Previous BIM-GIS Integration Approaches: Analytic Review and Discussion

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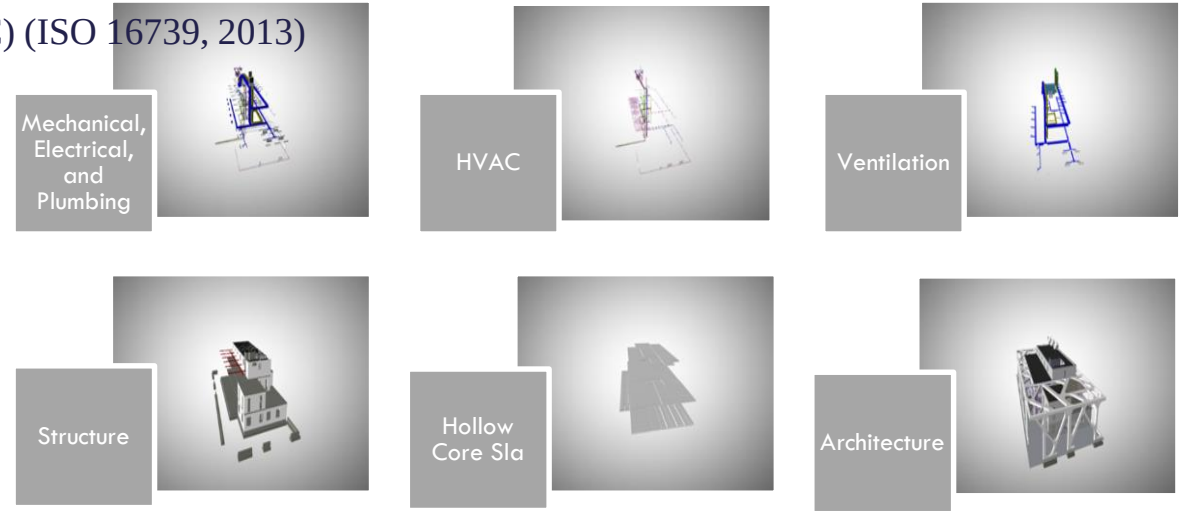
14-15 October 2020, Anglet, France

Summary

1. Introducing BIM and GIS
2. BIM and GIS differences/ characteristics
3. Interoperability level and approaches
4. Previous Adopted Approaches
5. Discussion
6. Conclusion

Building Information Model (BIM)

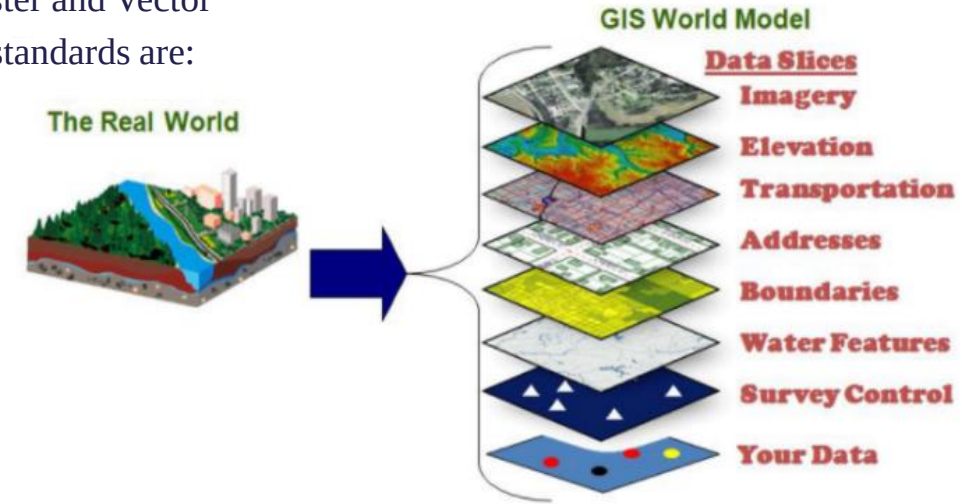
- BIM is a process for combining information and technology to create a digital representation of a project that integrates data from many sources and evolves in parallel with the real project across its entire timeline, including design, construction, and in-use operational information (David et al., 2015).
- BIM relies on the following standards:
  - Information Delivery Manual (IDM) (ISO 29481-1, 2016).
  - Model View Definition (MVD) (ISO 29481-3, 2010)
  - Industry Foundation Classes (IFC) (ISO 16739, 2013)



David, P., Paul, S., & Stefan, M. (2015). Building Information Modeling For Dummies.

