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Spatial plan registration and compliance checks in Estonia, based on LADM part 5: spatial plan information

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This research explores the automation of compliance checks in the early stages ofspatial planning by integrating Industry Foundation Classes (ISO 16739) withthe Land Administration Domain Model (LADM) Part 5: Spatial Plan Information (ISO 19152-5). Traditional planning processes rely on manual assessments,making them time-consuming, prone to errors, and inefficient. While recentresearch has focused primarily on automating the permitting phase, this studyaddresses an earlier step: verifying spatial plans against regulatoryframeworks. By introducing a standardized approach, the research aims toenhance data management, improve interoperability, and ensure adherence tointernational standards. Automating early compliance checks – such as verifyingbuilding height restrictions or required distances between structures – helpsstreamline the planning process, ensuring that only plans meeting regulatoryrequirements advance to the design approval phase. Estonia is selected as acase study due to its highly developed digital infrastructure and commitment toimproving e-government services.

Keywords: Land Administration, Spatial Plans, Compliance Checks, LADM, Spatial, IFC, BIM

1. Introduction

Conventional planning workflows are often manual, inefficient, and susceptible to errors. While recent research has largely focused on automating the permitting phase, this study targets an earlier stage: automating compliance checks between spatial plans and local regulations during the initial planning process. Ensuring that spatial plans conform to broader regulatory frameworks before reaching the permitting phase is essential. To address this, the research proposes a standardized approach that integrates Industry Foundation Classes (IFC) with the Land Administration Domain Model (LADM) Part 5 Spatial Plan Information (ISO 19152-5). This integration improves data management, enables seamless information exchange, and promotes compliance with international standards. By introducing automation in early compliance verification – such as assessing height restrictions and required distances between structures – the study aims to filter out non-compliant plans at an early stage, allowing only those that meet regulations to proceed to permitting, where detailed design evaluations occur.

This research develops a framework that combines IFC and LADM Part 5 to facilitate model-based compliance checks in spatial planning, using Estonia as a case study. Given Estonia's strong emphasis on digital transformation, its planning system presents an ideal environment for testing such innovations. The study primarily seeks to improve efficiency, interoperability, and standardization by integrating LADM Part 5 into the planning workflow, ensuring that spatial plans comply with overarching legal frameworks and municipal regulations before moving forward. The framework also supports validation both between different plan types (e.g. Master Plans and Detailed Plans) and within the same plan level (e.g. comparisons between two Detailed Plans).

The methodological approach follows a structured process. First, an Estonia-specific profile is developed based on LADM Part 5, adapting it to the country's planning system by detailing how spatial data is collected, maintained, and stored. Next, a dedicated database is created using this profile to serve as a foundation for compliance checks. IFC-based pilot datasets representing Detailed Plans are then imported into this system using customized scripts, allowing automated verification through standardized data processing structures. The findings demonstrate that integrating LADM with IFC enhances data consistency, promotes interoperability, and establishes a reliable framework for regulatory assessments. In addition, certain straightforward compliance checks can even be performed directly within

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the database using predefined queries, further improving the efficiency of the process (Batum 2024).

The paper is structured as follows: Section 1.1 introduces BIM-based compliance checks, while Section 1.2 provides an overview of LADM Part 5 and its implementations. Section 1.3 defines the research questions and scope. Section 2 presents the case study of Estonia, highlighting its current spatial planning situation. Section 3 focuses on the implementation of ISO 19152-5 in Estonia, including the development of the LADM Part 5 country profile. Section 4 describes technical implementation, covering the database structure, compliance checks, and 2D data investigations. Section 5 evaluates the system's effectiveness and alignment with international standards. Finally, Section 6 concludes the research and suggests directions for future work.

1.1. BIM-based checks

Advancements in hardware and software have accelerated the adoption of digital technologies in the Architecture, Engineering, and Construction (AEC) sector, opening up new opportunities to enhance workflows and data management (Atazadeh *et al.* 2021, Noardo *et al.* 2022, Sabri and Witte 2023). As part of this digital transformation, the integration of Geographic Information Systems (GIS) with Building Information Modelling (BIM) supports collaboration across various scales, from individual buildings to city-wide planning. These include automated permit checking, clash detection, integration of planning data with cadastral systems, and improved 3D visualization for stakeholder engagement.

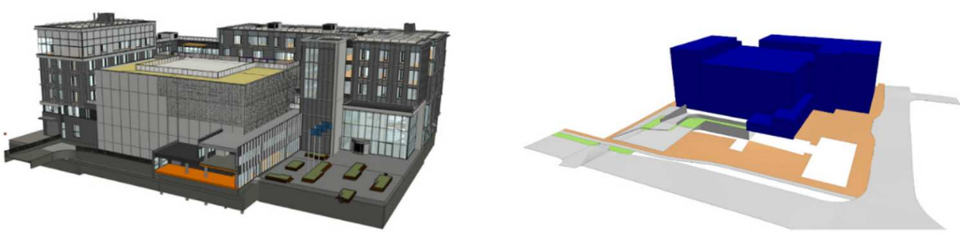
BIM is a process for developing a detailed 3D representation of an asset, incorporating both its physical characteristics and functional attributes. Unlike traditional Computer-Aided Design (CAD), which produces 2D or 3D drawings without differentiating between components, BIM employs an object-oriented approach. This means elements such as 'walls,' 'doors,' and 'windows' are classified as distinct objects with specific properties. Additionally, BIM extends beyond basic 3D modeling by integrating further dimensions, such as time (4D), cost estimation (5D), and asset management (6D), making it a more comprehensive tool for project lifecycle management.

Although BIM is primarily associated with detailed building modeling, its application in spatial planning is gaining popularity, as depicted in Figure 1. Plan data encompasses spatial information related to land use, zoning, land registration, and urban planning. Traditionally, such data has been stored in paper-based formats or CAD files that lack a structured data model. However, with the rise of digitalization and collaborative planning workflows, researchers have increasingly explored the use of Industry Foundation Classes (IFC) for representing planning data (Kardinal Jusuf *et al.* 2017, OGC 2016, Harrie *et al.* 2021). The shift toward digital spatial planning and the growing need for standardized data structures highlight the significance of frameworks such as the ISO standard Land Administration Domain Model (LADM, ISO 19152), which provides an organized approach for managing Land Administration Systems (LAS), including spatial plan data.

One key aspect impacted by integrated digital workflows is the regulation and permitting process, where there is a growing emphasis on digitization to improve efficiency and accuracy. Efforts to digitize these processes aim to enhance both efficiency and accuracy (Noardo *et al.* 2022; Ullah *et al.* 2022; CHEK: Digital Building Permit Process Map, 2023, ACCORD 2024; European Network for Digital Building Permits, n.d.). Traditionally, permitting involves manually reviewing submitted plans to ensure compliance with building regulations – an approach that is both time-intensive and prone to human error (Beach *et al.* 2020). By leveraging BIM models, compliance checks can be automated, reducing reliance on manual reviews and improving both speed and accuracy (Batum 2024).

While much of the existing research has centered on automating the BIM-based permitting phase (ACCORD 2024; CHEK: Digital Building Permit Process Map, 2023; Kallinen, 2023), less attention has been given to earlier stages – such as verifying compliance between spatial plans – despite their crucial role in the overall planning process. This gap in both research and practice is significant, as addressing inconsistencies at an earlier stage can help prevent complications during permitting and ensure the long-term viability of development plans. As Padeiro (2016) points out, a conformance-based approach is essential for assessing whether land-use plans align with broader planning objectives, helping to maintain consistency across different levels of spatial plans before development proceeds. Identifying conflicts early on reduces the risk of regulatory issues later in the permitting process.

Research also highlights how the misalignment between local and higher-level planning frameworks can result in fragmented and inefficient spatial development, emphasizing the need for vertical consistency in planning (Acheampong and Ibrahim 2016). For example, if a Detailed Plan proposes a 12-story building in an area where the Master Plan allows a maximum of 3 stories, checking for compliance with detailed building regulations – such as fire safety standards – becomes redundant, as the proposal itself is fundamentally non-compliant (Batum 2024). Addressing such discrepancies



1 Example of a BIM model of building design (left) and a BIM model of a Detailed Plan (right). Figure by Future Insight Group (2023).

early on prevents unnecessary permitting checks and minimizes delays caused by late-stage non-compliance issues.

1.2. LADM Part 5 and its implementations

The Land Administration Domain Model (LADM), provides a comprehensive framework for land administration, systematically recording and disseminating information about land ownership, value, use, and the relationship between people and land (UNECE 1996, Hull *et al.* 2024). In its latest revision, LADM has evolved into a multi-part standard known as LADM Edition 2. Among its various parts, Part 5 focuses on integrating land registry and planned land use information into a single conceptual model (Lemmen *et al.* 2023).

LADM Part 5 supports planning hierarchies, organizes plan units in a plan block, provides extensible code lists for spatial functions, supports permit registration related to relevant plan units, and allows open dissemination and clear 2D and 3D visualization of plan information. This integration ensures a comprehensive approach to land management by linking land tenure with spatial information (Indrajit *et al.* 2020). The primary goal is to document the rights, restrictions, and responsibilities (RRRs) associated with spatial plans, ensuring compatibility with data from land tenure, value, and development activities (Indrajit *et al.* 2021).

LADM country profiles are tailored versions of the standard that align with specific local land administration needs and systems. For instance, the Indonesian country profile integrates spatial planning information with land administration, addressing dynamic land use and urban planning needs (Indrajit *et al.* 2020). The Malaysian profile integrates 2D and 3D cadastral registration systems, enhancing information interoperability and supporting the National Spatial Data Infrastructure (SDI) (Zulkifli *et al.* 2014). These country profiles demonstrate the flexibility and adaptability of LADM to different national contexts, facilitating efficient land administration adapted to their specific requirements.

1.3. Research questions and scope

This study explores how LADM Part 5 can be integrated into the workflow for compliance checks between spatial plans. Unlike BIM-based permit assessments, the emphasis here is on the early planning stages – specifically, verifying that Detailed Plans conform to Master Plan regulations before entering the permitting phase. Figure 2 highlights this focus within 'Step 3' of the 'New Process' (red box), while the permitting stage (Step 4) falls outside the scope of this research.

Conducting compliance checks early in the process is essential to prevent non-viable projects from moving forward to the permitting stage. By identifying inconsistencies in advance, unnecessary reviews are minimized, and regulatory alignment is ensured. This research is conducted in collaboration with Future Insight, a software service provider based in the Netherlands that develops solutions to enhance collaboration and data integration in spatial planning projects, and the Estonian Ministry of Climate (Kliimaministeerium). The Estonia-based initiative, titled '*Detailed analysis of the use of the information model of the plan and creation of a prototype solution*,' serves as the case study for implementing and evaluating LADM Part 5.

While IFC is the primary focus due to the availability of case study data, a theoretical comparison with CityGML will provide additional insights into its

2 **Scope of the study.**

potential application for similar compliance-checking tasks in spatial planning. This comparison aims to assess how CityGML could function in similar scenarios.

A key consideration in the scope of this research is the dataset used. The technical implementation, particularly the development of a script to upload planning data into the new LADM database, focuses on Detailed Plans. This choice is driven by the research's emphasis on the IFC format, which is better suited for the level of detail required for such plans. Master Plan data, available in the case study as WMS and WFS services, was excluded from the implementation phase since these formats are less relevant to the primary focus on BIM-based 3D spatial data. However, both the LADM country profile and database were designed to support compliance checks between Master and Detailed Plans, ensuring that the necessary framework for cross-level planning checks was also implemented.

Additionally, to assess how Estonia's existing 2D-based system aligns with the proposed LADM framework, this study includes a theoretical analysis of current 2D data formats. This is detailed in section 4.3, where the limitations of 2D CAD drawings and CSV metadata are explored through a case example from Estonia's PLANK system (Estonia's e-construction spatial planning platform), outlined in section 2. The findings emphasize the constraints of the current 2D data environment and the need to move toward more integrated 3D models, such as IFC, to improve planning processes.

Building on this scope, the central research question guiding this study is:

> How can BIM/IFC be leveraged for the registration of spatial plans and compliance checking in Estonia, utilizing LADM Part 5 Spatial Plan Information (ISO19152-5)?

To address this, the study will explore several key aspects.

First, it examines how LADM Part 5 can be integrated with IFC models (LOD1- LOD2), developing an Estonian country profile that supports plan hierarchies, units, and metadata (see section 3.2). This conceptual model is then implemented in a PostgreSQL/PostGIS database, designed to support structured storage, versioning, and querying of spatial plan information (see section 4.1). Second, the study explores how the technical infrastructure enables automated compliance checks, including the use of FME scripts for importing IFC data and validating spatial constraints (see section 4.2). This is complemented by an assessment of which checks can be performed directly in the database using SQL (also in section 4.2). Third, the research includes a case study of Estonia's current 2D-based planning environment, analysing the limitations of DWG and CSV data from the PLANK system and how it aligns with the proposed LADM-IFC approach (see section 4.3). Fourth, a comparative reflection on CityGML is provided in section 6, outlining its strengths and weaknesses for spatial planning workflows compared to IFC. The potential for hybrid use of CityGML and IFC is discussed as a future direction. Lastly, the effectiveness of the proposed approach is evaluated in section 5, including a formal assessment of the Estonia-specific LADM profile using the ISO abstract test suite and pilot implementations of the compliance checking system.

In summary, this research aims to demonstrate how early-stage compliance checks in spatial planning can be enhanced through a standardized data model and digital workflow. By leveraging IFC and LADM Part 5, the study presents a framework that improves consistency, supports automation, and aligns national planning systems with international data standards. The results contribute to broader efforts in digital transformation and spatial data infrastructure development.

2. Case study: Estonia

The research is conducted in collaboration with Future Insight and focuses on a project ('*Detailed analysis of the use of the information model of the plan and creation of a prototype solution*,') partnered with the Estonian Ministry of Climate (*Kliimaministeerium*). This project builds on Future Insight's previous work in automated BIM-based building permit checks, which laid the groundwork for such systems in Estonia. The primary objective of the current project is to create a prototype for verifying compliance between Detailed Plans and Master Plans using IFC models, integrated with the Estonian e-construction platform, PLANK. This initiative is aimed at ensuring that Detailed Plans conform to higher-level zoning regulations before the building permit phase. By addressing potential inconsistencies and non-compliance early in the planning process, the project aims to reduce delays in later stages of construction, ensuring smoother transitions through the approval process and preventing issues that could arise during construction or registration.

The digitization of Estonia's planning process took a significant step forward with the launch of **PLANK** in 2022, a centralized database established by the Spatial Planning Act. This regulation ensures that digital versions of spatial plans from all 79 municipalities are available, containing required digital information and adhering to spatial data quality standards. PLANK aims to reduce the administrative burden on municipalities, maintain up-to-date plans, facilitate dissemination to stakeholders (including citizens), and promote the collaborative use of planning data across different information systems. The database includes automatic validation checks to confirm the accuracy and integrity of plans, ensuring that only validated plans are shared and displayed. However, these checks are limited to 2D data and do not address compliance between different plan levels, such as the Master Plan versus the Detailed Plan. Moreover, plans are only registered in PLANK *after* the planning process is complete, whereas it would be more beneficial to have the data available throughout the planning stages. This gap underscores the need for a system that can handle both 2D and 3D data to ensure continuous regulatory compliance during the planning process.

