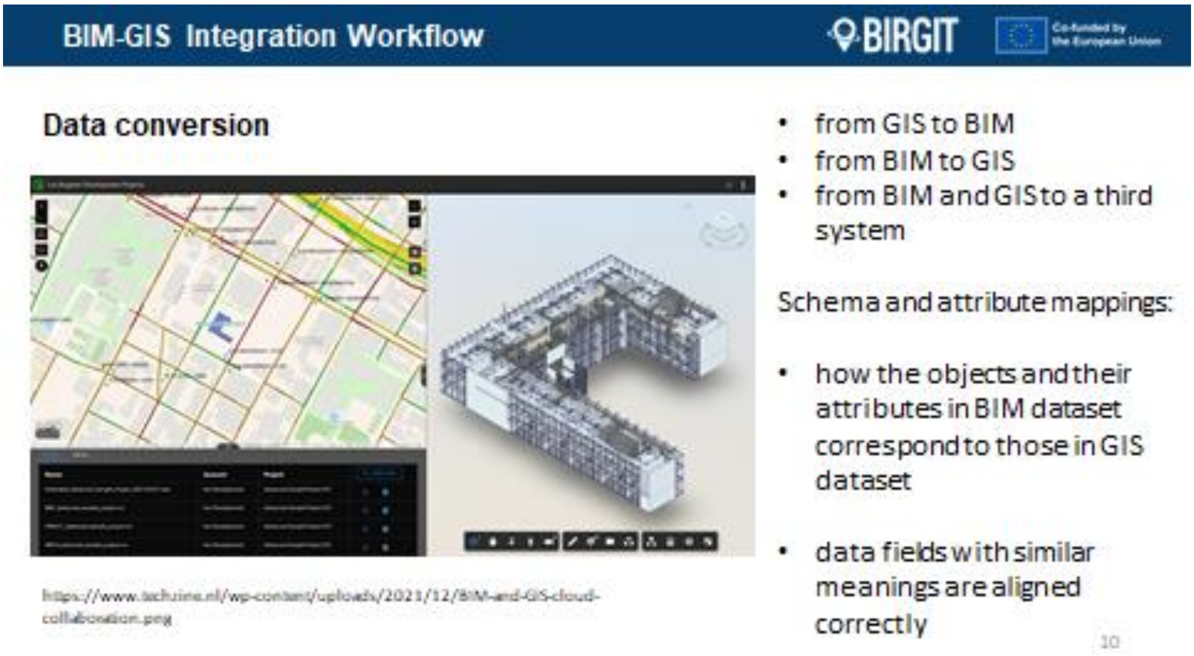


2. Data Quality

Data quality is crucial for reliable integration. The common rule is that the output dataset can only be as good as the input dataset.

So the second step is to check data consistency. Are the data accurate, without too many missing values? Do the data include comprehensive metadata?

In order to align the BIM and GIS datasets accurately, check also the georeferencing. Is the BIM model properly georeferenced? Are the coordinate systems compatible, or is coordinate transformation needed? What about units of measurements?

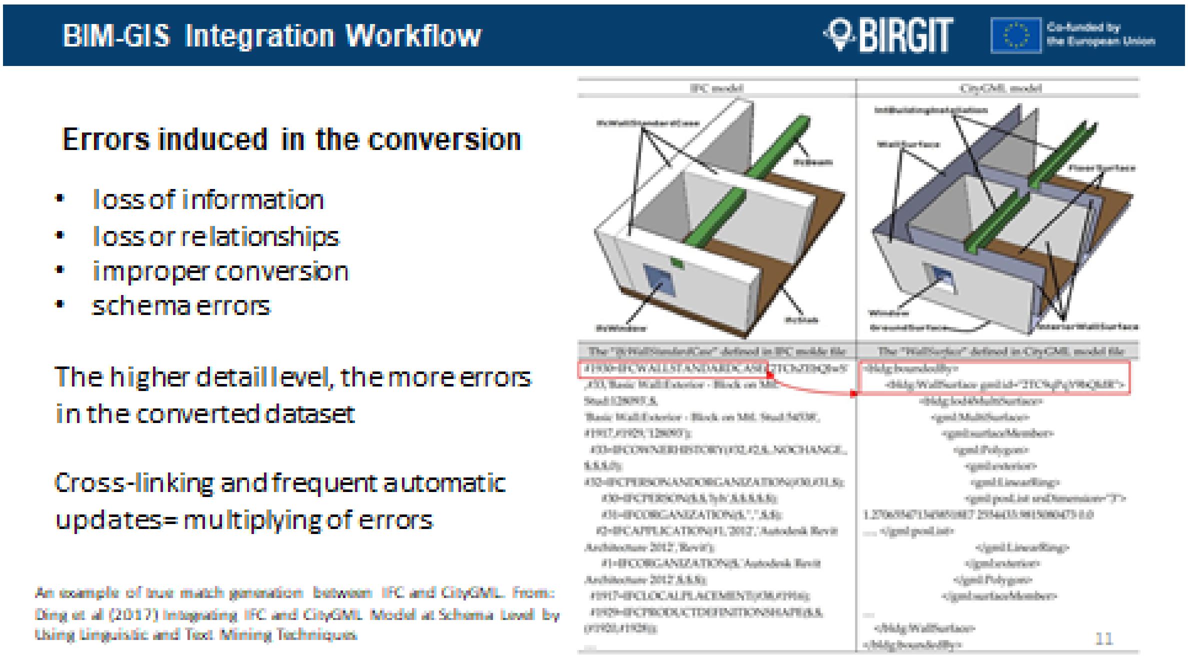


3. Data Conversion

The third step is the extraction and conversion of the data from their native formats to formats that are suitable for integration. i.e. Industry Foundation Classes (IFC) for BIM and GeoJSON for GIS.

