Standardization of Landscape and Environmental Planning for 3D/4D BIM and LIM Projects

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Abstract: As in object planning (architecture, civil engineering), standards for attribution in BIM models have now been developed for landscape and environmental planning. These standards, as well as first applications on real projects, will be presented from 2D to 3D and 4D.
The semantic standards will contribute significantly to lossless exchange of data and content on landscape and environment with the BIM collaborators and to a precise and direct digital communication. However, this cannot only mean – in accordance with the motto of previous mainstream BIM policy – faster and more cost-effective project planning. Rather, the concerns of nature and the environment can and must be given decidedly more attention and weight, so that potential environmental degradation can be recognized and evaluated at the earliest possible time, then designated clearly and distinctly and thus be resolutely avoided through the next planning steps.
BIM should help to substantially identify and implement the sustainability aspects of construction in the entire BIM cycle and in the spatial and temporal effects on landscape from the local to the global scale. It is in this, not just in the merely greater efficiency and cost savings, that the great opportunity of integrated digitization and interdisciplinary collaboration lies. This is the current task of landscape and environmental planning as well as of landscape architecture and, due to their expertise, also of civil engineering, architecture and urban planning. It is the big chance to make extensive use of the BIM method. First examples for this are given.

Keywords: Building Information Modeling, Geoinformation System, IFC, semantics, standards

1 Introduction

BIM planning is making great progress in Germany (BIM DEUTSCHLAND 2022). For example, major infrastructure projects, especially at DEUTSCHE BAHN (DEUTSCHE BAHN 2022), can now be handled exclusively using the BIM method. This also applies to Landscape and Environmental Planning, which is extremely important, as each infrastructure or building project regularly causes impacts upon all environmental factors. The environmental values and impacts (being analysed e. g. by the Environmental Impact Assessment (EIA)), should no longer be managed just by nearly isolated expert work, but the respective results have to be integrated into the so-called BIM collaboration model and communicated among all participating co-workers as clearly as possible. The decisive chance of the BIM collaboration is therefore a considerably higher intensity and quality in the interdisciplinary exchange and hence in the joint effort for the avoidance of further environmental effects upon species, soils, water, air, climate change, health, and the landscapes (see esp. NIKOLOGIANNI et al. 2022). The same is true for LIM projects, where building projects are not in the center of consideration, but landscape and environmental systems analysis and management as such, and, comparable to BIM, with various stakeholders and contributors.

For the highest quality in interdisciplinary work, however, comprehensive information and data exchange is fundamental and therefore requires overarching technical standards (e. g. OULLETTE 2018, VAN LUCKWALD & TEMMEN 2017, LIU et al. 2017).

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So far, the integration efforts for BIM-GIS collaboration (GIS as the fundamental software system for Landscape and Environmental Planning) have focused mainly on the aspect of lossless data exchange, as mentioned above. Here, the advantages of FME (Feature Manipulation Engine) or Open Source Approaches (OSA) in contrast to Data Interoperability Extensions (DIE), have become evident (e. g. GNÄDINGER & ROTH 2021, HERLE et al. 2020, ZHU et al. 2019, CARSTENS 2019).

2 Standards for Semantics

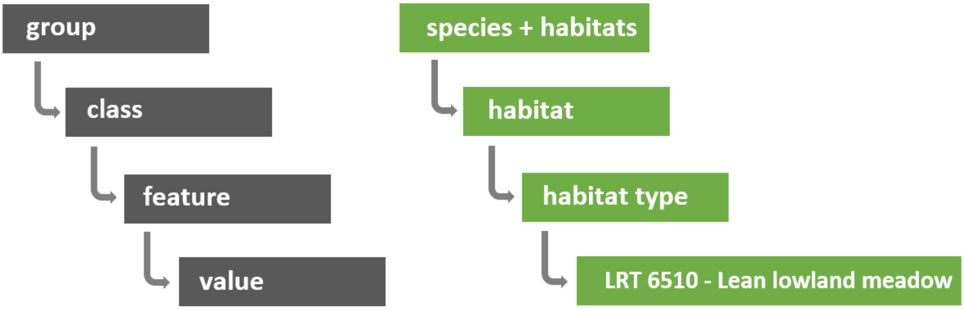

Fig. 1: Basic strucure of object class catalogue "landscape free space ", with four sections: groups, classes, attributes, and values (BRÜCKNER et al. 2022; graphics adopted from TAEGER 2022, modified and translated J. Gnädinger)