The project began with desk research and interviews with key stakeholders to better understand the challenges in Estonia's planning system. The findings pointed to the need for improved standardization, collaboration, and the adoption of 3D planning, as much of the existing planning data was in 2D formats with limited interoperability. To address these challenges, the project focused on incorporating IFC as a standardized format for spatial plans, ensuring compatibility with Estonia's e-construction platform. The prototype developed for the

Table 1. Seven checks for implementation [Detailed Plans (DP), Master Plans (MP)]

#	Check name	Detailed Description	Plans Needed
1	Check area measures	Calculates the area for each land use type, providing an overview of the building area.	DP-MP
2	Greenery demands (%)	Determines the percentage of greenery in the plan area to ensure it meets master plan requirements.	DP-MP
3	Maximum building height	Verifies that building heights comply with the maximum height regulations.	DP-MP
4	Building distance	Measures the distance between buildings in the digital twin to ensure compliance with fire safety regulations.	DP
5	Fire hydrants	Calculates the distance from buildable areas to fire hydrants, ensuring compliance with fire safety standards.	DP-MP
6	Protected area requirements	Checks for overlaps with protected areas like heritage sites or flood zones, issuing warnings or errors if detected.	DP-MP
7	Cadastral border distance	Measures the distance from buildable areas to cadastral borders (officially recorded legal boundary of a land parcel in a cadastral system) to ensure compliance with minimum distance regulations.	DP

project used Clearly.HUB[1] for data management and Feature Manipulation Engine (FME) for orchestrating checks, integrating Master Plan and object data from the city of Tallinn and the Estonian Land Board.

During the initial phase, stakeholder interviews identified 18 compliance checks, refined into a consolidated list based on clarity, feasibility, value, and 3D data advantages. After discussions with the project's working groups, 10 checks were shortlisted for further analysis. In the prototype phase, these checks were reassessed to determine data and infrastructure requirements. An agile approach was used, involving an iterative development cycle, data preparation, and implementation.

Ultimately, 7 checks were selected for implementation based on feasibility and data availability. More details on the selection process are available in the project report (Future Insight Group 2024). Table 1 presents the final checks and required plans. These automated checks allowed for assessing compliance between Master and Detailed Plans, with the results being visualized through Clearly.HUB.

3. Implementing ISO19152:5 – spatial plan information in Estonia

The methodology for creating the LADM country profile follows a three-step process: first, establishing an initial mapping based on LADM Part 5 classes; second, iteratively refining the profile through expert feedback and integration with national databases like PLANK; and finally, validating and optimizing the profile with real-world data to ensure its practical applicability and conformance to international standards.

3.1. Current situation in Estonia

Estonia's land administration and spatial planning system is governed by the Planning Act, adopted on January 28, 2015, and came into force on July 1, 2015.[2] This Act redefined the principles, procedures, and responsibilities related to spatial planning, establishing a legal basis for all planning activities. It focuses on creating preconditions for sustainable development, encompassing environmental, economic, cultural, and social aspects. Additionally, spatial planning, initially organized under the Ministry of Finance, was transferred to the Ministry of Regional Affairs as of July 2023.

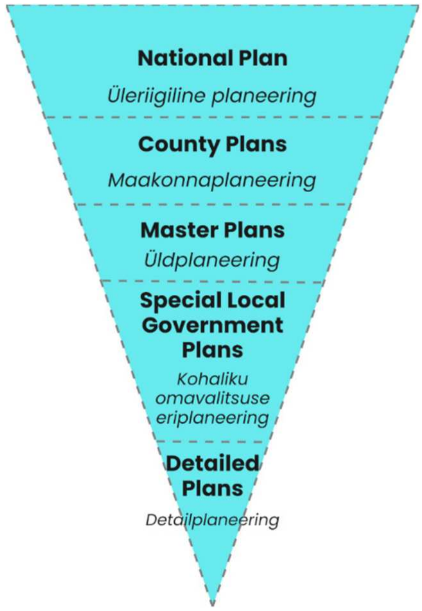
The Estonian spatial planning system is structured into a hierarchical framework involving various levels of spatial plans, seen in Figure 3. At the top of this hierarchy are national spatial plans, which provide key guidelines and strategies for the country's development. National Plans, including the National Spatial Plan (NSP) and National Designated Spatial Plans (NDSPs), set guidelines to help regional and local plans develop in a coordinated manner, ensuring that all plans support national priorities. The NSP, currently '*Estonia 2030+*'[3], outlines country-wide development principles and is managed by the Ministry of Regional Affairs and Agriculture.

At the local level, spatial planning involves County-wide Plans, Master Plans (also referred to as Comprehensive Plans in the Estonian context), and Detailed Plans. The Ministry of Regional Affairs manages County-wide Plans, while municipalities handle Master and Detailed Plans. Additionally, all local plans are reviewed by the Ministry to ensure alignment with national guidelines.

The **National Plan** provides a broad, long-term vision for the spatial development of Estonia. '*Estonia 2050*,'[4] initiated on January 5, 2023, aims to define Estonia's spatial structure and development principles up to 2050. It integrates regional characteristics and national objectives and is administered by the Ministry of Rural Affairs, with initiation and approval by the Government of the Republic.

The **County Plan** focuses on regional spatial development, balancing local and national needs, and provides guidelines for municipal planning. These plans integrate various sectoral interests and regional characteristics, influencing the preparation of municipal Master Plans. For example, the *Jõgeva County Plan*[5] outlines spatial development according to the vision and development trends agreed upon during the creation of the national plan 'Estonia 2030+'.

Master Plans are comprehensive plans that guide the development and use of land within specific areas. They provide a framework for land use, infrastructure, and community development. Municipalities are responsible for creating Master Plans, which align with County and National Plans and address local development needs. These plans set out general land use principles and development guidelines, providing a basis for more detailed planning activities.[6] An example of a Master Plan is the *Tapa Parish Master Plan*[7] (seen in left side of Figure 4),



3 Spatial plan hierarchy of Estonia.

which outlines spatial development principles for *Tamsalu* town and *Uudeküla* village.

Detailed Plans are the most specific level of planning, focusing on individual sites or projects. They provide precise instructions for land use, infrastructure, and construction. Prepared by local authorities or private developers, Detailed Plans ensure compliance with broader Master Plans and County Plans. These plans include detailed information on land use, building design, infrastructure, and other specifics necessary for implementation. An example is the *Põllu tn 4 Area and Surroundings Detailed Plan*[8] (seen in right side of Figure 4), which specifies construction rights and land use changes for a commercial building.

Special Local Government Plans (SLGP) address specific spatial needs at the municipal level, focusing on particular projects or areas of interest. Local governments develop these plans to meet unique local requirements not covered by general plans. SLGPs provide detailed guidance for specific projects, complementing broader County and National Plans. These plans ensure significant projects are planned in suitable locations without hindering other activities. Established by the planning law effective from July 1, 2015, SLGPs expire if not implemented within five years, making them suitable for near-term development rather than long-term strategic planning.

Each level of planning in Estonia is designed to address different aspects of spatial development, and it is crucial to assess the potential impacts of these plans on the environment. This is where ***Strategic Environmental Assessment*** (SEA)[9] becomes important. As it ensures that the potential environmental impacts of various plans are thoroughly evaluated and addressed.

In Estonia, the SEA process applies differently depending on the type of plan. For National Plans, SEA is a mandatory procedure, focusing on strategic assessments of long-term and large-scale impacts on the environment, while County Plans are also important in regional development, they typically do not require a separate SEA process. Master Plans, being more localized, often require a specific SEA to address the direct and indirect impacts of proposed developments. Detailed Plans generally do not require an independent SEA but must comply with the SEA findings and recommendations from Master Plans.

3.2. LADM Part 5 country profile development at a conceptual level

By developing a country profile, the specific needs of Estonia's LAS can be addressed, allowing spatial plans and permit checks to be effectively integrated into the broader national infrastructure.

The general layout of LADM classes and attributes might not always completely meet the needs of a country planning to utilize LADM. The country profile development involves creating or omitting classes, attributes and relationships if necessary to represent the specific needs of the country. There are two main approaches when developing an LADM country profile: a holistic view mapping all cadastral information, or a targeted approach focusing on specific parts based on the country's needs (Kalogianni *et al.* 2019). This research focuses on spatial data and permitting, making LADM's Part 5: Spatial Plan Information package the basis for the new Estonia country profile.

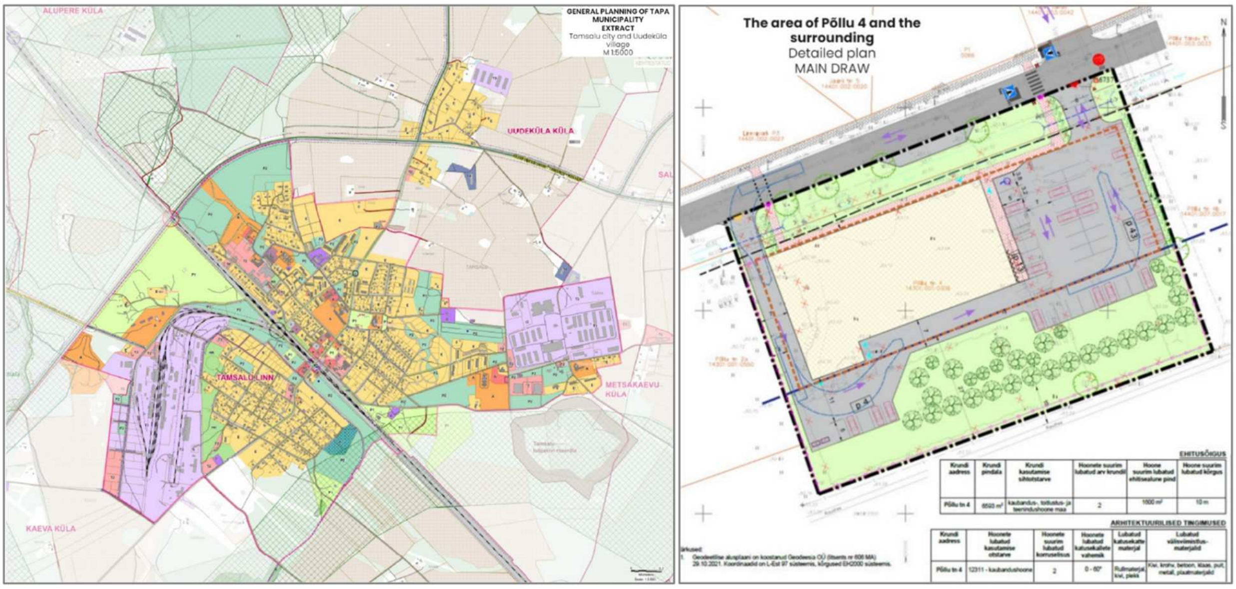
The development of the Estonia country profile began with a foundational mapping based on the initial LADM Part 5 classes, seen in Figure 5. This initial framework provided a standardized starting point, ensuring consistency with LADM's main structure. The first step in creating the country profile required the representation of different plan types, such as National Plan, County Plan, Master Plan, and Detailed Plan. During the initial mapping of the plan types to the existing classes, the following points from Kalogianni *et al.* (2019) were considered:

- **Inheritance from LADM core classes:** Classes specific to Estonia that were absent in representation in LADM Part 5 classes were created by including a prefix to indicate the country (e.g. 'EST' for Estonia). These classes would be inherited from the related LADM Part 5 classes.
- **Addition of new attributes:** Additional attributes were incorporated to accommodate national requirements and needs.
- **Maintaining associations:** The original associations defined in LADM Part 5 were preserved.

Furthermore, the final country profile will be assessed according the abstract test suite (ATS) of *ISO 19152:5* in Section 5: Evaluation and Discussion. Major sources that affected each country profile version are the following:

- **Version 1:** Data layer requirements
- **Version 2:** Data layer requirements + PLANK requirements and metadata
- **Version 3:** Data layer requirements + PLANK requirements and metadata + real data

The development of the Estonia-specific LADM profile evolved through three major iterations. The first version introduced new Estonian-specific classes ('EST') to represent different plan types, with attributes based on existing Estonian Plan data layer requirements (requirement tables are available in Appendix Tables A1–A4). The initial approach focused on translating Estonian attribute names and creating separate classes to explore



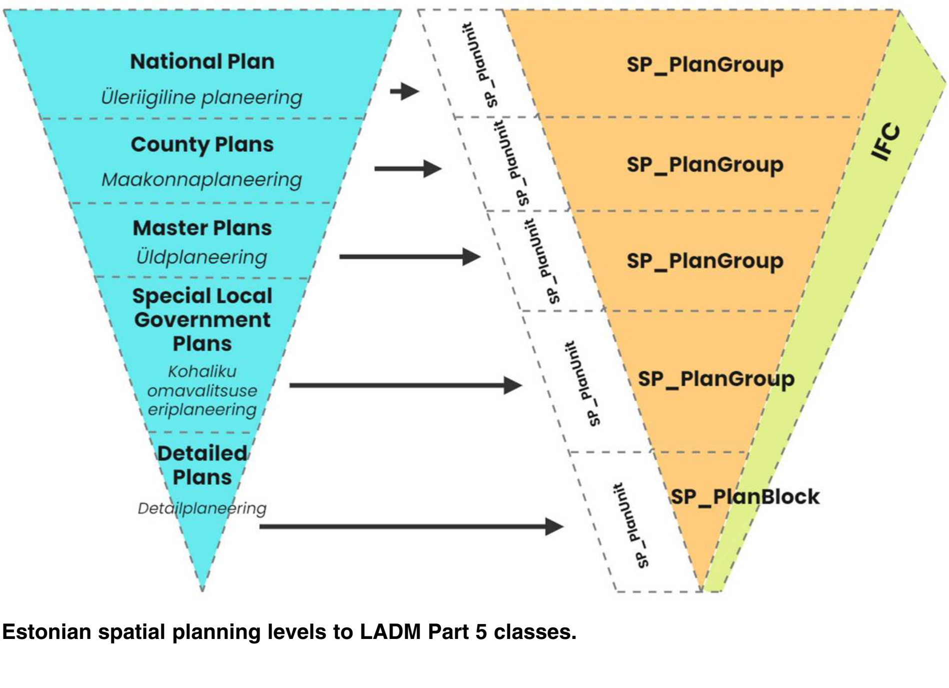
4 Tapa Parish Master Plan (left) showing Tamsalu town and Uudeküla village (scale 1:5000), and Põllu tn 4 Area and Surroundings Detailed Plan (right), illustrating land use and development specifics (scale 1:500). Figures by Kerttu Kõll, Janne Tekku, and Piret Põllendik with Entec Eesti OÜ, and Laura Andla.

the overlap with LADM Part 5 concepts. As the profile progressed, redundant attributes were eliminated, and LADM attributes were mapped to Estonian data.

The second version integrated feedback from Estonian Ministry experts and incorporated the database model from PLANK, Estonia's spatial plan database. This update significantly impacted the profile by reducing attribute redundancy, integrating metadata from PLANK, and creating code list classes for attributes specific to Estonia.

The final version of the profile, shown in full in the Appendix (Figure 31), introduced real data representations and optimized the model for practical use. This included incorporating real-life data, technical adjustments encountered while building the PostgreSQL database and loading spatial data via FME. The final result is a comprehensive profile that accurately reflects the management of Estonian spatial planning data, aligning both technical and conceptual requirements.

