

Applied Integration of GIS and BIM in Landscape Planning

Johannes Gnädinger¹, Georg Roth²

¹Prof. Schaller UmweltConsult (PSU), Munich/Germany · j.gnaedinger@psu-schaller.de

²Prof. Schaller UmweltConsult (PSU), Munich/Germany · g.roth@psu-schaller.de

Abstract: For the future of BIM collaboration, a close exchange of information between constructional and environmental issues is needed. The way there is via integration of the respective BIM construction models along with the respective data sets into the GIS model of the given environment. There are two technical approaches for this data integration. We present some examples from our real-life projects, showing how BIM-GIS integration and subsequent environmental assessments were carried out. Considerable non-automatic work is still needed. However, we clearly state added value for interdisciplinary cooperation as well as for a more adequate representation of environmental facts and hence for professional advances in landscape and urban planning.

Keywords: Geodesign, GIS, BIM, semantic 3D-model, landscape planning

1 Introduction

Today, most construction projects are designed and executed by architects and engineers using CAD (Computer Aided Design) software. Landscape planners however are mainly operating GIS (Geographical Information Systems) to assess the environmental impacts of those construction projects. Against the background of ongoing digitalization represented by applications such as virtual reality, robotics or drone mapping, and the focus on BIM (Building Information Modeling) in the field of construction, the urgent need for a seamless coupling of those two ecosystems becomes clearer every day.

The central concept of BIM lies in the intensified and systematized digital cooperation of all stakeholders involved, including planning, construction, project lead, customer, authorities and, increasingly importantly, the public. At its core, BIM is represented by a collaboration model built of multiple sub- or specialist models. A CDE (Common Data Environment) serves as the central tool for communication, logging and file exchange and is generally coupled with the collaboration model. This architecture allows for a consistent data flow and prompt collision control between different technical expert groups over the whole building lifecycle. Another term often used for the BIM concept is “digital twin”.

The concept of BIM is not new. The term was first used in the early 1990s (VAN NEDERVEEN & TOLMAN 1992) and has evolved in different places around the globe. During the past couple of years, BIM developed from a mainly experimental approach and new business opportunity to a widely used tool which can also be called a megatrend in construction in Germany, and also – and for an even longer period – in a variety of other countries. This is due to the high efforts of the government and economy. For example, multiple infrastructure projects were used as pilots to gain deep practical knowledge about the BIM method. The Deutsche Bahn for instance has made the application of BIM a mandatory requirement for all of their construction projects (DB 2021).

Regardless of those efforts, integrated and systematized BIM processes with workflows in all project phases of all environmental planning instruments (e. g. EIA) do not exist so far. That applies to the used software systems and their interactions, the common Industry Foundation Classes (IFC) interface as well as paperless, 3D-applications at the building site. Due to a partly still competing development of international and national BIM standards (e. g. ISO, CEN, DIN), as well as worldwide efforts for unified data exchange standards (buildingSMART International), it is supposed that a complete transformation to digital BIM processes will be reached only in a few years from now. The trend, however, points in the direction of a rapid change to the application of the BIM method as part of an extensive digitalization movement in the construction sector.

As BIM not only includes engineering and architecture, but all stakeholders involved in a construction project, it also has effects on the work of landscape and environmental planners. Until now however, there is still rather weak activity in this field. This is due not least to the misinterpretation of BIM solely as a 3D visualization software which may seem unnecessary for landscape planning from a conservative viewpoint. That however misses the core of BIM not only being one of many software tools, but a complete method placing its focus on the sharing of data and information as well as optimizing the communication during the whole building lifecycle (DVW & RUNDER TISCH GIS 2019), or the management of a settlement quarter or of a city.

The objective of this article is to evaluate the practical application of integrated GIS and BIM planning, especially in the early planning phases. Therefore, two projects performed by Prof. Schaller UmweltConsult (PSU) will be presented where current software technology was used for realizing this interconnection of both worlds. The examples will be examined for findings helpful to environmental planning as well as to interdisciplinary work. Our work aims to represent a solid and practical groundwork for a further integration of BIM and GIS in order to get the most out of the available data.

2 State-of-the-Art Methods

In the GIS context, the goal of coupling the design process – and here you could e. g. also understand BIM as a method for integrated collaboration models – with geospatial data and analyses and is named geodesign (FLAXMAN 2010, MILLER 2012, STEINITZ 2012). It is a GIS-based method for digitalizing planning workflows of engineers, architects and designers in one process and through optimizing it by using 2D and 3D geodatabases. It is based on proven GIS applications from a variety of fields (e. g. landscape planning, landscape architecture, geography, environmental sciences) and offers an interdisciplinary synergetic approach for solving critical planning problems in the built environment. The methods discussed in this paper can therefore be seen as parts of that bigger picture called geodesign.