Class	Feature	Value
Landscape_free space_overarching the natural goods		
reference area	type of reference area	reference area of soil climatic reference area
protected area, -object …	type of protect. area, -object	natural reserve national park landscape reserve legally protected habitat
Natural good: Species and habitats		
habitat	habitat-occupying species habitat type conservation status	Triturus cristatus reproduction habitat special species protection …

Fig. 2: Detail from object class catalogue "landscape_free space ", with examples from sections class, feature, and value (BRÜCKNER et al. 2022; translation J. Gnädinger)

A decisive factor for successful model coupling and BIM collaboration is that uniformly structured expert models and the underlying data standards for semantics exist. Otherwise, the attribution would remain idiosyncratic in each planning case, although a generalization would be of decisive advantage. WIK et al. (2018) developed a set of definitions and parameters, aiming at a unified landscape object standard for Norway. Similarly, an object catalogue was recently developed in the German buildingSMART landscape architecture specialist group (Figure 1, Figure 2) and is now published (BUILDINGSMART 2023). The catalogue is currently being adopted and developed further by major German infrastructure institutions.

The class catalogue should now serve to carry out the attribution of the BIM environmental models uniformly, whether in GIS or in CAD, so that on the one hand all environmental planners use this standard. In addition, the other BIM collaborators should always be able to read in the attributes in a uniform structure and terminology and, as far as required, understand and interpret these data, not least because contents and terminology are very specialized and fundamentally different from those of the technical planners (civil engineers, architects).

3 First Application of the Object Class Catalogue in 2D and 3D

The availability of standards for the attribution in Landscape and Environmental Planning (for analysis and preparation of measures) and as well as in Landscape Architecture (for design and realisation of measures) means that systematic and generally valid requirements of the client can now be applied to the specialist models of landscape and environmental planning. First applications of the catalogue in 2D, in a real "classical" planning project (Second S-Bahn Main Line Munich) are represented by Figure 3, as an example.

Fig. 3: Application of object class catalogue on a 2D use case in Munich, with respective data in the attribute table (pop-up window right) as well as in the legend (left) (SAALA et al. 2022)

Based on this, the further focus was on 3D application. For an infrastructure project in Hamburg (VET Suburban), GIS point data with attributes were transformed to 3D objects and exported in IFC format via FME. All attributes were included as custom property sets (Figure 4). This approach was the basis for the subsequent application of the object class catalogue in 3D models.

The availability of the catalogue as well as the availability of technology to create landscape elements in IFC format now enables Landscape and Environmental Planning to effectively participate in the real BIM collaboration.

Fig. 4: Data transformation from 2D to 3D-IFC via FME. Left: 2D data from tree cadastre in Hamburg, with attributes of trees (pop-up window left). Right, after transformation: 3D trees as part of 3D city model, with identical attributes (pop-up window right) (BAREISS & GNÄDINGER 2022a).

4 Standards as a Prerequisite for Decisive Added Value for Planning and Policy

It can be assumed, that the introduced technological process of standardizing attribution and as well as geometric features will substantially help Landscape and Environmental Planning as well as Landscape Architecture to better communicate and share their analytical results like ecological and aesthetical insights. Beyond this, our field of expertise might even gain more insights within our own domains of research and practice, as we no longer produce just maps in 2D, but models in 3D and 4D in order to reconstruct more realistic objects of the real world: functioning, and also changing environmental systems of all kinds and on all scales. Doing so, we expect an added value to our work and more informative results.

As an example for this added value, we modeled 3D trees including breeding cavities for determining potential conflicts with infrastructure elements, respectively construction site elements. The data were sampled by digital field data collection: locations, dimensions and physical status of the trees as well as of the cavities – for example cavity numbers per tree, heights, expositions and respective further observations. The post-processing of these 3D trees allows for a rich and highly integrated data analysis as well as for a rapid collision detection with potential construction elements and therefore for a quick feedback loop between all planners and stakeholders involved.