Then, there are three patterns for data conversion, i.e., from GIS to BIM, from BIM to GIS, and from BIM and GIS to a third system.

This step includes schema and attribute mappings. It defines how the objects and their attributes in the BIM dataset correspond to those in the GIS dataset, so that data fields with similar meanings are aligned correctly. For instance, that IfcBuilding is mapped as GML Building, IfcSpace as Building Room and that IfcRoof corresponds to Roof Surface in GML. We come back to this in next lecture L1.3.



Errors induced in the conversion

As the 3D datasets are huge and complex, it is hard to avoid all the errors when working with them.

Even if checking data quality first, the input data will never be perfect, so some errors originate already at the input. Others appear during the conversion. As semantic, geometric and schematic part of data is converted, thus semantic, geometric and schematic errors appear after the conversion. These include common translation errors as loss of information, loss of relationships, improper conversion or schema errors.

If the original data were not properly georeferenced, one can expect even topological errors, such as invalid 3D geometries, overlapping or inconsistent spaces.

There are two important things to realize as well.

First, datasets modelled at a higher level of detail tend to have more errors. Because BIM usually provides highly detailed datasets, IFC-sourced 3D GIS models would naturally be prone to more errors, compared to original CityGML models.

Cross-linking of various project components and their frequent automatic updates, e.g. in CDE, SDI or in digital twin, may result in multiplying errors through the time.

This is a huge challenge, as safe operation requires errorless functionality.

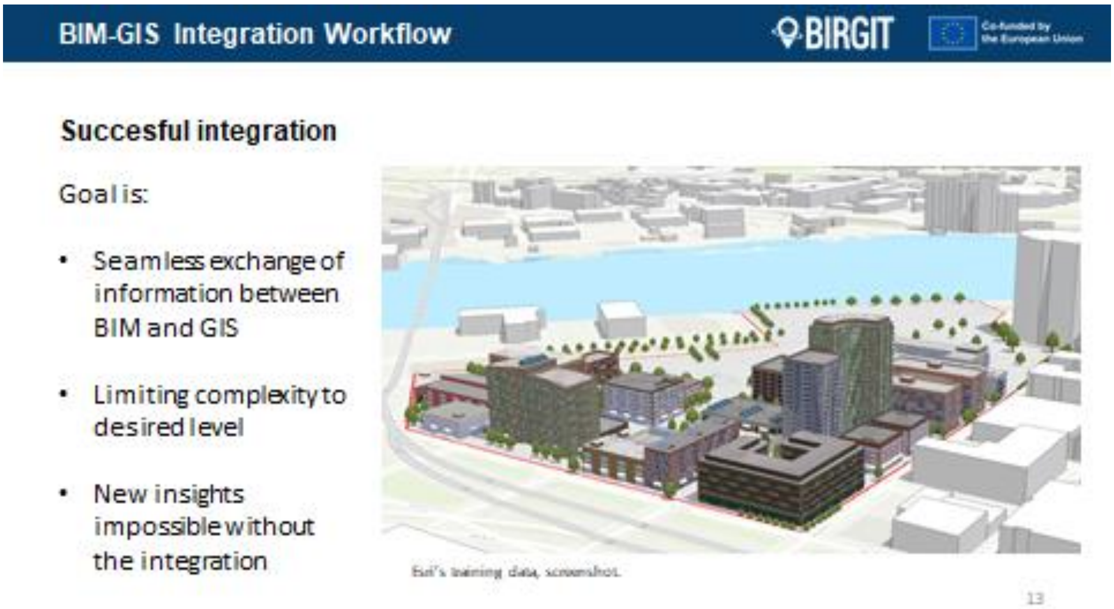
4. Validation and documentation

A way to deal with this problem is to perform thorough validation of the integrated dataset, as the fourth step of the workflow.

In CityGML 3.0, all geometric representations are defined in the Core module only. It simplifies the validation, because most checks can be performed on the CityGML Core module and then automatically applied to all thematic modules.

Besides the validation, there should be established procedures for updating the integrated dataset as new data becomes available or changes are made to the original datasets, to keep the information up-to-date.

All the data sources and integration steps should be properly documented for new users and for project transparency.



Successful integration

Properly done integration should lead to holistic system thinking in all stages of the life-cycle.

It should also limit the complexity of the models to a desired level, where all important information is easily available. There should be clearly defined goals with the integration, i.e. not just to do it because it is possible.

The main gain of the integration is that it generates new information and stakeholders can answer questions otherwise impossible if only one system would be used.

However, the integration provides many other advantages, such as:

- sharing of relevant up-to-date reliable information and understanding of projects in context, including usage of interactive maps shared via web

- improves workflows among many stakeholders which usually participate on any project and in a long term

- enhances communication/understanding in the whole process of societal planning, e.g. when comparing diverse future scenarios

References

Integrating IFC and CityGML Model at Schema Level by Using Linguistic and Text Mining Techniques Xiaohui Ding1,2,3,4, Ji Yang1,2,3,4,* , Lingjia Liu5,*, Wumeng Huang1,2,3,4, Peng Wu6 IEEE Access 2017

Tan, Y.; Liang, Y.; Zhu, J. CityGML in the Integration of BIM and the GIS: Challenges and Opportunities. Buildings 2023, 13, 1758. https://doi.org/10.3390/ buildings13071758