Geographic Information System (GIS)

- GIS is a system designed to capture, store, manipulate, analyse, manage, and present all types of geographical data
- It is used to determine:
  - Location feature and their relations
  - Changes of area over time
  - Density of feature in specific space
  - The spatial data comes in two formats: Raster and Vector
- The international organization developing GIS standards are:
  - ISO TC 211 (ISO 191xx, 2005)
  - OGC (Open Geospatial Consortium)



BIM and GIS differences

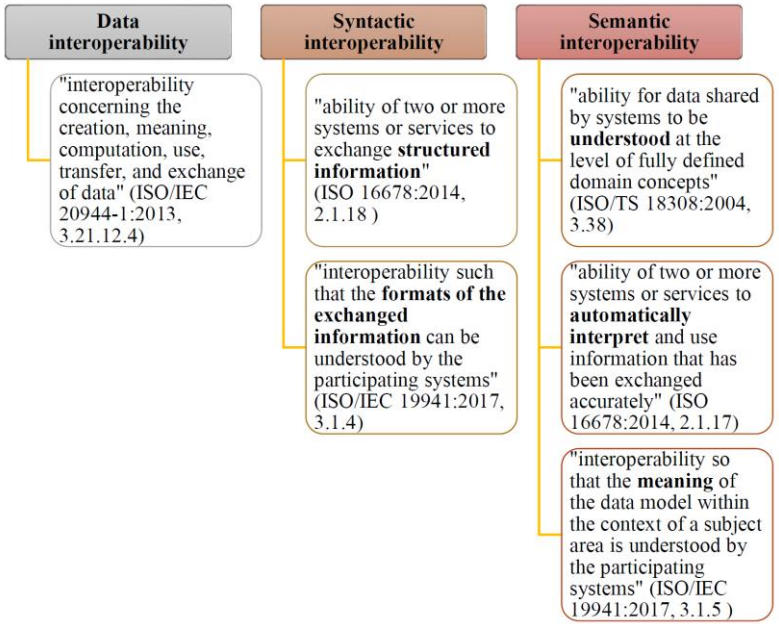
BIM	Vs.	GIS
Building Model	Modelling Environment	Outdoor Environment
Local Reference System	Reference System	Global Reference System
High Level of Details	Details of Drafting	Less Details with large scale
Documentation, analyse, etc.	Application Area	Urban representation, planning, etc.
Revit, Autodesk, etc.	Tools	ArcGIS, QGIS, etc.
IFCOWL	Semantics	ISO TC 211 Ontologies
Don't link building life cycle phases	Temporal Aspects	Support element representation in different life cycle phases

BIM and GIS Characteristics

BIM	Vs.	GIS
Express Schema	Schema	Unified Modelling Language (UML)
Standard for the Exchange of Product model data	Data	Geography Markup Language (GML3.2 and 3.3)
Ifc, ifcxml, ifcowl, etc.	File Format	LandXML, XML, GML, etc.
Global Unique Identifier (GUID)	Identifier	Object identifier (ObjectID)
IFC and industrial data	Standard	OGC, ISO TC 211, OpenGIS Feature

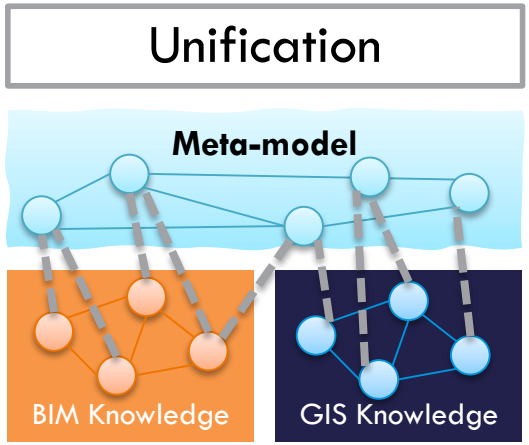
Interoperability level

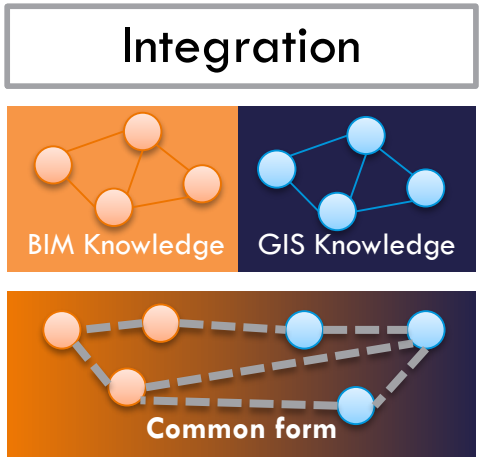
- “Capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units".
- Existing standards identify three main levels of interoperability:

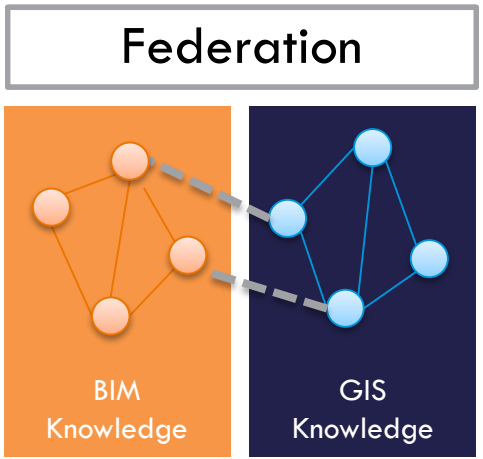


Interoperability approaches

- ISO 11354 defines 3 approaches to reach semantic interoperability:
  - Unification approach
  - Integration approach
  - Federation approach







Previous Approaches

	Reference	Approach
1	(Mignard & Nicolle, 2014)	Create an Urban Information Model (UIM) as a crossroads between building model and geographic information systems, which allows to integrate all the information about the city, including urban proxy elements, networks, buildings, etc. into an ontology.
2	(Floros et al., 2017)	Present a framework, where an IFC model is generated and converted to a LOD 3 CityGML Model, which is validated and evaluated on its geometrical correctness and semantical coherence.
3	(Deng et al., 2016)	Present a reference ontology called Semantic City Model and adopt an instance-based method to achieve automatic data mapping between IFC and CityGML at different levels of details (LOD).
4	(Sebastian et al., 2013)	Aim to enable an open information capture, exchange, sharing, comparison and storage of the relevant building and GIS models for designing energy-efficient buildings in healthcare districts.
5	(Wook Kang & Hee Hong, 2013)	Propose a BIM-GIS-based architecture model in which data were extracted from different heterogeneous systems such as BIM, GIS, and Facility Management database using ETL. The architecture is used for facility management, energy management, and design evaluation.
6	(Vilgertshofer et al., 2017)	Achieve to connect a tunnel model represented in both CityGML and the IFC data model by applying semantic web technology to emphasize the important role of semantic technologies in allowing the coexisting and coherence between the entities of both standards

[1] Mignard, C., & Nicolle, C. (2014). Merging BIM and GIS using ontologies application to urban facility management in ACTIVe3D. Computers in Industry, 65(9), 1276–1290. https://doi.org/10.1016/j.compind.2014.07.008

[2] Floros, G., Pispidikis, I., & Dimopoulou, E. (2017). Investigating integration capabilities between IFC and CityGML LOD3 for 3D city modelling. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLII-4/W7, 1–6. https://doi.org/10.5194/isprs-archives-XLII-4-W7-1-2017

[3] Deng, Y., Cheng, J. C. P., & Anumba, C. (2016). Mapping between BIM and 3D GIS in different levels of detail using schema mediation and instance comparison. Automation in Construction, 67, 1–21. https://doi.org/10.1016/j.autcon.2016.03.006

[4] Sebastian, R., Böhms, H. M., Bonsma, P., & van den Helm, P. W. (2013). Semantic BIM and GIS modelling for energy-efficient buildings integrated in a healthcare district. ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences, II-2/W1, 255–260. https://doi.org/10.5194/isprsannals-II-2-W1-255-2013

[5] Wook Kang, tea, & Hee Hong, chang. (2013). The architecture development for the interoperability between BIM and GIS. 12

[6] Vilgertshofer, S., Amann, J., Willenborg, B., Borrmann, A., & Kolbe, T. H. (2017). Linking BIM and GIS Models in Infrastructure by Example of IFC and CityGML. Computing in Civil Engineering 2017, 133–140. https://doi.org/10.1061/9780784480823.017

Previous Approaches

	Reference	Approach
7	(Boguslawski et al., 2015)	Integrate BIM and advanced GIS analysis to improve 3D analytical model for emergency response. The objective is achieved by using Green Building XML (gbXML) and Industry Foundation Classes (IFC), and GIS analysis methods and data structure, as data input.
8	(Amirebrahimi et al., 2016)	Present an integrated framework that allows for a case-by-case analysis of flood damage to a building and its components. In addition, it provides a comprehensive understanding of flood risks at different levels of the community.
9	(Zhang et al., 2019)	Propose a new urban management method through the combination of the GeoSOT grid code and BIM technology, where a real-time 3D visualization earth platform was built by using the Cesium platform to achieve refined and efficient management of urban components
10	(de Laat & van Berlo, 2011)	Describe the development of a CityGML extension called GeoBIM to get semantic IFC data into a GIS context.