The general model is presented in Figure 6. Details in the left part (seen in orange classes, detailed in Figure 7) focused on representing and storing information about the source data and metadata of the uploaded plan. The right part of the model (seen in blue, detailed in Figure 8) represents the different country profile classes, their units and relationships with each other. Part 5 classes as super classes for country profile classes, such as allowing *EST_DetailedPlan* to inherit attributes from *SP_PlanBlock* and the *VersionedObject* class in addition to its own specific attributes. Main plan classes



5 Mapping of Estonian spatial planning levels to LADM Part 5 classes.

(*EST_NationalPlan, EST_CountyPlan, EST_MasterPlan, EST_DetailedPlan*) have an 'aggregation' relationship vertically with each other, representing conceptual geometry aggregation rather than strict composition. This allows for flexibility in spatial plan representation as in reality multiple smaller scale plans are not always represented by one higher scale geometry. Additionally, each plan class is associated with a unit class (e.g. *EST_DetailedPlan with EST_DetailedUnit*) to represent detailed elements with specific functions like a building or a park area, facilitating detailed information storage and easy retrieval. This hierarchical and granular approach ensures each unit within a plan can be individually addressed for comprehensive planning and management. Finally, Part 5's *SP_Permit* class is linked to *EST_DetailedUnit*, representing the most granular level of information in the model, building scale data.

4. Implementation

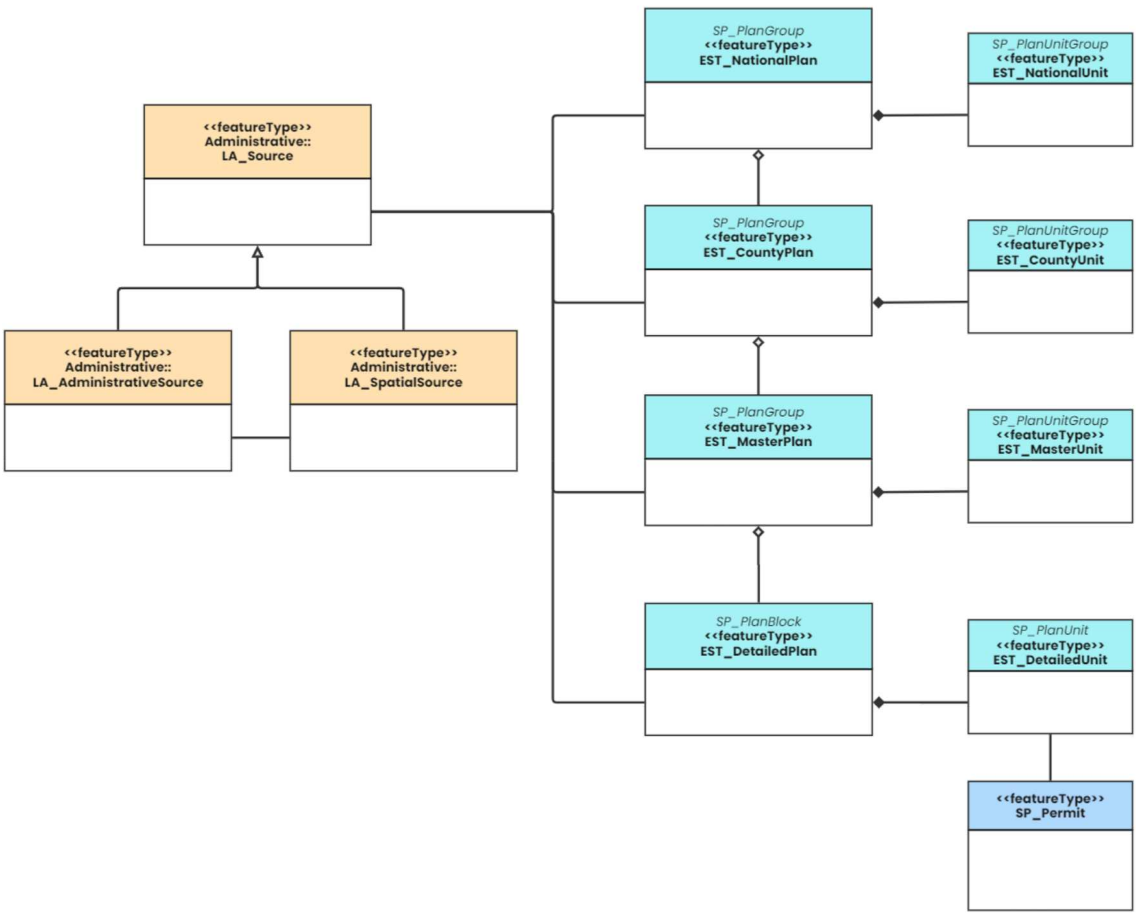
4.1. LADM database

The implementation of the LADM database began by selecting PostgreSQL with the PostGIS extension as the database software due to its robustness and support for spatial data types. The initial step in developing the database involved creating the feature classes of the country profile as separate tables. These tables serve as the primary repositories for all imported data. Key feature classes include *EST_NationalPlan, EST_CountyPlan, EST_MasterPlan, EST_DetailedPlan, EST_NationalUnit, EST_CountyUnit, EST_MasterUnit, EST_DetailedUnit,* as well as original LADM classes, such as *SP_Permit, LA_Source, LA_AdministrativeSource,* and *LA_SpatialSource*, where no changes were needed.

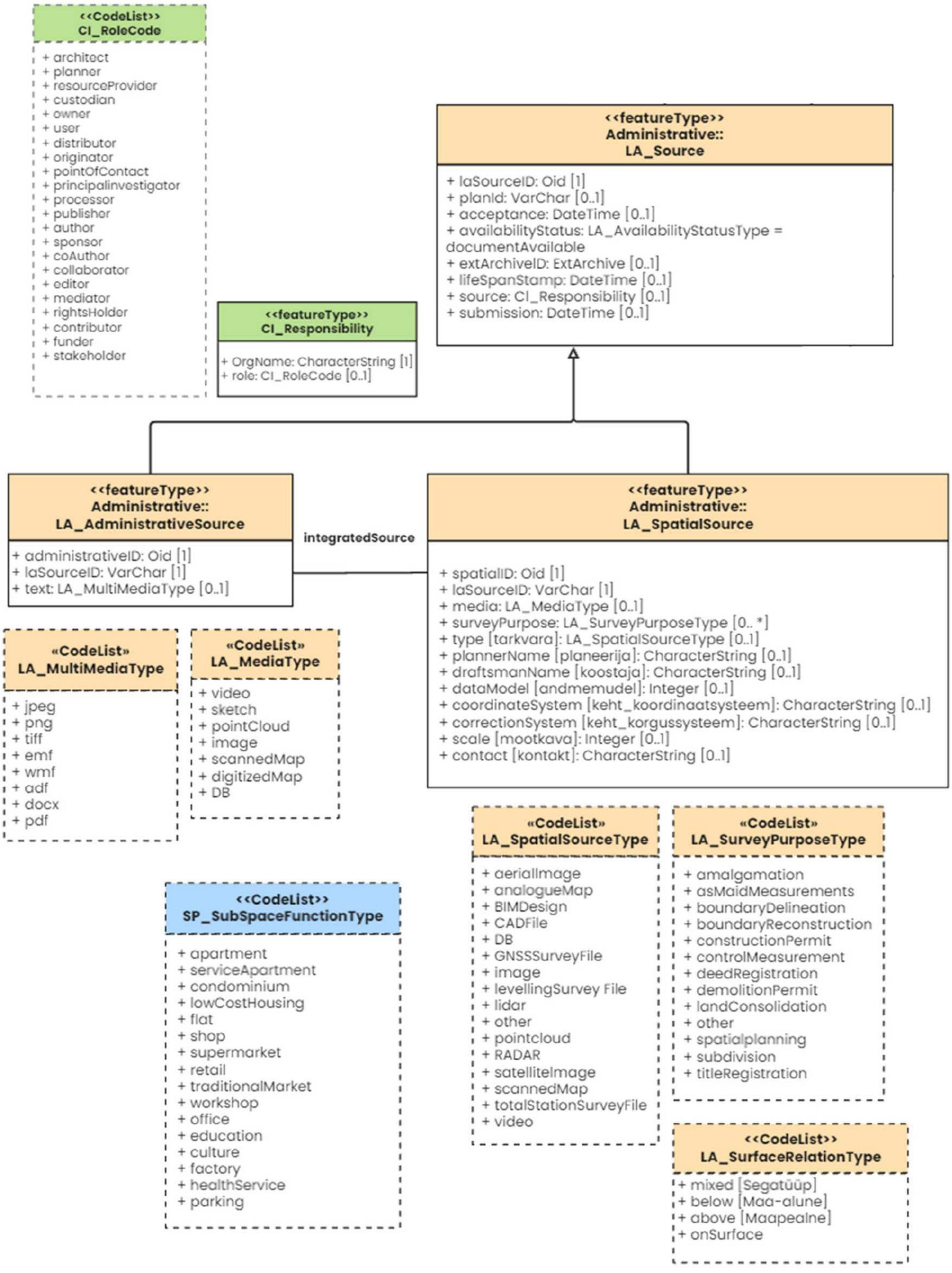
To create connections between the plan tables (such as **est_national_plan, est_county_plan, est_master_plan,** and **est_detailed_plan**) and their corresponding unit tables (like **est_national_unit, est_county_unit, est_master_unit**, and **est_detailed_unit**), additional foreign key attributes were incorporated into the unit tables. An example of this setup is shown in Figure 9. In this figure, the **county_plan_id** acts as the primary key in the **est_county_plan table** and as a foreign key in the **est_county_unit** table. This structure allows for direct identification of which unit (represented by **county_plan_unit_id**) corresponds to a specific version of a plan.

It's important to clarify that different **county_plan_id** values in the *EST_CountyPlan* table do not necessarily represent different plans. Instead, the '**plan_id**' attribute (e.g. '100110' in Figure 9) indicates the actual plan identity. The exact meaning of this attribute and how it is derived will be explained in more detail later. In essence, different **county_plan_id** values correspond to different versions of the same plan, as indicated by the consistent **plan_id**.

A key design choice was the implementation of intermediate tables to manage many-to-many relationships within the model. A notable example of this is the connection between plan classes and *LA_Source*. Both theoretically and practically, a single plan in the database can be linked to multiple source datasets. For example, a



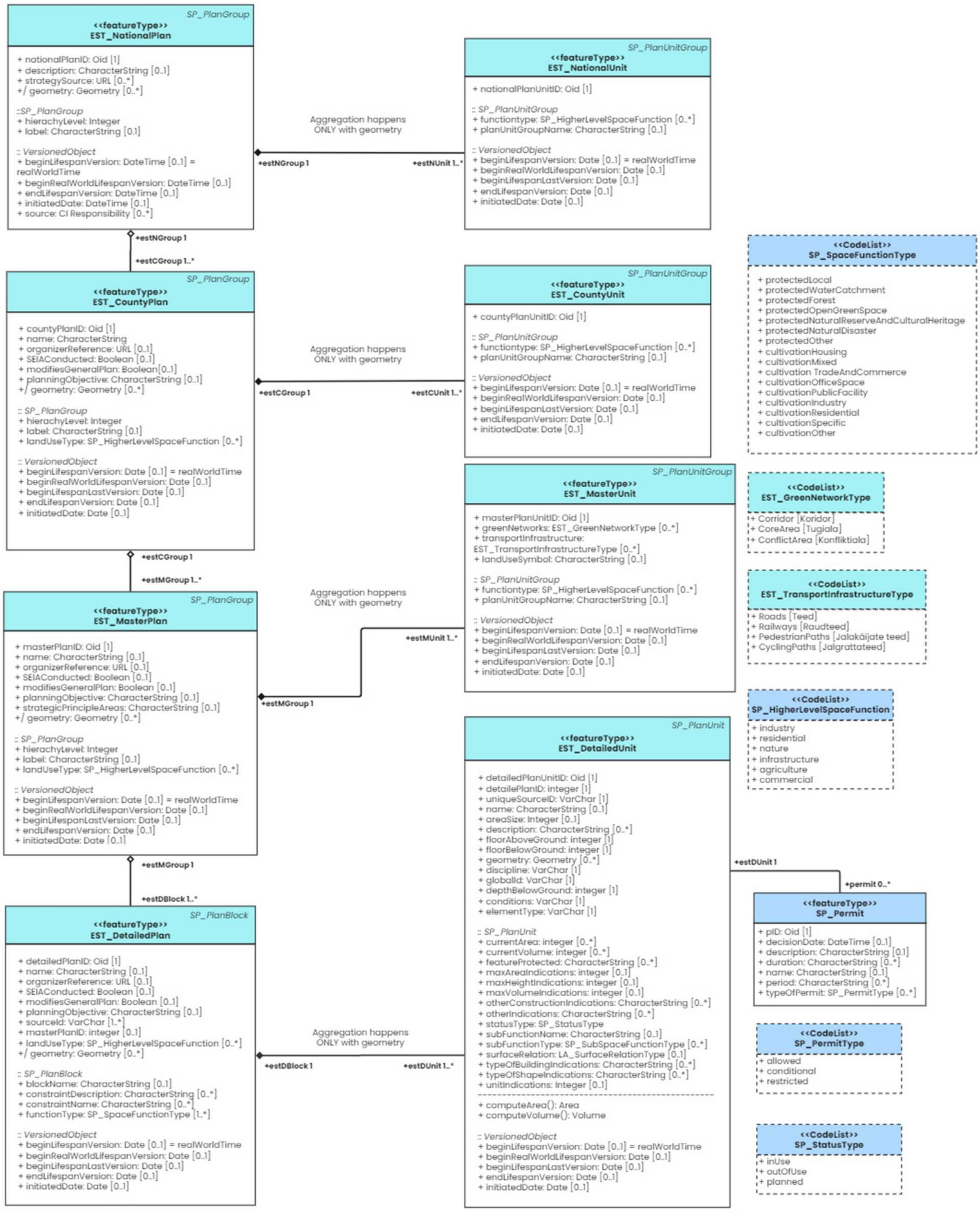
6 Simplified Estonian LADM Country Profile.



7 Representing and storing information about the source data and metadata.

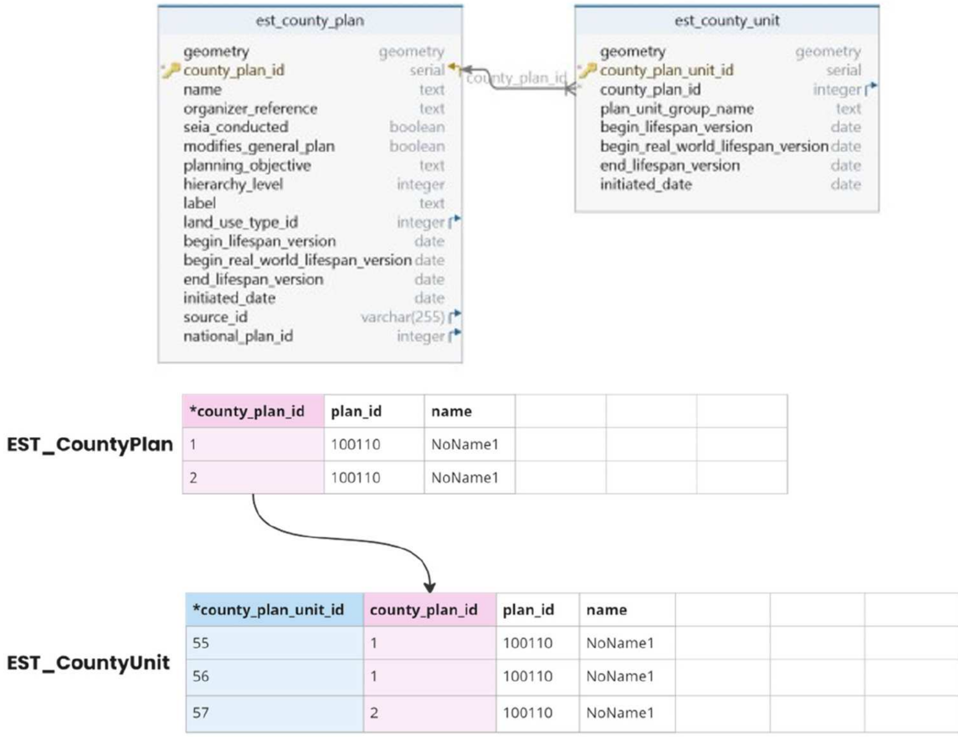
Detailed Plan might consist of various CAD files and 2D PDF documents. Similarly, a single source dataset can be associated with multiple plans, such as a comprehensive topographical survey in *LA_Source* being referenced by both a Master Plan and a Detailed Plan. This dual relationship between plans and sources is depicted in Figure 10. To accurately capture these relationships, intermediate tables such as *national_plan_la_source, county_plan_la_source, master_plan_la_source,* and *detailed_plan_la_source* were created in the database.

