BIM & GIS – New Dimensions of Improved Collaboration for Infrastructure and Environment

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Abstract: Digitization in the AEC market and regulations for BIM-compliant planning and construction of public infrastructure in Germany push the development of digital workflows. In the AEC market prevails a BIM-focused view of infrastructure lifecycle but the integration of geospatial data gains more attention in recent years. The article focuses on the integration of BIM and GIS and examples of technology Software integration enabling new forms and quality of collaboration.

Keywords: BIM-GIS integration, BIM-GIS collaboration

1 Introduction

In 2015 the German Federal Ministry of Transport and Digital Infrastructure (BMVI) published the BIM-Decree to implement the BIM methodology for big projects in public infrastructure (BMVI 2015).

The background and reasons were adverse run of infrastructure projects regarding time, costs and quality. The main objectives of the BIM decree are aiming at the improvement of economic efficiency, cost reliability, meeting deadlines, better quality and documentation, improved risk management, legal certainty and others.

The means to achieve the objectives are better collaboration of all parties concerned which includes BIM and GIS. Today´s web-technology and new software development supports the geospatial collaboration with web-based services, integration of spatial data and the design of digital workflows in AEC projects.

2 BIM and GIS

2.1 Digital Twin and Digital Environment

The digital infrastructure and its components (BIM-models and digitized existing buildings) is a part of the digital spatial environment and has to be considered in a holistic approach for all planning and execution work.

On the technical side, integration of BIM models in GIS or geospatial data from GIS in BIM authoring systems is an essential requirement for the evolution of integrated workflows.

2.2 BIM and GIS – Authoring Systems, Infrastructure Lifecycle and Workflows

Digitization enables the design of seamless workflows and overcomes system limits. The demand for digitized processes increases to the extent as qualitative and economic benefits are recognized.

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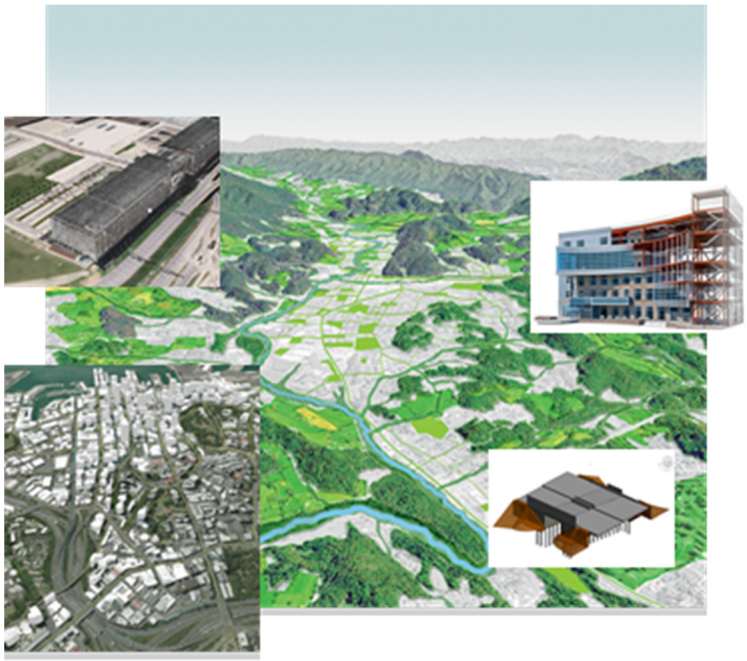