[7] Boguslawski, P., Mahdjoubi, L., Zverovich, V., Fadli, F., & Barki, H. (2015). BIM-GIS modelling in support of emergency response applications. 381–391. https://doi.org/10.2495/BIM150321

[8] Amirebrahimi, S., Rajabifard, A., Mendis, P., & Ngo, T. (2016). A framework for a microscale flood damage assessment and visualization for a building using BIM–GIS integration. International Journal of Digital Earth, 9(4), 363–386. https://doi.org/10.1080/17538947.2015.1034201

[9] Zhang, H., Cheng, C., & Miao, S. (2019). A Precise Urban Component Management Method Based on the GeoSOT Grid Code and BIM. ISPRS International Journal of Geo-Information, 8(3), 159. https://doi.org/10.3390/ijgi8030159

[10] de Laat, R., & van Berlo, L. (2011). Integration of BIM and GIS: The Development of the CityGML GeoBIM Extension. In T. H. Kolbe, G. König, & C. Nagel (Eds.), Advances in 3D Geo-Information Sciences (pp. 211–225). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-12670-3_13

Adopted approaches

	Previous Studies	Semantic Interoperability			Syntactic Interoperability
		Unification Approach	Federation Approach	Integration Approach	
1	(Mignard & Nicolle, 2014)	✓			
2	(Floros et al., 2017)			✓	
3	(Deng et al., 2016)	✓			
4	(Sebastian et al., 2013)				✓
5	(Wook Kang & Hee Hong, 2013)				✓
6	(Vilgertshofer et al., 2017)			✓	
7	(Boguslawski et al., 2015)				✓
8	(Amirebrahimi et al., 2016)				✓
9	(Zhang et al., 2019)				✓
10	(de Laat & van Berlo, 2011)				✓

Discussion

	Previous Studies	Modelling Environment	Reference System	Details of Drafting	Application Area	Semantics	Standard	Temporal Aspect
1	(Mignard & Nicolle, 2014)	✓	✓	X	X	✓	✓	✓
2	(Floros et al., 2017)	X	✓	X	X	✓	✓	X
3	(Deng et al., 2016)	X	X	X	X	✓	✓	X
4	(Sebastian et al., 2013)	✓	X	X	X	X	X	X
5	(Wook Kang & Hee Hong, 2013)	✓	X	X	X	X	X	X
6	(Vilgertshofer et al., 2017)	X	✓	X	✓	✓	✓	X
7	(Boguslawski et al., 2015)	✓	X	X	X	X	X	X
8	(Amirebrahimi et al., 2016)	✓	X	X	X	X	X	X
9	(Zhang et al., 2019)	✓	X	X	X	X	X	X
10	(de Laat & van Berlo, 2011)	✓	✓	X	X	X	X	X

Discussion

- Syntactic approaches transform data from one format to another without taking into consideration its meaning
- Semantic approaches adapted (unification and integration approaches)
- Limits generated by the approaches adopted are:
  - Data losses
  - Specific to a certain use case
  - Mostly connect IFC to CityGML
  - Prefer one domain(GIS) over the other (BIM)
  - Focuses only on building model
  - Most approaches are uni/bidirectional conversion

Conclusion and future work

- The approaches adopted have not surpassed all the incompatibilities between both domains
- No previous approaches have adopted the federation approach
- Achieving semantic interoperability through the federation approach -e.g. FOWLA (Farias et al, 2015)- and evaluate it is ability to overcome incompatibilities between both domains.
- (Hbeich & Ana, 2020) where we have suggested some semantic links between BIM and GIS Knowledge base

Farias, T. M., Roxin, A., & Nicolle, C. (2015). FOWLA, A Federated Architecture for Ontologies. In N. Bassiliades, G. Gottlob, F. Sadri, A. Paschke, & D. Roman (Eds.), Rule Technologies: Foundations, Tools, and Applications (Vol. 9202, pp. 97–111). Springer International Publishing. https://doi.org/10.1007/978-3-319-21542-6_7

Hbeich, E & Roxin, A. (2020). Linking BIM and GIS Standard Ontologies with Linked Data. Proceedings of the 8th Linked Data in Architecture and Construction Workshop – Dublin, Ireland.

Thank you for your attention

QUESTIONS?