Figure 11 illustrates how the primary and foreign keys function in this context using the example of the *master_plan_la_source* table in the database. This table contains two primary keys: **master_plan_id** and **la_source_id.** Each **master_plan_id** serves as a foreign key linking to the *EST_MasterPlan* table, while each **la_source_id** references the *LA_Source* table. These two keys together uniquely identify each record in the table, enabling a single Master Plan to be linked to multiple source datasets, and vice versa.



8 Plan classes and their units.

Figure 12 presents the overall model structure in the database, excluding the codelist tables. The codelist tables – such as *SP_HigherLevelSpaceFunction, CI_RoleCode, LA_MultimediaType, LA_MediaType, EST_TransportInfrastructureType, EST_GreenNetworkType, SP_SubSpaceFunctionType, SP_StatusType, SP_SpaceFunctionType, SP_PermitType*, and *LA_SurfaceRelationType* – play a crucial role in maintaining the integrity of the country profile. These tables store predefined codelist values, either newly created for Estonia or derived from LADM standards. They are intended to be static, with records that should remain unchanged unless adjustments to the country profile require updates. For example, Figure 13 demonstrates how the *SP_Permit* table utilizes a codelist value from the *SP_PermitType* codelist table, ensuring that only valid, predefined permit types are used, thus preserving consistency.



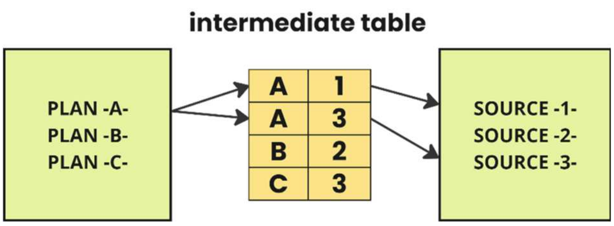
9 EST_CountyPlan and EST_CountyUnit relationship in the database.

Furthermore, to optimize the database, some sequences, triggers, views, and functions were implemented.

Sequences are mainly used to generate unique identifiers for records in various tables, ensuring that each entry has a distinct and traceable ID. For instance, sequences *like ci_responsibility_id_seq, ci_rolecode_id_-seq, detailed_plan_id_seq*, and many others are created to automatically increment IDs, starting from 1, whenever a new record is inserted. This guarantees the uniqueness of each plan record's identifier.

The database also contains several trigger functions to enhance efficiency and maintain data integrity. For example, the *insert_default_administrative_source* and *insert_default_spatial_source* trigger functions run after a new entry is inserted into the *la_source* table through FME. These triggers call the *insert_default_administrative_source* and *insert_default_spatial_source* functions to insert corresponding 'dummy' entries in the *la_administrativesource* and *la_spatialsource* tables. This mechanism can be seen in Figure 14.

For versioning, both the database and FME script were utilized. The upload date (**begin_lifespan_version**) is added



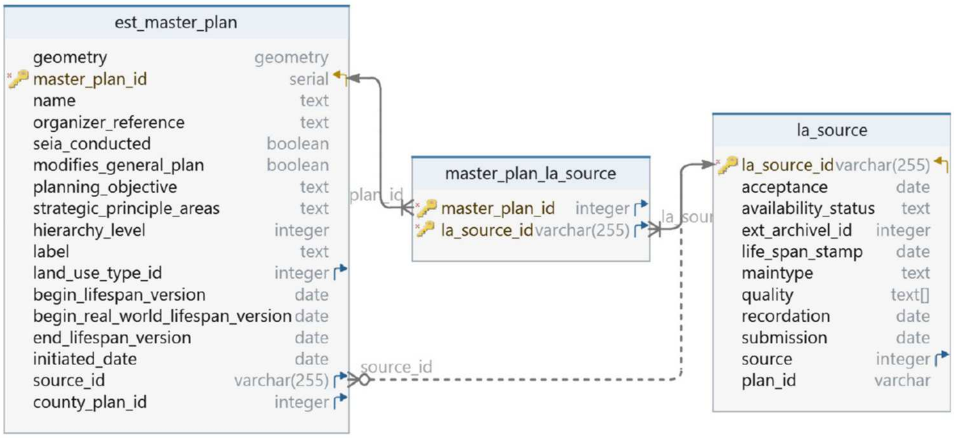
10 Many-to-many relationships represented by intermediate tables.

through the FME script before uploading to the database. An attribute for the last version (**begin_lifespan_lastversion**) was added to every plan and unit table to manage different versions. Functions named with the plan levels (e.g. *update_d_plan_beginlifespanlastversion*) update the begin_lifespan_lastversion field, ensuring all records with the same plan_id reflect the most recent date. During the import process, **begin_lifespan_version** and **begin_lifespan_lastversion** are set to the current date to mark records as the latest version. Initially, complex logic caused infinite loops and errors, but refining the logic solved this. The trigger *trg_update_d_unit_lifespan* activates after an insert or update, ensuring accurate versioning without errors. The same logic applies to other plan and unit tables. Figure 15 illustrates an example scenario demonstrating how the versioning works in the database.

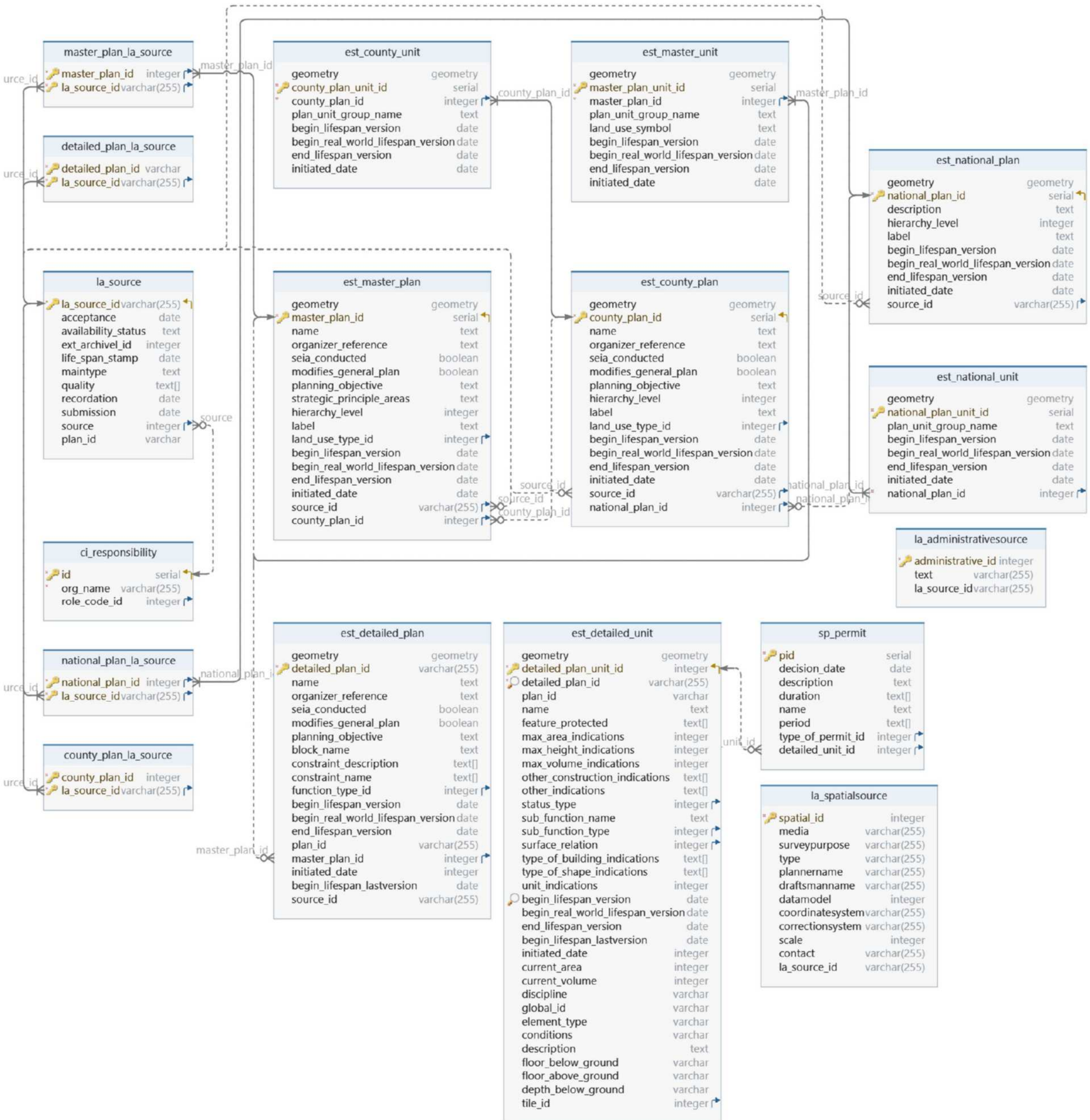
To further enhance the database's legibility further, several views were also implemented. For instance, the *est_detailed_plan_unit_count* view was created to aggregate detailed plans and their corresponding unit counts. This view provides a summarized count of units associated with each Detailed Plan, making it easier for users to get an overview of the data without needing to perform complex joins or queries themselves.

Most functions and triggers were created during the testing phase using FME to import data, allowing realistic optimization for Estonian data requirements. This iterative process was crucial for finalizing the database setup. A database dump script for deploying the database from scratch and a reset script to clear all records except codelist values are available on GitHub.[10] These scripts ensure the database's integrity during testing and development.

Figure 16 illustrates the overall system architecture for both the database and the import process. The



11 Example of primary and foreign key relationships in the master_plan_la_source table.



12 Model structure in the database without the codelist tables.

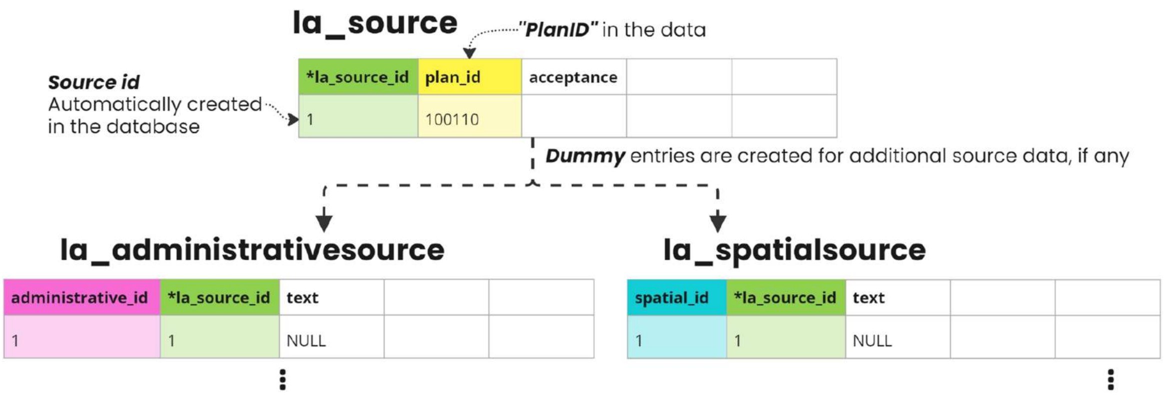
SP_Permit

pID	decision_date	name	type_of_permit	period	detailed_unit_id		
12	01-01-2023	Permit A	1	12 months	100		
13	15-10-2023	Permit B	3	3 months	54		
14	28-05-2023	Permit C	1	6 months	17		

SP_PermitType

ID	type
1	allowed
2	conditional
3	restricted

13 Example of how codelist values are represented in the database.



14 "Dummy" entries for la_administrativesource and la_spatialsource.

steps with a white background indicate the procedures followed for the project by Future Insight. The figure also shows that the initial starting point remains consistent to facilitate better integration with the actual project pipeline. Once the database was established, FME scripts were developed to handle the importation of spatial data.

Importing begins with the preparation of IFC data, ensuring that the data conforms to the required standards and formats. FME is used to manipulate and transform Estonian IFC data into a format compatible with the developed LADM database. The basis for the FME script is derived from the case study project, utilizing the scripts created by the company for permit checks. These scripts automate the extraction, transformation, and loading of data for the checks.

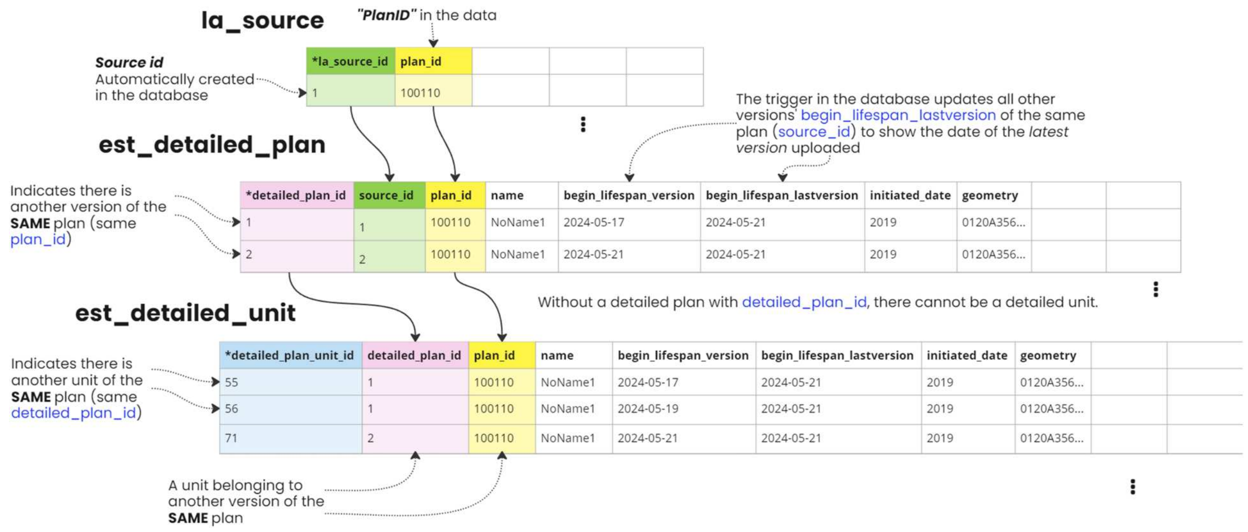
The process can be divided into two main parts. The first part involves general data extraction and initial validation methods for the IFC data. This includes verifying the completeness of metadata, ensuring spatial data integrity, and validating object properties and layer naming conventions, all according to the Estonian layer requirements. The second part of the process handles the necessary data transformations and additional data extraction mechanisms needed to comprehensively represent the data in the LADM profile. This phase includes transforming the data to meet specific schema requirements and finally importing the transformed data into the new PostgreSQL database.