Fig. 1:
BIM and 3D-CAD models as part of the digital spatial environment

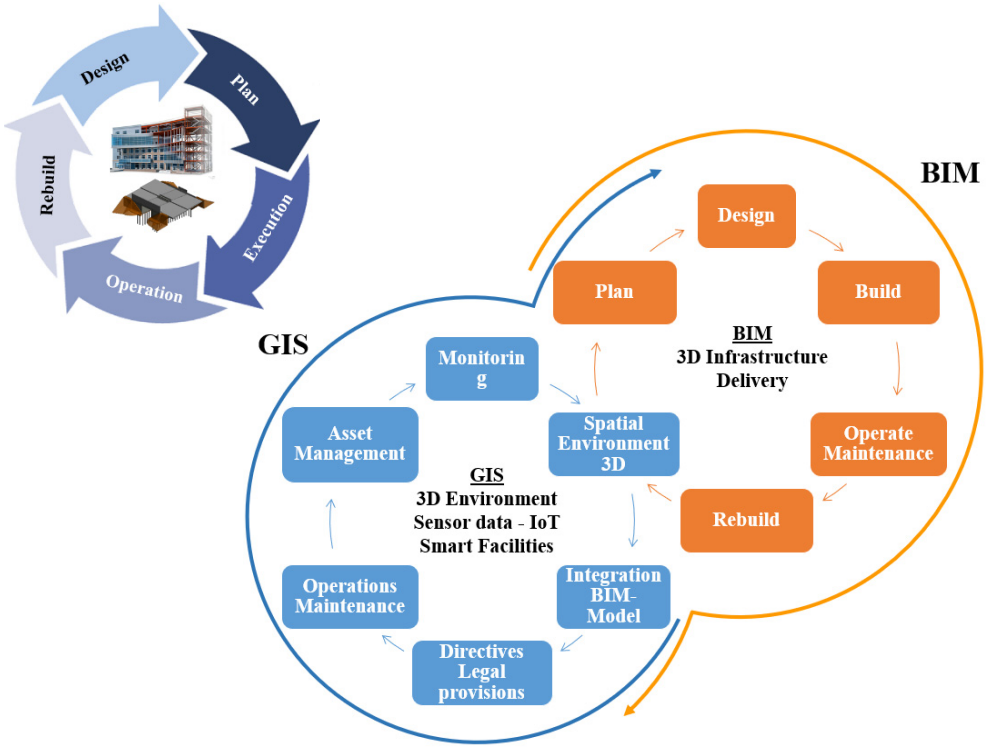

Fig. 2: BIM and GIS authoring Systems interacting in infrastructure lifecycle

Authoring systems of GIS and BIM data are technologically different and designed for different purposes. But on the practical level grows the need to process the results of each system in joined workflows.

A more comprehensive illustration of infrastructure lifecycle (Figure 3) shows how many BIM-related activities require spatial data for further solution (outer area).

This relation concerns all disciplines involved in carrying out activities in the 5 phases Plan & Design, Execution, Management (operation and maintenance) and Rebuilding.

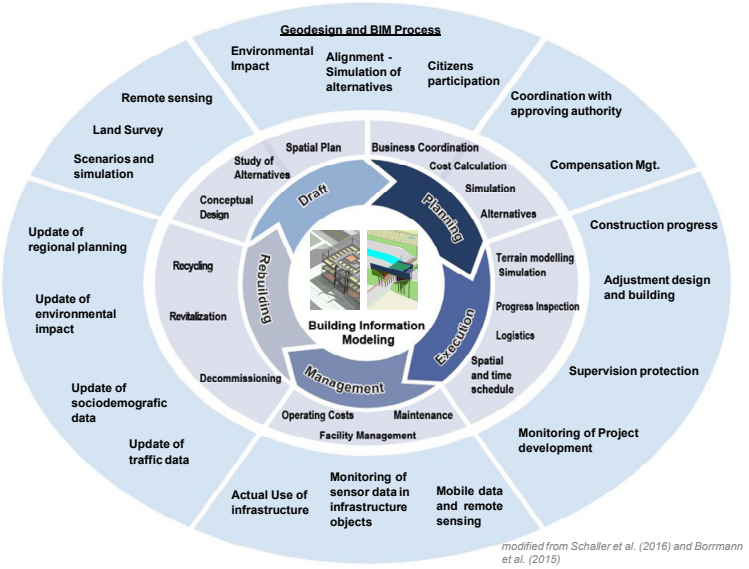

Fig. 3: Infrastructure lifecycle

If we look at detailed workflows, they are frequently composed by activities of various disciplines and data sources (Figure 4).

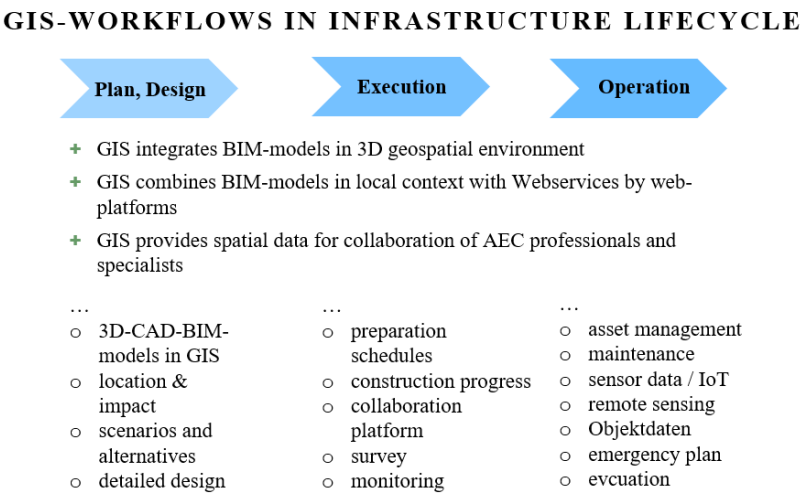

Fig. 4: Selected GIS workflows in infrastructure lifecycle

An essential requirement for BIM-GIS workflows is the integration of BIM-models in GIS systems.