Withing GIS there are different ways of implementing this integration. The main focus hereby usually lies on the conversion of data between the different GIS and BIM data formats without losing or changing relevant information. The most common approaches can be categorized as follows:

- 1) Proprietary interfaces provided by the used software.
Meanwhile, it is common that both GIS and BIM software provide import and/or export functionality of different data formats that can be applied by both used platforms. In

current Esri products, for example, a direct import of .rvt files produced by the BIM Software Autodesk Revit is offered.

2) Data format conversion using ETL Tools (Extract Transfer Load).

Tools like FME (Feature Manipulation Engine, by Safe Software Inc.) can be used to transform a variety of (geo-)data formats and include all common GIS formats as well as a variety of CAD and BIM formats. The approach offers more control and flexibility in the translation process and can therefore lead to more correct results than the mostly black box imports of approach 1). In the case of FME it also offers import logging for further control over the process. A visual comparison of the results of both approaches is shown in Figure 1.

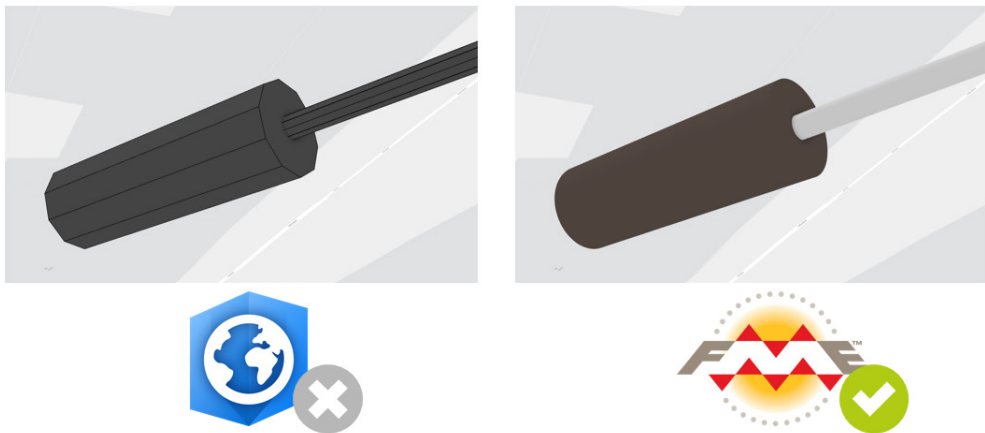


Fig. 1: Results of a data conversion from a .rvt file using ArcGIS Pro (left) and FME (right)

Based on those insights, the second approach was used in the following two project examples.

3 Selected Projects

The practical application of a deepened BIM and GIS integration has numerous positive effects on the planning process. This can be shown using two examples by PSU, one being the A99 expansion project, the other in the context of the Second S-Bahn Main Line in Munich. From these two projects, we illustrate just a few extracts of the entire GIS-based environmental assessments and the comprehensive BIM infrastructure project.

3.1 The A99 Expansion Project

For testing different workflows and data exchange procedures for the implementation of the German Road Map for Digital Design and Construction, the German Federal Ministry of Transport and Digital Infrastructure (BMVI) has launched a number of pilot projects (BMVI 2015). One of those is the eight-lane expansion of the Motorway A99 in the Munich Metropolitan Region, commissioned by the Motorway Authority of South Bavaria and projected by the SSF Engineering Group. The focus of this project lies on defining future requirements for a frictionless information sharing between environmental planners and civil engineers in

order to incorporate all concerns into the engineering process from the start of planning, to project implementation, to completion and monitoring of environmental measures.

For achieving those targets, an integrated data exchange concept (Fig. 2) was elaborated. Its key concept is the integration of the BIM planning process into a geodatabase structure. This way the corresponding information can be exchanged and processed very quickly. For this purpose, 2D and 3D CAD and BIM data were integrated into the GIS data model. By assessing the GIS model, the parties were enabled to determine the potential impact of construction projects on the environment as well as technical or infrastructural constraints.

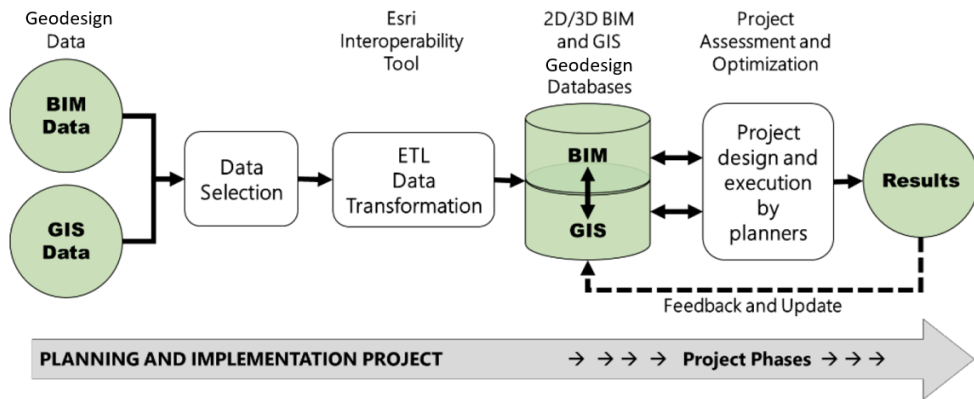


Fig. 2: The integrated data exchange concept (PSU)