Additionally, various *User Parameters* were created to make the FME workflow more generic and flexible for various input data. Key parameters include database connections, source dataset paths, and domain-specific (also reffered as *discipline* in the research and case study) property sets and their syntax.

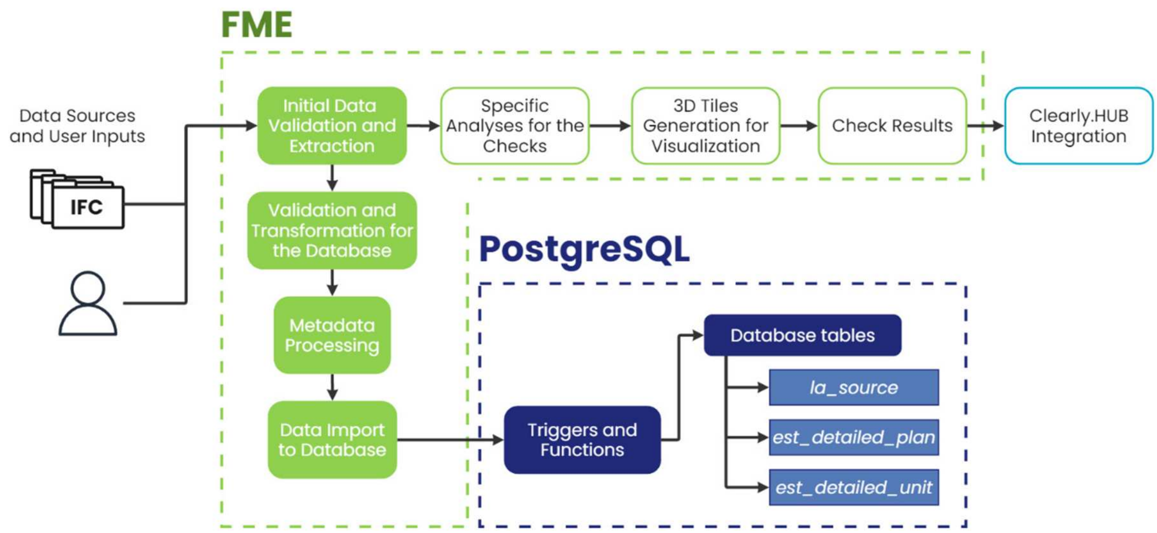
Figure 17 shows detailed explanation of the general FME workflow. After the IFC files are read, the data's *IfcPropertySet* and *IfcAnnotation* are compared against each other. The aim is to only keep the matched discipline records with a property set and exclude everything else. A '*discipline*' represents specific thematic categories (i.e. layering) within the Estonian IFC data, such as public spaces, landscaping, building zones, access routes, utility conditions, plot areas, land use types, and transportation networks. Next, the script checks if the *plan_ala* or *dp_krunt* is in the kept disciplines. These layers represent the planning area and the plot area, respectively and according to Estonian layer requirement, it is mandatory that every plan data must have both layers.

After the initial data extraction and validation, the second stage (i.e. 'Validation and Transformation for the Database' in Figure 17) of the script begins with excluding some objects from the records for development purposes, like trees. To avoid any relevant data loss during the import, these objects will be included again in the end, right before importing the data into the database.

Following the exclusion of some elements, the final data extraction and transformation before the LADM part focuses on geometries. When reading IFC files in FME, the '*Body*' geometry often includes aggregated property



15 Example of how the versioning in the database works.



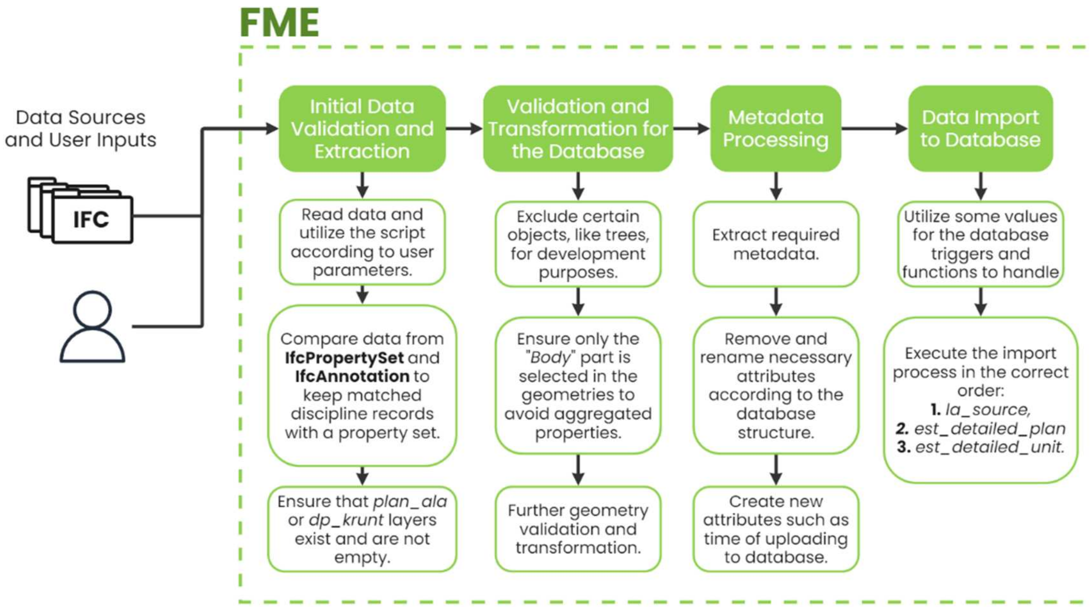
16 Overall system architecture of the process.

information. To ensure predictable and clean geometry data for the database storage, it is important to avoid these aggregates and extract only the '*Body*' part of the geometry. This ensures that the extracted geometries are consistent and free from unwanted aggregation. After the geometry validation, the workflow focuses on specific layers, such as the planning area (i.e. *plan_ala*) and plot area (i.e. *dp_krunt*) layers, applying some checks and transformations. steps include validating layer presence, converting geometries to 2D representations, and ensuring that lines are closed to form valid polygons. For other disciplines, similar validation and transformation processes are applied to ensure all geometries are correctly formatted and meet the required standards before continuing with the LADM part of the FME script. This guarantees that the spatial data is accurately represented, is consistent, and ready for the next steps.

The first table in the database to import information into is the *la_source* table. As previously explained, the database has been developed with sophisticated constraints such that every plan uploaded must first have source data uploaded to the *la_source* table. This is crucial to maintain the integrity and traceability of the spatial data within the database.

Since the *la_source* table primarily stores metadata about the source rather than the spatial information itself, the geometry is removed from this table. Figure 18 illustrates an example of pilot data, '*Põhi*,' in the *la_source* table. Notice that there is one entry to represent one source data, which in this case refers to the combined IFC files representing the *Põhi* Detailed Plan. Another important column is the *plan_id*. It allows the data to be correctly uploaded to the Detailed Plan and Unit tables, as the database can now recognize the plan id and connect it to the source file.

The order of the script's import to the database is crucial, even after the *la_source* table. The correct import sequence for a spatial plan should be *la_source, est_detailed_plan*, and *est_detailed_unit* (for Detailed Plans). For example, for a county plan, the order would be *la_source, est_county_plan,* and *est_county_unit*. This approach aligns with the constraints established during the



17 Detailed process of the FME scripts that are utilized for importing data to the database.

database creation, which state that one or more plan units cannot exist without the plan existing first. Additionally, there are technical constraints in the database to enforce this rule. Therefore, the script's execution order meticulously conforms to these constraints.

After the data is imported into the *la_source* table, the script continues with the transformation of the geometries. A significant design choice involved selecting the geometry to be imported into the *est_detailed_plan* table. Since the unit table was developed to store every geometry element as a unit (e.g. a building, a tree, a street, etc.), the plan table was designed to show one entry representing the data and metadata of the entire plan. This led to the decision to merge the geometries into one mesh to represent the plan as a single geometrical entry. This approach was also considered more practical for simple visualization purposes of the plan in the database or as 3D Tiles.

The IFC data, originally represented as unit elements in terms of geometry, required necessary transformations to merge these units into one geometry. To accurately represent the plan area (*plan_ala*, represented as a 2D line in the Estonian data), additional manipulations, such as creating a 3D platform of the plan area, were performed. These steps ensured that the final mesh visually reflected the entire plan area in 3D. Figure 19 shows an example of the final geometry product that is to be uploaded to the *est_detailed_plan* table.

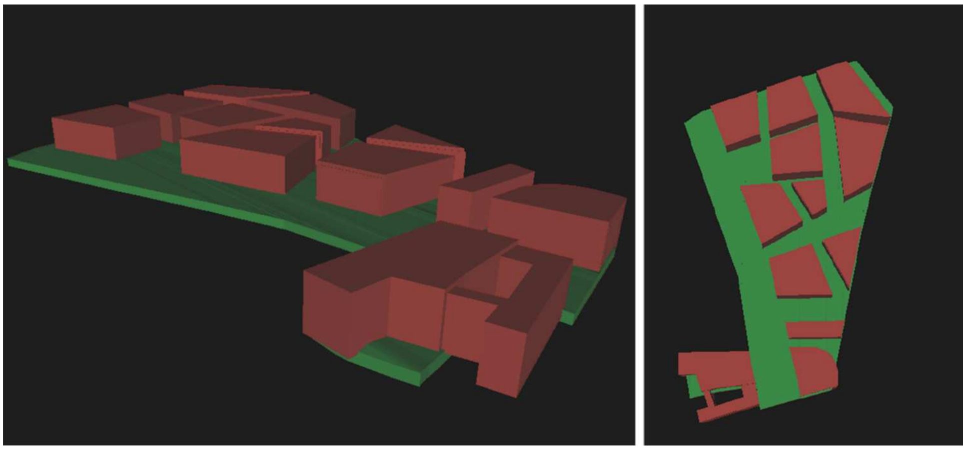
After forming the plan geometry, the current date and time are added as an attribute, representing the *begin_lifespan_version* in the plan tables to indicate the upload time. Finally, after renaming attributes, cleaning unnecessary data, and merging with the geometry to represent a single record, the data is imported into the *est_detailed_plan* table in the database. Figure 20 shows an example representation in the database for the Põhi dataset. For better legibility, the continuation of the first row is pasted below, ensuring the complete information of the single entry is clearly visible and understandable. It should be noted that most of the null fields in the database come from the lack of the necessary data in the pilot dataset.

After importing the necessary information into *est_detailed_plan*, the script prepares and transforms data for the *est_detailed_unit* table. An SQL query executed in the FME script ensures that the later imported data is recognized as units of the same plan by retrieving the most recently imported Detailed Plan's ID from the *est_detailed_plan* table from the database. This allows the corresponding units to be linked to the specific plan with a foreign key. Therefore, the source, plan, and its units should be uploaded together to maintain data integrity, although this constraint can be optimized for more flexibility in the future development of the research.

Moreover, testing mechanisms were implemented to categorize codelist values. For example, the *la_surface_relation* codelist table, illustrates a mechanism for

	la_source_id [PK] character varying (255)	acceptance date	availability_statu text	ext_archivel_i integer	life_span_stam date	maintype text	quality text[]	recordation date	submission date	source integer	plan_id character varying
1	1	[null]	[null]	[null]	[null]	[null]	[null]	[null]	[null]	[null]	210011

18 Example entry to the la_source table using the pilot data, Põhi.



19 Final Geometry Product for est_detailed_plan table.

categorizing incoming data. This was tested with flexible methods, such as automatically recognizing and labeling vegetation elements as 'on surface' or comparing the depth below a building with the floors above and below it. For instance, if an element is below ground, it is assigned a value of code id '2,' which the codelist table maps as code label 'below.' This ensures that the incoming data matches the predefined codelist values set by the country profile and the database.

Finally, after all the extraction, transformation, and manipulation of the data, the resulting unit records are imported into the *est_detailed_unit* table in the database. Figure 22 shows an example of how different units are stored with their own metadata. The building geometry highlighted in red represents the sixteenth unit, which is highlighted in blue below.

To test the accuracy of the imported results compared to the raw input IFCs, another FME script was created to read the recently imported data from the database. Specifically, for the units in the *est_detailed_unit* table, the only requirement is to input the *detailed_plan_id* into the reader, so it only reads the plan units of the specific plan requested. For versioning, this query can be made more specific to isolate the requested plan and the version available in the database.

The results, seen in Figure 21, showed that the geometries accurately reflected the original pilot dataset, and the metadata was stored correctly without any errors. The only shortcoming encountered was PostGIS's inability to natively render geometry appearance/style, such as the color of the elements. This limitation stems from a technical issue with PostGIS. While there wasn't a solution to overcome this limitation during the research, future optimization efforts could explore alternative options. For example, using a database that supports styling features like MongoDB with GeoJSON for rendering styled geometries could be considered. Additionally, developing custom scripts to store and apply styles separately from the geometry data could also be a potential solution, although it would make the process more complex.

Referring to the initial system architecture in Figure 16, the updated system architecture in Figure 23 demonstrates how the process of reading the Estonian spatial data previously uploaded to the database can be implemented into the case study project with Future Insight for the prototype of seven compliance checks. In this updated system, Estonian plan data can be directly read from the database, transformed into 3D Tiles, and then used to develop and execute the checks, with the results visualized in Clearly.HUB. This approach enhances scalability, as the database (and country profile) is designed to handle and store comprehensive plan data from various levels.

The FME scripts developed for extracting and loading plan information also extract metadata (not currently needed for the seven checks) to fully represent the plan in the database. By reading previously uploaded plan data from the database, the compliance check process becomes simpler and shorter. Specifically, this would eliminate the need for the hefty extraction and transformation processes, developed specifically for the required information for the checks. Since the database is designed to represent the plan data comprehensively, the required information for the checks and more is directly accessible from the database, provided the plan data contains it.