2.3 BIM and GIS Integration

There are two concepts for the integration of BIM models in GIS, which are mostly applied.

One is the transformation of IFC data with FME® (Feature Manipulation Engine, Safe Software Inc.), integrating BIM models in IFC-format into ArcGIS with ArcGIS data interoperability extension.

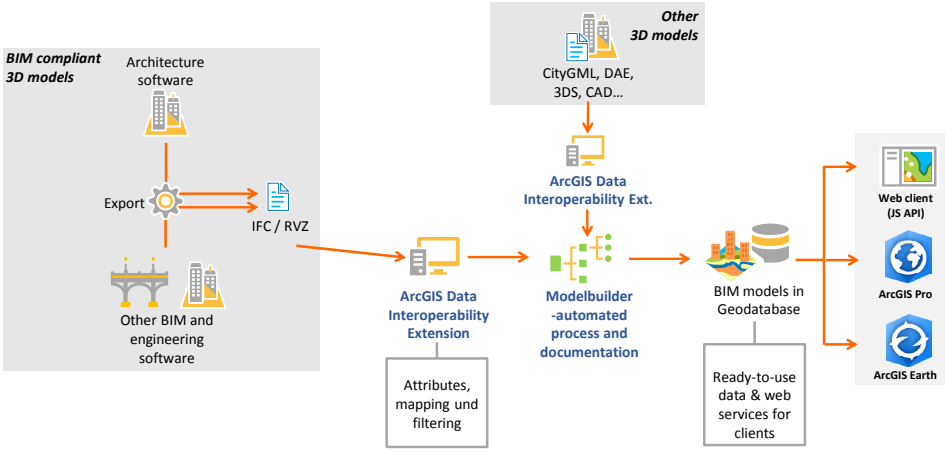

Fig. 5: Integration of BIM models in IFC-format into ArcGIS by FME®

The other way of integration is the direct read in of BIM-Revit®-models (Autodesk Inc.) by ArcGIS Pro. It is a first development to converge a GIS and a BIM platform by means of lean processes. Direct read requires specific software integration.

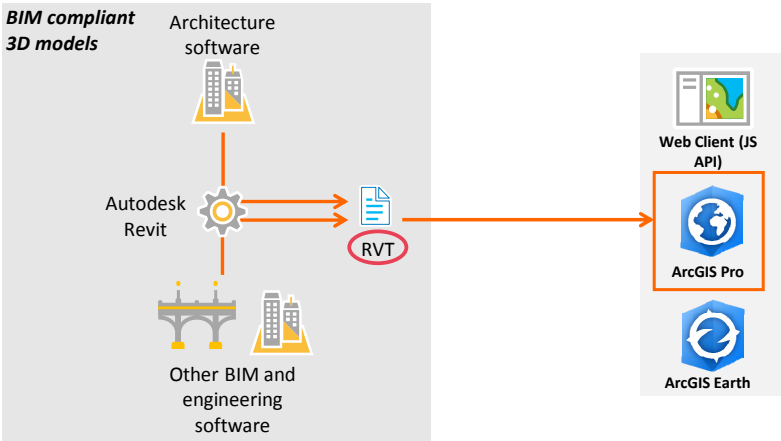

Fig. 6: Integration of Autodesk BIM models (Revit®) by direct read in with ArcGIS Pro

Both methods allow to integrate BIM models in geographic data, including the attributive and metadata. The integrated models can be used for a wide range of analysis, scenarios and visualization in GIS. Examples are listed in section 2.6.

Andrews (2019) recently exposed the future integration of BIM-models (digital representation of assets) and the knowledge, that integration must be adapted to rapidly changing technology, data collection and workflows.

Integration workflows will change because previous file formats have certain limitations in ongoing technology development (no streaming, data loss, incomplete duplication, unidirectional).