Similarly, a GIS-based tool for designing, planning and complementing of tree alleys in Mecklenburg-Vorpommern, Germany, was developed. We programmed a form in which the desired tree species, tree qualities, distances to the road and between the trees are to be entered. The result is calculated immediately and the respective tree models become elements of the Landscape Information Model (LIM). The growth of the trees over the years, starting from the time of planting, can be simulated (4D) and the design model is ready to be discussed among the stakeholders involved (Figure 4).

Fig. 5: Planning tool (LIM) with 4D simulation of tree growth along a road (BAREISS & GNÄDINGER 2022b)

In this way, for example the change in the aesthetic appearance over the decades as well as the necessary distances to the roadside due to the increasing trunk diameters can be represented. Different tree species as well as their habitus in youth, middle age and old age and even the species-specific appearances during the seasons could also be displayed by integration of a software extension with 3D plant models by LAUBWERK (2022). Here, the transition or overlap between Landscape Planning and Landscape Architecture becomes obvious, as aesthetics, design and free space planning get relevant.

5 Discussion

What is the state of the development towards BIM in Landscape and Environmental Planning? Initial standards for interdisciplinary data exchange at the semantic level are in place, but further refinement in the attribution of natural goods and more experience based on further projects are still needed, not least at the geometric level. Thus, the technical conditions for BIM collaboration are essentially in place, although there is still much need for optimization in detail towards automation, i. e. the replacement of semi-automated and still necessary manual work (GNÄDINGER & ROTH 2021).

We are now in a position to analyse the environmental impacts of infrastructural or urban development projects and to exchange information with our planning partners directly, i. e. in a collaborative model, and to work together on optimizing solutions and on reducing impacts upon all natural assets. The content and results of Landscape and Environmental Planning are obviously getting into sharper focus of planning partners, especially engineers and architects, and further stakeholders through BIM-GIS integration (and of Landscape Architecture through the BIM capability of the CAD expert software) than was previously the case. For this, the standardization processes are fundamental and extremely valuable.

However, standardization is only the necessary foundation – it is not sufficient for real, even greater attention to environmental concerns in all planning and construction activities for infrastructure and urbanism. This is because, despite appropriate analysis, planning and compensation measures, the landscape, soils, ecosystems and climate continue to be stressed by construction and operation beyond sustainable capacities. Building activities are therefore not yet sustainable in the comprehensive sense.

6 Outlook

With regard to standards, the existing object catalogues – of which the buidingSMART catalogue is presumably just one – must be further developed and coordinated with each other so that unified and non-differentiating standards soon apply. Especially in the international context, this is certainly a great challenge, since the methods of Landscape and Environmental Planning as well as the professional legislation differ greatly from country to country.

BIM will not just contribute to optimizing time schedules and cost plans, but to all relevant sustainability aspects of building activities through the whole life cycles (6D). Beyond the specific infrastructure or urban project, the remaining environmental effects in space and time (improvement or additional deterioration) have to be examined. It turns out that extensive new digital tasks emerge, especially for landscape and environmental planning, for the use of GIS and for interdisciplinary work.

There are other "next steps" needed to support a comprehensive, transformative effect of landscape and environmental policy:

- The systematic development of methodological workflows in all phases of the BIM cycle, since only selective ones were developed so far
- The application of GIS also in the area of long-term environmental data management on larger scales, e. g. for infrastructure providers, cities and regions (6D, 7D)
- CO_2-e balances for projects, considering all sectors, such as industry and building, transport, land use, energy etc.
- Implementation of ecological services into BIM- and LIM-models.

The (increasingly digitally supported) landscape ecological and landscape architectural research as well as applied planning, are challenged to further explore their methods of analysis, their modes of representation, the integration and processing of information from external professional models, the potentials of 3D to 7D in geometrics and semantics, the possibilities of communicating content to planning partners, politics and the public and to make them further usable with regard to priority in protecting nature and environment.

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