Query | Query History

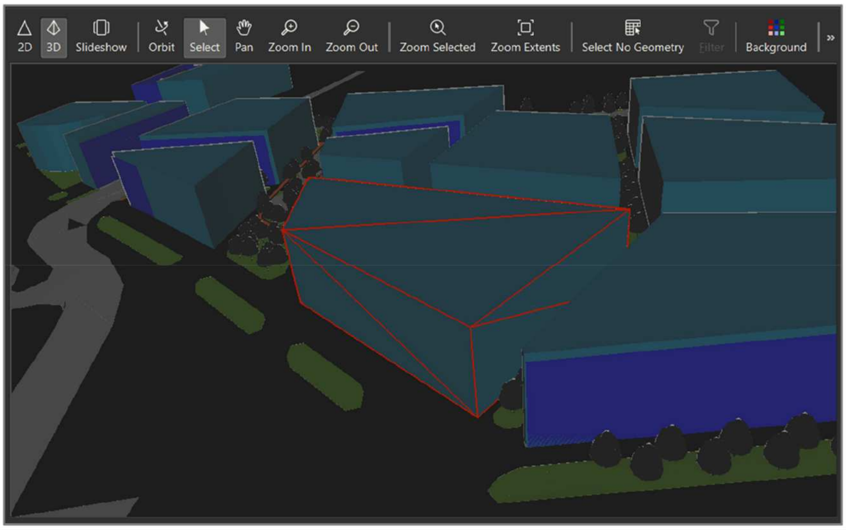
```
1 SELECT * FROM public.est_detailed_plan
2 ORDER BY detailed_plan_id ASC
```

Data Output | Messages | Notifications

	geometry geometry	detailed_plan_id [PK] character varying (255)	name text	organizer_reference text	seia_conducted boolean	modifies_general_plan boolean	planning_objective text	block_name text	constraint_description text[]	constraint_name text[]
1	01070000A0E50C...	1	NoName1	[null]	true	[null]	Arendamine	[null]	[null]	[null]

	function_type_id integer	begin_lifespan_version date	begin_real_world_lifespan_version date	end_lifespan_version date	plan_id character varying (255)	master_plan_id integer	initiated_date integer	begin_lifespan_lastversion date	source_id character varyin
1	[null]	2024-08-04	[null]	[null]	210011	[null]	2019	2024-08-04	442244

20 Example entry to the est_detailed_plan table using the pilot data, Põhi.



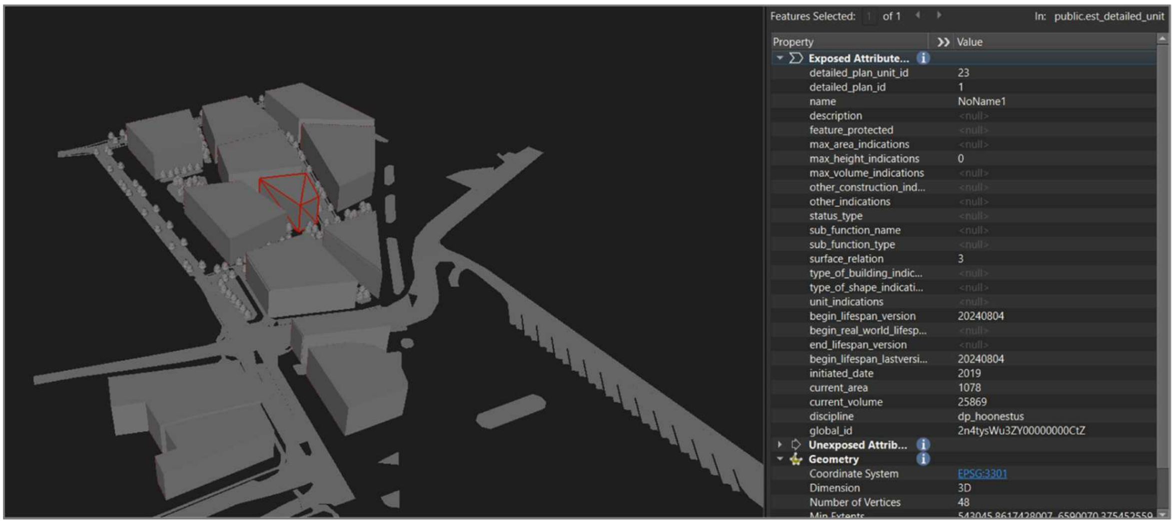
	current_area	current_volume	floor_above_ground	floor_below_ground	max_height_indications	ifc_unique_id
7	3825.435294091...	63451.18653629036	5	1	24	2n4tysWu3ZY000...
8	1334.245009290...	29353.390204384643	5	1	24	2n4tysWu3ZY000...
9	2638.274029955...	46510.990954235196	5	1	24	2n4tysWu3ZY000...
10	877.1721401932...	19297.787084251762	5	1	24	2n4tysWu3ZY000...
11	1062.882424950...	23383.413348913193	5	1	24	2n4tysWu3ZY000...
12	3574.453215939...	53217.0964902878	5	1	24	2n4tysWu3ZY000...
13	3614.229775483...	86741.51461159858	<missing>	<missing>	0	2n4tysWu3ZY000...
14	2919.119912232...	70058.87789357157	<missing>	<missing>	0	2n4tysWu3ZY000...
15	3133.738321008...	75209.71970420341	<missing>	<missing>	0	2n4tysWu3ZY000...
16	4144.975745226...	99479.4178854475	<missing>	<missing>	0	2n4tysWu3ZY000...
17	2718.710644916...	65249.055477986774	<missing>	<missing>	0	2n4tysWu3ZY000...
18	1374.112807205...	32978.707372933335	<missing>	<missing>	0	2n4tysWu3ZY000...
19	963.1652064284...	23115.964954283078	<missing>	<missing>	0	2n4tysWu3ZY000...

21 Read geometries and metadata from the database.

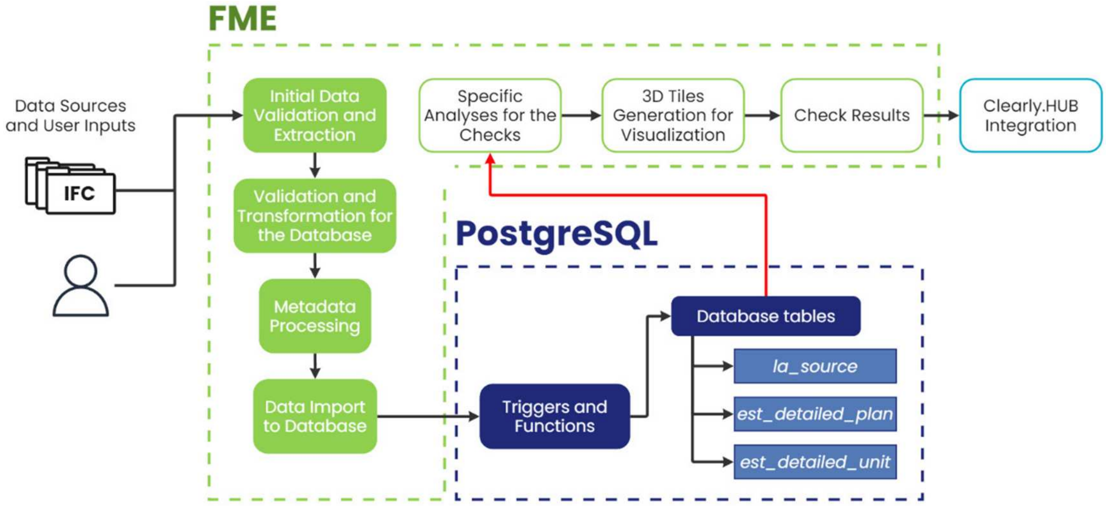
Additionally, users can access different versions of the uploaded plans directly from the database and easily compare the compliance check results for each version. Further optimizations with larger datasets will enhance both the FME scripts and the database, making the process more scalable and efficient for Estonia. This would also simplify the development of additional compliance checks in the future. The implications, benefits and constraints of this approach are all summarized in Section 5: *Evaluation and Discussion.*

4.2. Checks within the database

This section examines the use of compliance checks within the LADM framework, focusing on cases where SQL queries alone can validate compliance based on data already stored in the LADM database. This exploration aims to evaluate the potential and limitations of using the LADM database for compliance checks, specifically identifying which checks can be fully automated and executed using simple SQL queries.

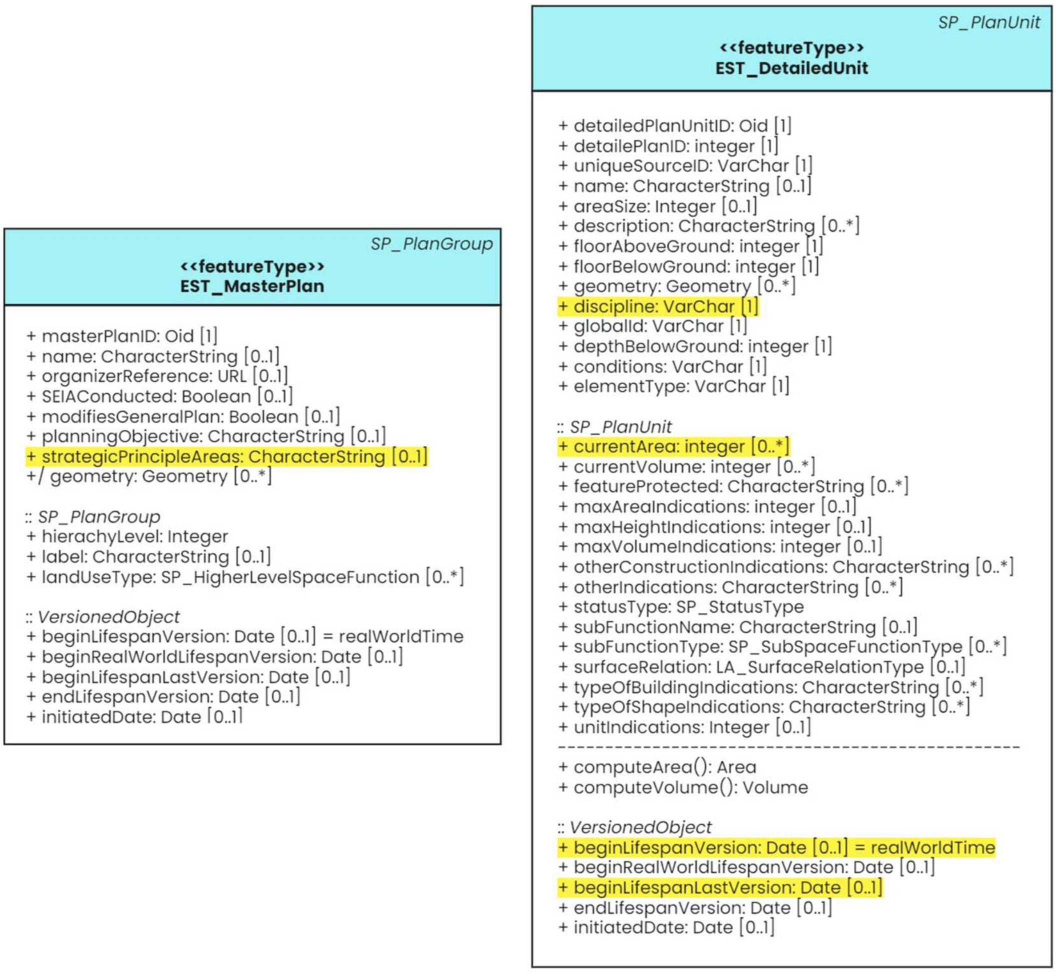


22 Example unit geometries stored as individual records with specific metadata.



23 Updated system architecture diagram representing how to implement the LADM database process into the case study project with Future Insight.

As an example case, Table 1, Check 2: '*Greenery demands (%)*' is a compliance check that can be executed directly within the database. It verifies whether the greenery area in a Detailed Plan meets the minimum percentage required by the Master Plan. This is done by querying the *est_detailed_unit* class, which stores spatial unit data, including landscape areas (**dp_haljastus**). The total greenery area (*currentArea for* **dp_haljastus**) is compared with the total plot area (*plan_ala*). The calculated percentage is then checked against the *est_master_plan* class, where constraints like '*min 30% greenery for a 5000 m² area*' are defined. Figure 24 illustrates the relevant classes and attributes.



24 Classes and attributes needed (highlighted in yellow) to execute the greenery compliance check in the database.

```sql
WITH latest_versions AS (
    SELECT
        dp.detailed_plan_id,
        dp.name AS plan_name,
        dp.begin_lifespan_version,
        dp.end_lifespan_version,
        dp.master_plan_id,
        ROW_NUMBER() OVER (
            PARTITION BY dp.detailed_plan_id
            ORDER BY dp.begin_lifespan_version DESC
        ) AS version_order
    FROM
        est_detailed_plan dp
    WHERE
        dp.detailed_plan_id = '101'  -- Example plan ID for comparison
        AND dp.begin_lifespan_version = dp.begin_lifespan_lastversion -- Identifies the most recent version
)
SELECT
    lv.detailed_plan_id AS detailedPlanID,
    lv.plan_name,
    lv.begin_lifespan_version AS plan_start_date,
    lv.end_lifespan_version AS plan_end_date,
    SUM(CASE WHEN du.discipline = 'dp_haljastus' THEN du.current_area ELSE 0 END) AS greenery_area,
    SUM(CASE WHEN du.discipline = 'plan_ala' THEN du.current_area ELSE 0 END) AS plot_area,
    ROUND(
        SUM(CASE WHEN du.discipline = 'dp_haljastus' THEN du.current_area ELSE 0 END) /
        SUM(CASE WHEN du.discipline = 'plan_ala' THEN du.current_area ELSE 0 END) * 100, 2
    ) AS greenery_percentage,
    mp.strategic_principle_areas AS master_plan_requirement
FROM
    latest_versions lv
JOIN
    est_detailed_unit du ON lv.detailed_plan_id = du.detailed_plan_id
JOIN
    est_master_plan mp ON lv.master_plan_id = mp.master_plan_id
WHERE
    lv.version_order <= 2  -- Select the last two versions based on lifespan versioning
    AND mp.strategic_principle_areas ILIKE '%min 30% greenery for an area of 5000 square meters%'
GROUP BY
    lv.detailed_plan_id, lv.plan_name, lv.begin_lifespan_version,
    lv.end_lifespan_version, mp.strategic_principle_areas;
```

25 SQL query to be performed for the greenery compliance check.

Table 2 Example outcome of the greenery compliance check.

Detailed Plan ID	Plan Name	Plan Start Date	Plan End Date	Greenery Area	Plot Area	Greenery Percentage	Master Plan Requirement
101	Central Park	2024-01-01	2024-03-31	1500	5000	30.00	min 30% greenery for an area of 5000 square meters
101	Central Park	2024-04-01	2024-06-30	1400	5000	28.00	min 30% greenery for an area of 5000 m^2

The compliance check for greenery requirements can be automated using a SQL query within the LADM database. This query calculates the greenery percentage in a Detailed Plan, verifies compliance with the Master Plan's minimum threshold, and compares different plan versions to track compliance over time.

For demonstration, a hypothetical Detailed Plan, 'Central Park' (**detailed_plan_id** = '101'), is analysed. The Master Plan mandates at least 30% greenery in a specified area for sustainable development. The Detailed Plan has undergone multiple phases, with different versions stored in the LADM database. The SQL query identifies the latest two versions by checking the **beginLifespanVersion** timestamps, allowing planners to assess changes in compliance between them. Figure 25 displays the example SQL query required for this check.

The query retrieves relevant data, calculates the greenery ratio by comparing landscape area to the total plot area, and checks compliance against the Master Plan. This helps determine if recent modifications align with regulations or if deviations need to be addressed. The results displayed in Table 2 illustrate the compliance status of the last two versions of the Detailed Plan Central Park. The first version, valid from January 1, 2024, to March 31, 2024, meets the required standard with a 30% greenery ratio, aligning well with the Master Plan's requirement of having a minimum of 30% greenery in the specified area. However, the latest version, valid from April 1, 2024, to June 30, 2024, shows a reduction in the greenery area to 1400 square meters, which represents only 28% of the total plot area. This percentage falls below the minimum requirement set by the Master Plan, indicating the compliance check is not successful.

This scenario highlights the LADM database's capability to facilitate certain compliance checks directly. However, three key limitations exist. First, there is no visual representation of results, unlike web-based prototypes using WFS and WMS, which offer graphical outputs. Second, all required data must already be in the database, as this approach does not support API access to external sources. Lastly, while SQL is effective for many checks, its ability to handle complex compliance scenarios remains an area for further exploration.

4.3. Investigating 2D Data

Despite Estonia's progress in digitalizing spatial planning with PLANK, the system remains heavily reliant on 2D formats like CAD drawings and PDFs. Since its mandatory adoption in November 2022, PLANK has standardized digital plan accessibility, yet most submissions remain 2D. While 3D models are used for visualization in tools like *Photoshop, Lumion,* and *Twinmotion*, they are not integral to planning data.