"In the push to true digitalization, digital representation of an asset needs to be accessible quickly in a distributed environment that can be updated and upgraded to adjust to more complex query, analysis, and inspection over time and across the lifespan of the asset. I expect integration technologies to continue to mature over time as BIM becomes richer in content and as the need to use BIM data in GIS context for lifecycle asset management becomes more critical to sustainable human habitation" (ANDREWS 2019).

Future integration efforts will evaluate aspects like extraction of common geometries like rooms, spaces, footprint of a building or data for navigation (indoor) because they can be useful for GIS applications or asset management.

The approach of BIM- and GIS workflows makes it necessary to define specifications for features in BIM models needed for GIS workflows before design and construction begins – and which are also needed for use during lifecycle management.

Digital Landscape Architecture typically is at the intersection of the BIM- and GIS authoring systems. A very useful example is the A99 Geodesign project described by SCHALLER et.al (2017).

In landscape architecture, environmental impact studies, proposal design and approval of planning are established workflows since long.

Subject to change is the digital transformation of these workflows and their dependencies and interactions.

2.4 BIM-GIS Collaboration

Regarding practical aspects in Geodesign, collaboration is established since long for proposal design, approval and implementation.

Digitization of collaboration processes requires technologically new methods and data management. In the digital context digital data play an even bigger role as before anyway (IoT).

Considering this development, it can be assumed that collaboration will also develop fast.

Figure 7 illustrates BIM-GIS collaboration workspace from both sides BIM and GIS in order to design common digital workflows.

The first to rows show basics like arrangements about data base and questions of integration. The two lines at the bottom consider BIM-GIS use cases like Plan and Design or clash detection.

The two examples refer to a few general cases and to Plan and Design. The matrix can be extended to the complete infrastructure life cycle and implement BIM-GIS uses cases from the phases Construction, Operations and Maintenance or Rebuild.

Geographic Information ArcGIS Authoring System and Platform Combined GIS Resources for BIM-GIS Projects (Desktop, platform, mobile)	BIM-GIS Collaboration Workspace GIS-BIM	BIM Information BIM Authoring System and Platform BIM Resources for BIM-GIS Projects (Desktop, platform, mobile)
- Basic requirement: Coordination of common BIM-GIS data basis and technical agreements	- Implementation of virtual workspace for spatial and digital collaboration (platforms, workflows, entitlements, etc.) - Defining required spatial data depending on project needs - Decision-making procedures	- Basic requirement: Coordination of common BIM-GIS data basis and technical agreements
- Integration procedures for BIM models in GIS - Provision of GIS platform - Integration procedures for BIM models in GI (methodology)	- Concept and implementation of BIM-GIS collaboration in relation to Infrastructure Lifecycle and the tasks to be processed - Technical requirements - Agreements for integration of BIM models in GIS and use of GIS data in BIM-modelling	- Provision of BIM models in IFC - Way and extent of data integration
- Provision of geospatial data for the area or extension of planned infrastructure (Desktop, web, mobile)	- Geographic localization of BIM model by integration and geographic coordinate system - Site impact analysis of planned infrastructure (detection of potential conflicts - Compensation measures for temporal and permanent land use	- BIM use case: Plan & Design of a road, waterway, bridge, tunnel, rail or building infrastructure
- Supply of spatial data on web platform for mobile use, including UAV, VR and AR	- Clash detection of planned infrastructure with other uses or properties - Documentation of building inspection, comparison and alignment (local and track building)	- BIM use case: Clash detection and provision of BIM model on platform for inspection on site

Fig. 7: Summarized illustration of digital process-based BIM-GIS collaboration model

2.5 Technology and Software Developed for Improved BIM-GIS Collaboration

In the following a few examples of integrated BIM and GIS work are illustrated based on demo videos from Autodesk and Esri. It shows that the tools for digital BIM-GIS collaboration already exist.

Based on platform technology it is possible to use geospatial data with the BIM system to support the design process of an infrastructure or to integrate BIM models in GIS for the support of design, build and operate activities.

The results of BIM-GIS collaboration can be discussed life between the professionals and specialists. Necessary changes can be applied in the BIM or the GIS-System.