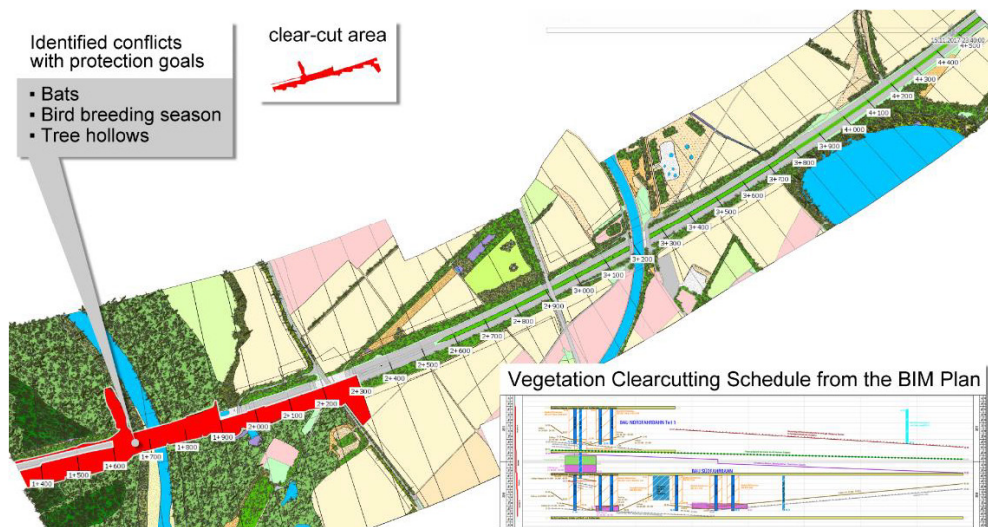


Fig. 3: Identification of potential conflicts between the BIM schedule for vegetation clearcutting and protected flora and fauna (PSU)

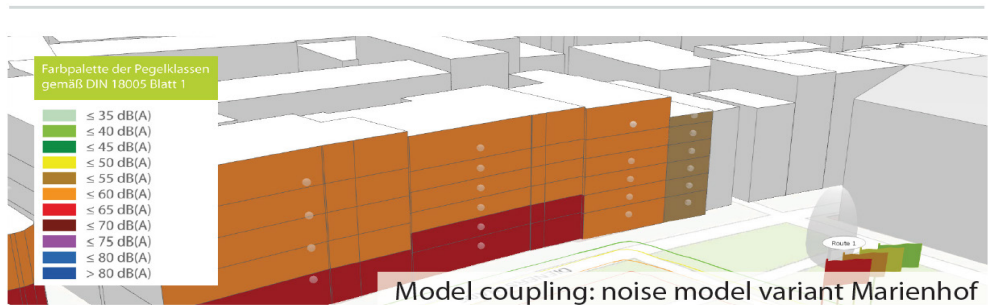


Fig. 5: Noise Model at Marienhof (PSU, Moehler + Partner)

Another application from this project is the modelling of 3D trees including breeding cavities for determining potential conflicts with infrastructure elements as shown in Figure 6. The location and dimension of the trees are based on current field data collection and the BIM construction models are always kept up to date within the GIS model. This allows for a rapid collision detection and therefore for a fast feedback loop between the planners involved.