This reliance on 2D data limits automation in compliance checks and hinders interoperability with future 3D systems. PLANK validates metadata and spatial integrity but lacks support for 3D-based processes. As Estonia moves toward BIM and 3D spatial data, addressing these limitations is crucial.

This section examines the constraints of 2D data through an example Detailed Plan uploaded to PLANK. The analysis highlights challenges in automated compliance checks, interoperability, and transitioning to 3D models like IFC.

Key questions explored:

(i) Can the data be effectively represented in the Estonian LADM Part 5 country profile and stored in PostgreSQL?

(ii) Does it contain sufficient information for extraction and processing via FME import scripts for automated checks?

The aim is to determine whether 2D formats and external CSV metadata provide a viable foundation for automation or if significant adaptations are required for full LADM alignment.

The '*Põllu tn 4 detailed plan*' (Põllu tn 4 maa-ala ja lähiümbruse detailplaneering)[11] is used as a case study to evaluate its alignment with the country profile and determine whether its current data format allows for efficient extraction and integration into an LADM-based database using import scripts. The dataset primarily consists of 2D CAD drawings in DWG format, metadata stored separately in CSV files, and supporting documents in PDF. While the dataset includes 3D renderings, these are embedded in PDFs for visualization purposes rather than structured as machine-readable 3D data.

To ensure clarity and consistency in this report, all information regarding Põllu tn 4 will be presented in English from this point onward.

Currently, the data available in PLANK for Põllu tn 4 includes the following components (Figure 26):

(i) **2D CAD file (DK202)** – the primary planning document in DWG format, containing spatial data that represents the planning solution.

(ii) **Smart Data Table (DK401)** – metadata stored separately in a CSV file, providing details on various design elements, such as plot attributes and construction parameters.

(iii) **3D visualizations (PDF)** – simplified renderings primarily intended for presentation purposes rather than technical analysis or compliance verification.

This dataset reflects the current state of digital spatial planning in Estonia, where plans are still largely represented in 2D formats, with limited integration of structured 3D data.

Given these characteristics, this investigation focuses on the 2D data stored in separate formats – CAD for spatial design and CSV for metadata – assessing its limitations and its alignment with the LADM framework. Additionally, it examines whether modifications are necessary to integrate this data into automated compliance-checking workflows.

The analysis began with the DWG file of the plan. Figure 27 presents a snippet of the file, showing the plan data and its layers. To understand its structure, specific objects were selected along with their associated metadata. However, as seen in the example, the DWG file primarily serves visualization purposes rather than providing detailed metadata on spatial attributes. For instance, the selected element belongs to the '*dp_krunt*' layer, which categorizes it thematically (e.g. a land plot or building block). Beyond this categorization, most of the data pertains to visual properties such as line weight, color, and transparency, rather than meaningful planning information like zoning regulations or unit attributes.

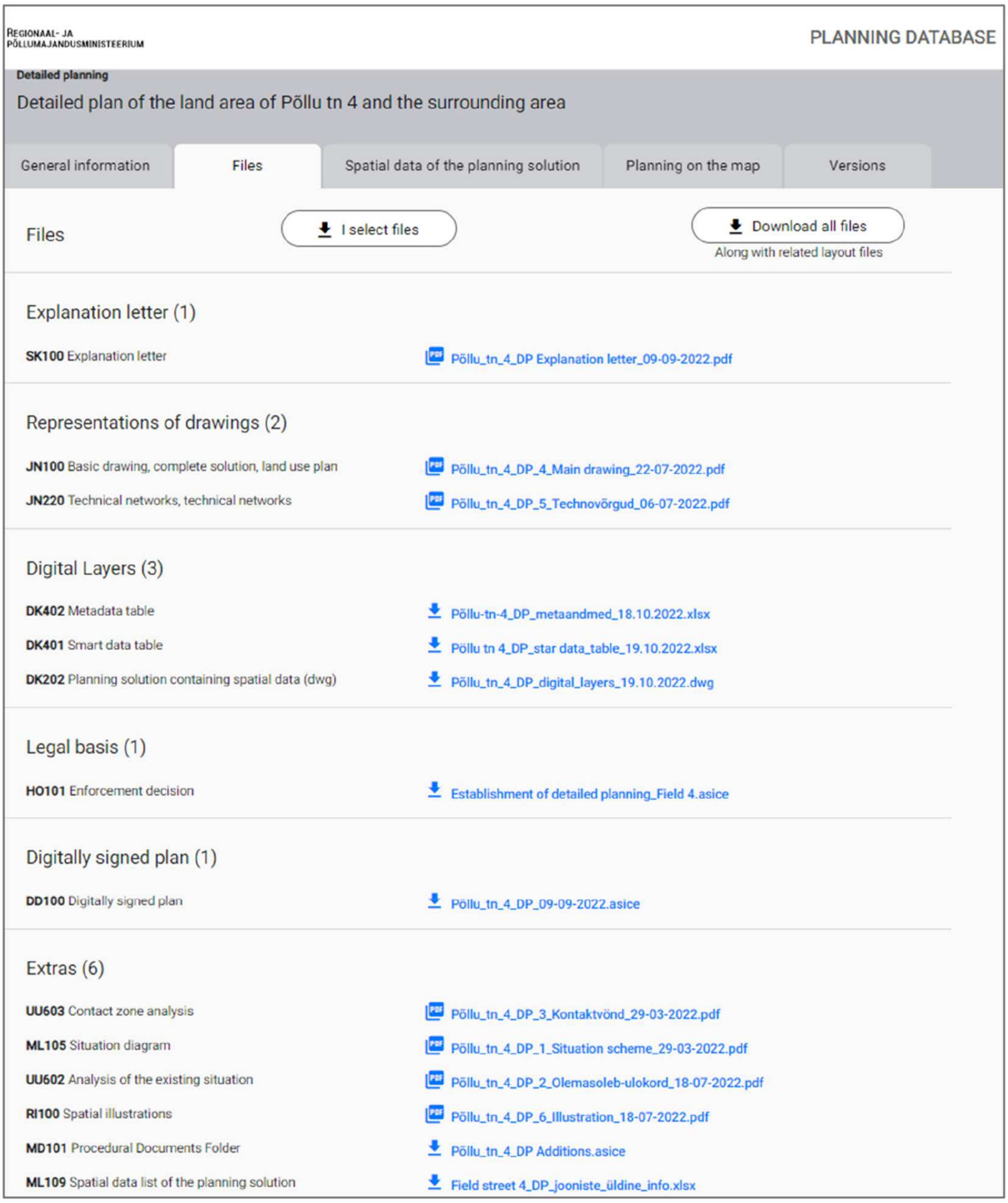
This lack of embedded metadata poses a challenge for integrating DWG data into structured frameworks like the LADM Part 5 country profile. While the file contains geometric layouts and basic visualization elements, key information – such as land use, building heights, or functional classifications – is absent and must be sourced from external files like CSVs or supporting documents.

Following this, the related CSV metadata files were examined, starting with 'DK402, the metadata table' (Figure 28). This table contains essential information, such as the architect and author, which aligns with the *LA_SpatialSource* and *LA_AdministrativeSource* classes in the LADM country profile. Notably, PLANK mandates this metadata, making it possible to integrate it into an LADM database and ensuring that automation processes benefit from relevant contextual details.

Next, the 'DK401 Smart Data Table' was reviewed. As seen in Figure 29, this table stores additional metadata about design elements and spatial attributes. Its structure is similar to the metadata from the 3D IFC datasets examined earlier in this study. However, a key distinction is how the data is stored – while IFC files embed both geometric and semantic data within a single structured format, the current 2D-based planning system separates metadata into external CSV files like DK401. This fragmentation requires additional processing steps to link spatial data with its corresponding attributes, complicating automated workflows such as compliance checks.

Lastly, the 'RI100 Spatial Illustrations' PDF was analysed (Figure 30). This document contains 3D renders of the detailed plan, which serve primarily as visualizations rather than structured spatial data. While these renders offer a polished representation of the project, they lack technical details necessary for compliance checks or LADM database integration. Despite the effort involved in producing them, they remain disconnected from the actual plan data and metadata, making them ineffective for enhancing digital planning workflows in Estonia (Figure 31).

The investigation into the Põllu tn 4 detailed plan and its associated 2D data has highlighted key challenges related to Estonia's reliance on 2D CAD drawings and fragmented metadata storage in CSV files. These findings



26 Available files for Põllu tn 4 on PLANK.

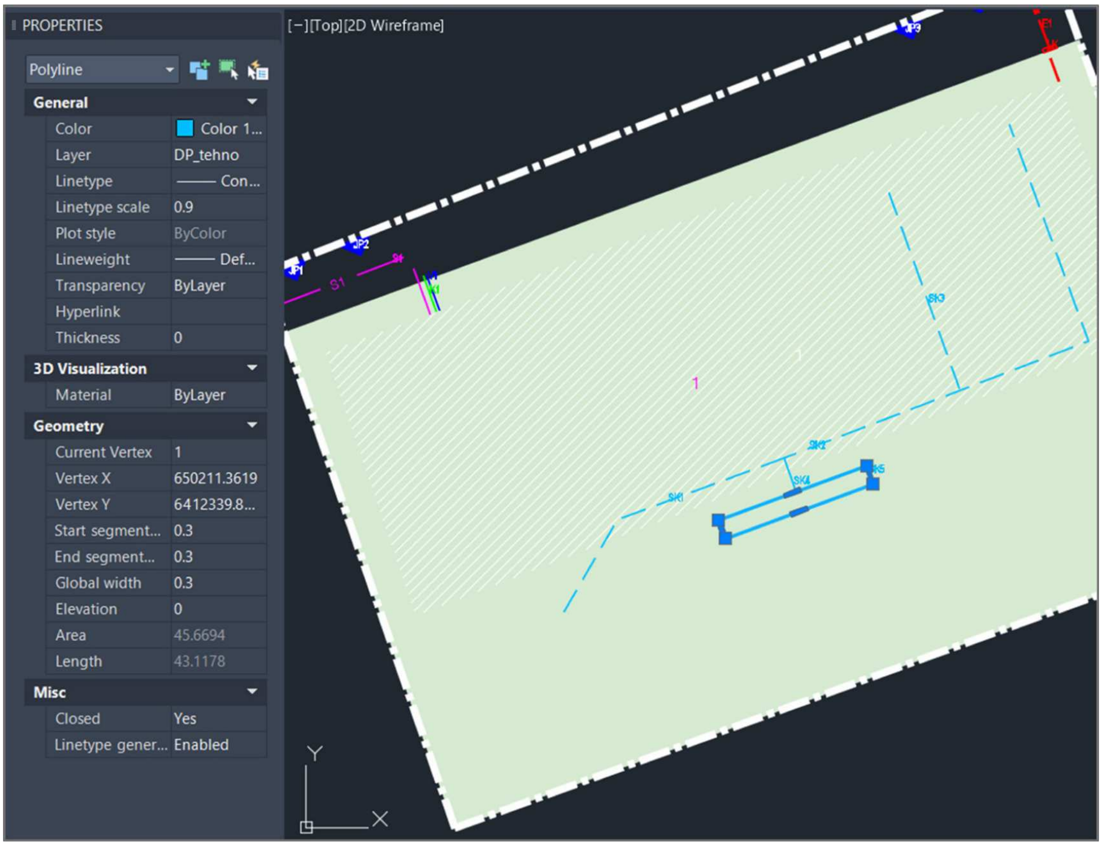
address the two main questions posed at the beginning of this section:

(i) Can the data be effectively represented in the Estonian LADM Part 5 country profile and stored in the PostgreSQL database?

While the DWG files provide a basic geometric layout that can be stored in the LADM database, the absence of embedded semantic information within the CAD files presents a major limitation. Key metadata required for compliance checks – such as zoning regulations, building heights, and land use – is distributed across separate CSV files (e.g. DK401 and DK402). This fragmentation makes seamless integration into the LADM Part 5 framework challenging without additional processing. Although the CSV metadata can be incorporated, it requires tailored import scripts to correctly map and structure the information, demonstrating that the current format is not immediately suitable for automated compliance checking.

(ii) Does the data provide the necessary information for automated compliance checks and extraction using FME import scripts?

The current data format does not fully support efficient extraction and automated compliance checking. While some metadata is available in CSV files, essential spatial attributes and regulatory details (e.g. zoning rules, heights) are missing from the CAD file itself. These must be manually linked to the geometric data, adding complexity to automation workflows. The separation of geometry and metadata requires additional processing steps to integrate these elements effectively. Additionally, while 3D renderings are included, they lack the technical details needed for compliance verification



27 Example of selected metadata for an object in the DWG file (AutoCAD display).

	A	B	C	D	E	F	G	H
1	planeerija	koostaja	tarkvara	andmemudel	keht_koordinaatsysteem	keht_korgussysteem	mootkava	kontakt
2	Laura Andla	Laura Andla, planeerija	Autodesk Autocad LT 2017	100	L-EST97	EH2000	1:500	laura@arhpro.ee
3								
4								

28 Snippet from the DK401 Smart Data Table showing metadata associated with various design elements in the Detailed Plan, stored externally from the DWG file.

and primarily serve visualization purposes rather than functional analysis.

In conclusion, Estonia's reliance on 2D formats and scattered metadata in spatial planning poses significant challenges for digital transformation. While the data available in PLANK could be adapted for integration into the LADM Part 5 country profile and automated compliance checking, substantial modifications would be required. These include embedding richer semantic information within planning data, improving metadata management, and reducing dependence on external CSV files to create a more structured and automated workflow.