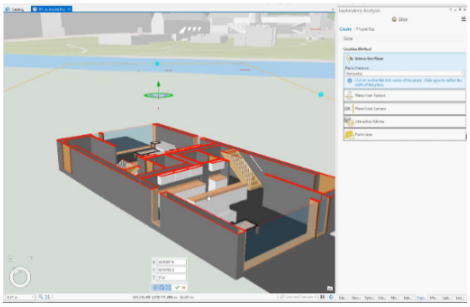

Fig. 8: IFC Quick Import of BIM model in ArcGIS

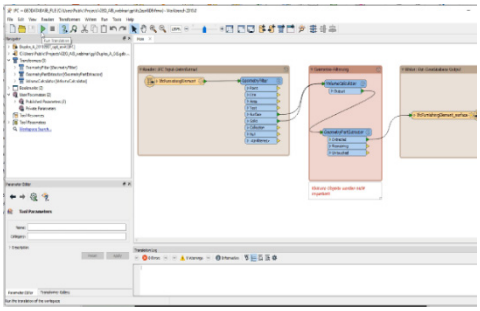

Fig. 9: IFC Import in ArcGIS with workbench and data selection

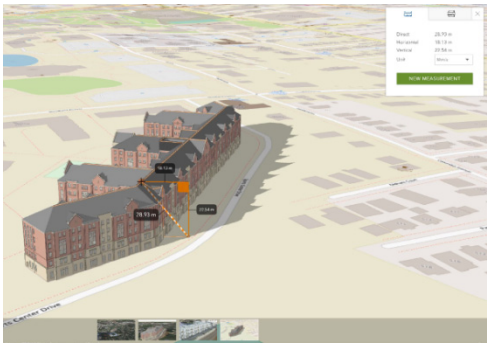

Fig. 10: Direct read of BIM data (Revit®) with ArcGIS Pro

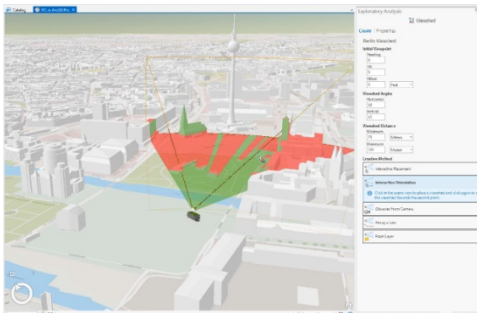

Fig. 11: Analysis of BIM model and display as webscene

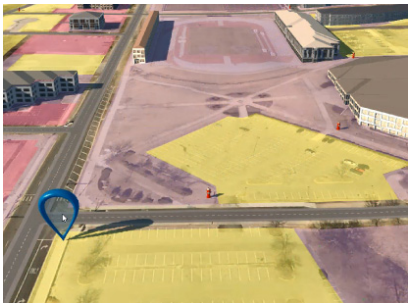

Fig. 12: Autodesk Connector for ArcGIS, Use of geodata from ArcGIS online in Infraworks®

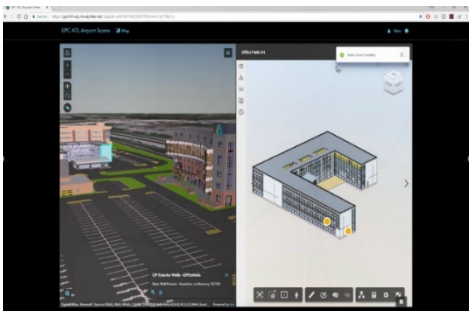

Fig. 13: GIS platform Esri (left) and BIM360 platform Autodesk (right) for collaboration

3 Discussion and Outlook

BIM-compliant infrastructure and the digitized assets of existing infrastructure have their geographic reference in digital geospatial environment.

For any idea, plan or project of infrastructure assets, which affects geospatial matters, one must refer to geographic information, i.e. to Geographic Information Systems.

Human activity turned to be a very complex impact on nearly any kind of resources and carries a lot of risks.

Due to the complexity of this impact the tasks to be solved are more and more complex.

And even more important is the challenge how to apply alternatives and options to reduce harmful or fatal implications for the environment in the future.

To meet the requirements of a more sustainable and responsible layout and management of infrastructure it is necessary to implement integrated teams and partnerships, which use consequently digital data, technology and solutions in all phases of infrastructure lifecycle.

Multidisciplinary spatial analysis is one key for better understanding of complex impacts and to reduce exactly those impacts in ongoing infrastructure implementation.

Combining BIM and GIS data with technology (platform, web services) and solutions (software, apps) is not a vision but already applicable. The capabilities of these tools are much higher than currently applied.

Digitization will continue to evolve rapidly. It is necessary to gain experience with these new technologies and adapt them to the given conditions at organizations and firms. This in mind one should not wait too long to start.

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