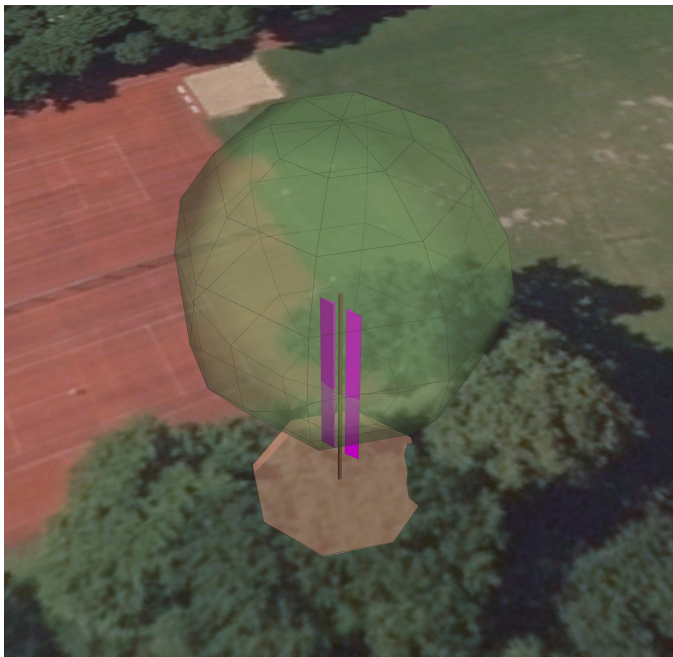


Fig. 6: Tree with breeding cavities modelled in GIS for collision control (PSU)

4 Discussion

The examples clearly show that the integration of BIM and GIS data is possible with state-of-the-art data transformation tools. Even though there are still some difficulties to overcome (like a substantial amount of manual work for transforming GIS geometries to BIM and vice versa), the benefits of shared data already outweigh those problems.

The example of the 2nd SBSS provides some possibilities of using 3D data generated in both GIS and BIM software. With the exact representation of planned construction objects in the GIS model, the results of environmental analyses, like noise effects or species endangerment, directly refer to the predicted impact. By means of the 3D visualization, the existing situation, as well as the effects of the construction project on the environment, become directly perceivable. This results in a more intensive data exploitation as well as in a more convincing information transfer. The benefit of visualizing planning related information stored in BIM in a GIS not only in 3D but also in 4D gets obvious in the A99 example. The implementation of the clear-cutting schedule into the 3D model enables planners from other disciplines to directly understand potential effects caused by time collisions.

For a seamless integration however, there are still some barriers that need to be overcome. Most of the tools only allow for an integration of BIM data in GIS software. In current projects however it is required to also make the GIS data available in the BIM collaboration model. Due to the complex structure of BIM formats like IFC and unclear or missing definitions for GIS objects, the transformation from GIS to BIM still requires a lot of manual work and individual workarounds. This especially applies to the missing of standardized class catalogues for GIS objects like e. g. habitat types. This makes a productive and timely exchange of data still nearly impossible and therefore is one of the main reasons for the still existing delay of (seamless) model coupling.

It also needs to be mentioned that the discussed methods as shown in the two case studies are mainly based on Esri and the connected BIM products. As of today, there are other BIM solutions that allow for a variety of workflows for integration of both methodologies. Those developments show how many opportunities this fast-changing technology offers but also outlines the need for standardized procedures and their integration into major software solutions to ease the overall collaboration between both worlds.

5 Conclusion and Outlook

Several examples for coupling of data sets and models from different sources and planning contributions exist. There is evidence for the technical integration of 3D geometries and attributes from different professional sources, allowing to perform the required landscape and environmental analyses within a semantic 3D GIS data model. Within the BIM cycle, workflows, data and information exchange have to be systematically developed for the planning phases of all environmental instruments and finally as standard procedures for planning practice.

References

- BMVI – German Federal Ministry Of Transport (Ed.) (2015), Road Map for Digital Design and Construction: Introduction of modern, IT-based processes and technologies for the design, construction and operation of assets in the built environment. BMVI. http://www.bmvi.de/SharedDocs/EN/publications/road-map-for-digital-design-and-construction.pdf?__blob=publicationFile (26.03.2021).
- DB – Deutsche Bahn (2021), Building Information Modeling bei der DB Netz AG. <https://www1.deutschebahn.com/db-netz-bim> (09.01.2021).
- DVW E. V. – Gesellschaft für Geodäsie, Geoinformation und Landmanagement & RUNDER TISCH GIS E. V. (Eds.) (2019), Leitfaden Geodäsie und BIM, Version 2.0, DVW-Merkblatt 11-2019.
- EUBIM TASKGROUP (2016), Handbuch für die Einführung von Building Information Modelling (BIM) durch den europäischen öffentlichen Sektor.
- FLAXMAN, M. (2010), Geodesign: Fundamentals and Routes Forward. Presentation to the Geodesign Summit, 6 January 2010, Redlands, CA. <http://www.geodesignsummit.com/videos/day-one.html> (09.01.2021).
- MILLER, W. R., ESRI (2012), Introducing Geodesign: The Concept. <https://www.esri.com/library/whitepapers/pdfs/introducing-geodesign.pdf> (09.01.2021).
- VAN NEDERVEEN, G. A. & TOLMAN, F. P. (1992), Modelling multiple views on buildings. *Automation in Construction*, 1 (3), 215-224. doi:10.1016/0926-5805(92)90014-B.
- STEINITZ, C. (2012), A Framework for Geodesign: Changing Geography by Design. Esri Press, Redlands, CA.