L29

	A	B	C	D	E	F	G
1	objectID	kruntOID	ehTyyp	arv	pind	korgus	
2	1	1	10	2	1600	10	

plan_ala | DP_krunt | DP_krundisihtotstarve | DP_hoonestus | DP_juurdep | DP_tehno

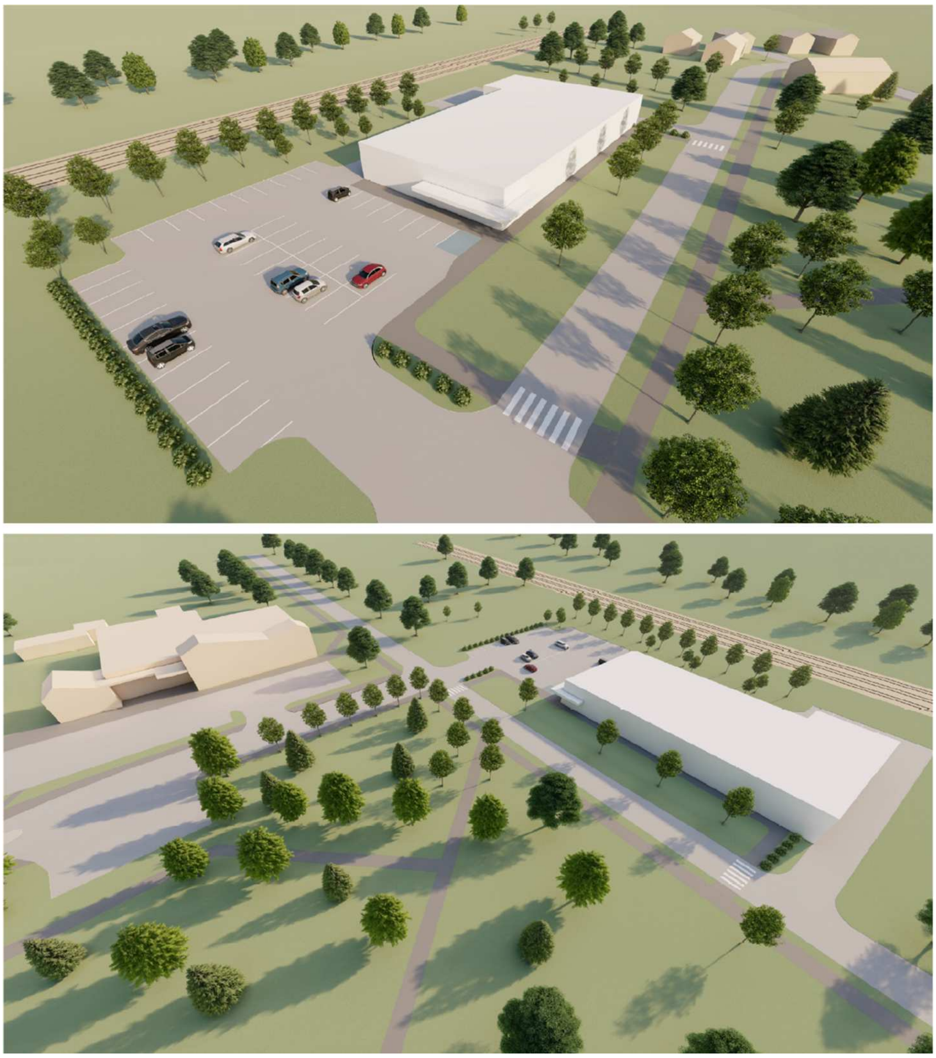
	A	B	C	D	E	F
1	objectID	nimetus				
2	JP1	Teenindava transpordi juurdepääs krundile.				
3	JP2	Jalakäijate juurdepääs krundile.				
4	JP3	Jalakäijate juurdepääs krundile.				
5	JP4	Sõiduautode juurdepääs krundile.				

plan_ala | DP_krunt | DP_krundisihtotstarve | DP_hoonestus | DP_juurdep

	A	B	C	D	E	F	G	H	I	J
1	planNim	planLiik	planKSH	planEesm	planViide	muutev	algatKp	vastuvKp	kehtestKp	kehtestNr
2	Põllu tn 4 maa-ala	30	ei	Planeeringualale ehitusõiguse	https://antsla.ee/et/algatatud-	ei	22/09/2021	03/08/2022	21/09/2022	2-3/347
3										

plan_ala | DP_krunt | DP_krundisihtotstarve | DP_hoonestus | DP_juurdep | DP_tehno | +

29 Snippet from the DK402 Metadata Table, showing key information such as the planner, software used, coordinate system, height system, and contact details.



30 3D renders of the planned development from the 'RI100 Spatial Illustrations' PDF file.

5. Evaluation and discussion

This chapter evaluates the Estonia-specific LADM profile, its database, and FME scripts, focusing on effectiveness, limitations, and compliance with international standards.

5.1. LADM profile assessment

To ensure conformance with LADM, the Estonia profile is assessed using the Abstract Test Suite (ATS) of ISO 19152:2012a. The ATS provides model-based test cases to evaluate compliance, though it is not directly executable. Since ISO 19152:2012 does not yet cover Part 5, an additional assessment follows the upcoming DIS 19152-5 (2024) draft.

The Estonia profile meets Level 2 conformance under ISO 19152:2012, meaning it implements core and common LADM classes. It extends these with attributes specific to Estonia, such as 'landUseType' (EST_DetailedPlan) and 'strategicPrincipleAreas' (EST_MasterPlan), ensuring national requirements are met while maintaining LADM integrity.

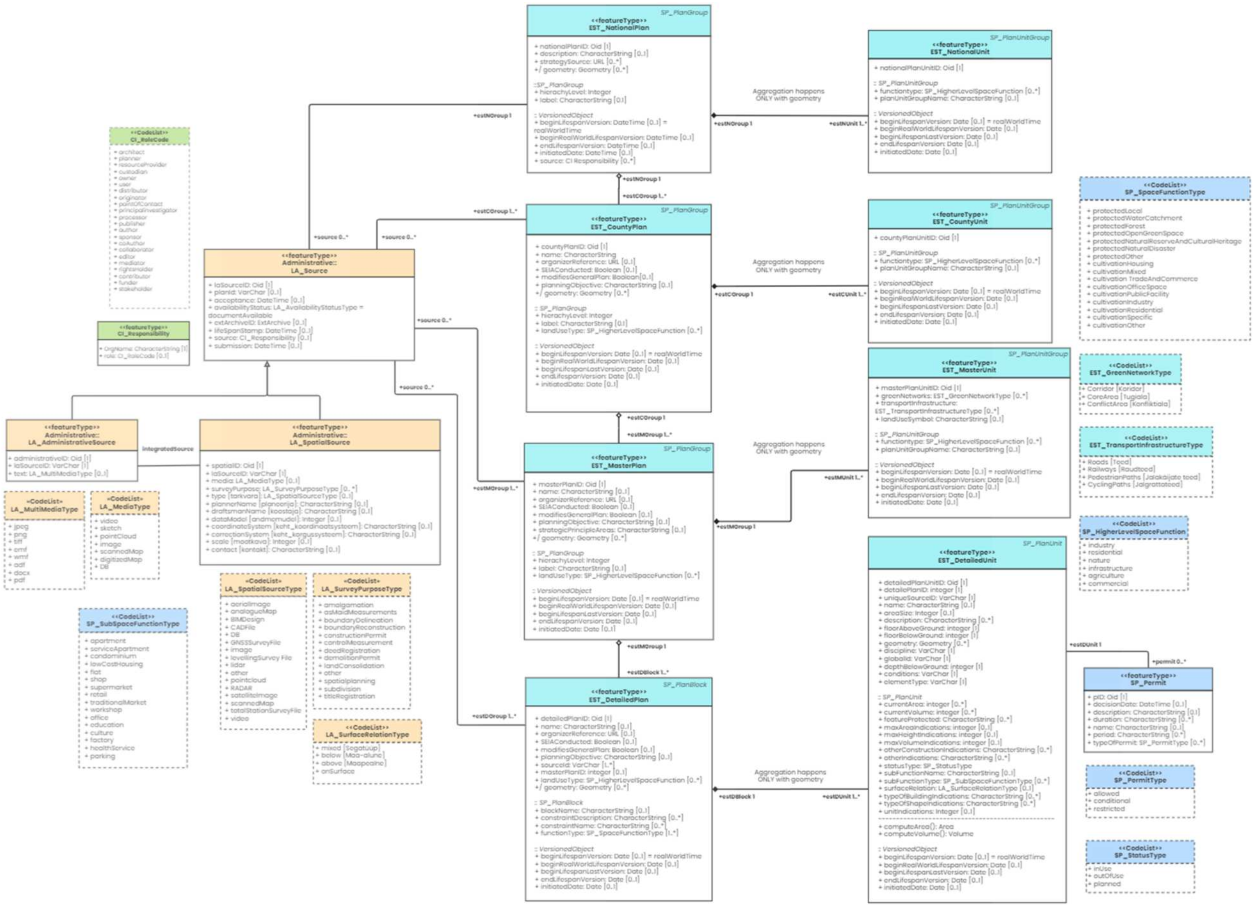
The profile is also evaluated against the ATS of DIS 19152-5 (2024), focusing on compliance with LADM Part 5. It successfully meets six key criteria, including plan visualization, participatory monitoring, and hierarchical planning structures. Permit registration, while theoretically supported, was not tested due to research focus on compliance checks.

Overall, the Estonia profile demonstrates strong adherence to international standards, achieving Level 2 conformance under ISO 19152:2012 and mostly conforming to DIS 19152-5 (2024).

5.2. Database and FME script evaluation

Performance testing of the LADM PostgreSQL database and FME scripts was limited due to insufficient data. The FME script's data import process relies on retrieving unique plan IDs from the database, which introduces constraints when importing multiple plans sequentially. Additionally, the script depends on predefined discipline names for IFC data filtering, posing scalability challenges.

To improve adaptability, a preliminary machine learning (ML) model was developed to predict and classify discipline names based on Estonian-language labels in the IFC files. The model was trained using synthetically generated datasets that mimic the structure and variability of Estonian planning data. This allowed the script to automatically map non-standard discipline names to known



31 Final Estonia LADM Part 5 Country Profile's UML model.

categories, improving the robustness of the import process.

The full workflow, including ML-based classification and database import, was implemented as an automated Python script (*main.py*)[12] requiring minimal user input. While the initial results were promising, the performance and accuracy of the ML model were not formally evaluated, as this component was exploratory and fell outside the primary scope of the research. Further testing and validation are planned for future work.

5.3. Pilot dataset evaluation

The IFC files used in this research were tailored in collaboration with Future Insight Group and the Ministry of Climate of Estonia, as Estonia primarily relies on 2D formats like CAD for planning. Since there is no official use of IFC for spatial plans, these files were customized to include relevant compliance attributes. While this enabled testing, the lack of standardization means findings remain somewhat theoretical.

Standardizing IFC data in Estonia would improve compliance checks across different planning levels and support future optimizations of the LADM framework.

6. Conclusions and future work

This research explored the integration of LADM Part 5 with IFC and CityGML to improve the representation and management of spatial plans. Findings indicate that LADM Part 5 can effectively align with IFC by mapping relevant classes, enabling structured representation of spatial units, plan blocks, and hierarchies. However, practical implementation revealed inconsistencies in how data is stored within IFC models, necessitating customized approaches, including tailored scripts and databases.

CityGML offers advantages in handling broader urban planning and zoning tasks but presents challenges when applied to detailed spatial plans. Its strengths lie in representing high-level spatial structures, while IFC is better suited for capturing detailed building-level data. A combined approach – leveraging CityGML for large-scale plans and IFC for detailed ones – would likely yield the most efficient results, particularly in compliance-checking workflows.

The research also examined the potential of LADM Part 5 in automated compliance checking, highlighting its ability to standardize spatial data and improve accuracy. While theoretical advantages are evident, real-world implementation remains limited. The prototype developed demonstrates potential but requires further integration into existing Estonian systems for full validation. Estonia, despite its advanced BIM-based checking systems, still relies on fragmented and largely 2D planning data, which limits automation potential. Transitioning toward standardized 3D models, improved semantic consistency, and centralized databases will be crucial for future advancements.

The study confirmed that LADM Part 5 can effectively represent Estonian spatial plans, though adjustments were needed to align with national requirements. The iterative development of an Estonian country profile ensured compatibility with existing planning workflows and databases. While the approach was primarily tested on detailed plans, it can be adapted for broader applications, including county and national plans.

Future research should focus on expanding real-world testing, particularly in permitting workflows, to refine the integration of LADM Part 5 with spatial planning data. Scaling up the system will help identify potential challenges and optimizations necessary for handling diverse datasets. Additionally, enhancing IFC's role in plan information modeling and addressing interoperability gaps between different data formats will further improve automation and compliance-checking efficiency.

Notes

1. https://www.futureinsight.nl/clearly-hub (a web-based spatial data management platform)
2. https://www.riigiteataja.ee/akt/111062024012
3. https://eesti2030.files.wordpress.com/2014/02/estonia-2030.pdf
4. https://riigiplaneering.ee/en/national-spatial-plan/national-spatial-plan-2050/national-spatial-plan-2050
5. https://planeeringud.ee/plank-web/#/planning/detail/10100015
6. https://planeerimine.ee/ruumiline-planeerimine-2/kov-planeeringud/
7. https://planeeringud.ee/plank-web/#/planning/detail/20100048
8. https://planeeringud.ee/plank-web/#/planning/detail/30100010
9. https://environment.ec.europa.eu/law-and-governance/environmental-assessments/strategic-environmental-assessment_en
10. https://github.com/simaybtm/LADM-4-Estonia
11. https://planeeringud.ee/plank-web/#/planning/detail/30100010
12. https://github.com/simaybtm/LADM-4-Estonia/tree/main/ML_4_Estonia

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Disclosure statement

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Appendix

Table A1 Estonian Master Plan data layer requirements. (Translated to English)

Core Layer Name	Name	Division Layers	Mandatory	Spatial Data Requirements	Smart Data	Point	Line	Surface
plan_ala	Planning Area	–	Mandatory	–	Mandatory	–	–	Allowed
yp_arhVoistlus	Area with Mandatory Architectural Competition for Detail Planning	Allowed	–	–	–	Allowed	–	Allowed
yp_DPKoKo	Area with Mandatory Detail Planning	–	–	–	–	–	–	Allowed
yp_EKV	Construction Prohibition Zone Increase or Decrease	Allowed	–	–	–	–	–	Allowed
yp_jaade	Waste Management	Allowed	–	–	–	Allowed	–	Allowed
yp_juurdep	Access	Allowed	–	–	–	Allowed	Allowed	Allowed
yp_kaldaehitis	Water and Shore Construction	Allowed	–	–	–	Allowed	Allowed	Allowed
yp_kallasrada	Shore Path Closure and Modification	Allowed	–	–	–	–	Allowed	Allowed
yp_KKTingimus	Area with Environmental Condition Set by Master Plan	Allowed	–	–	–	–	–	Allowed
yp_KOVKultparand	Local Cultural Heritage or Heritage Conservation Object	Allowed	–	–	–	Allowed	Allowed	Allowed
yp_KOVLoodus	Local Government Nature Conservation Proposal	Allowed	–	–	–	Allowed	Allowed	Allowed
yp_maakas	Land Use Purpose	Allowed	–	–	–	–	–	Allowed
yp_maapar	Land Improvement Systems	Allowed	–	–	–	–	–	Allowed
yp_maavara	Restriction from Mineral or Mining	Allowed	–	–	–	Allowed	Allowed	Allowed
yp_ORME	Construction with Significant Spatial Impact	Allowed	–	–	–	Allowed	Allowed	Allowed
yp_puhke	Recreation and Leisure Area	Allowed	–	–	–	–	–	Allowed
yp_rand	Beach	Allowed	–	–	–	–	–	Allowed
yp_rohev	Green Network	Allowed	–	–	–	–	–	Allowed
yp_strateegia	Strategic Principle Areas	Allowed	–	–	–	–	–	Allowed

(*Continued*)

Table A1 Continued.

Core Layer Name	Name	Division Layers	Mandatory	Spatial Data Requirements	Smart Data	Point	Line	Surface
yp_sund	Need for Expropriation in Public Interest	Allowed	–	–	–	Allowed	Allowed	Allowed
yp_tehno	Technical Construction	Allowed	–	–	–	Allowed	Allowed	Allowed
yp_tiheas	Dense Settlement Area	–	–	–	–	–	–	Allowed
yp_tingimus	Condition Set by Master Plan	Allowed	–	–	–	–	–	Allowed
yp_transp	Transportation Construction or Area	Allowed	–	–	–	Allowed	Allowed	Allowed
yp_vaartMaastik	Valuable Landscape	Allowed	–	–	–	Allowed	Allowed	Allowed
yp_vaartMiljoo	Valuable Milieu	Allowed	–	–	–	Allowed	Allowed	Allowed
yp_vaartPollum	Valuable Agricultural Land	Allowed	–	–	–	–	–	Allowed
yp_vaartRohe	Valuable Green Area	Allowed	–	–	–	–	–	Allowed
yp_vaartVaade	Valuable Views	Allowed	–	–	–	Allowed	Allowed	Allowed
yp_veehaare	Water Intake	Allowed	–	–	–	Allowed	–	Allowed
yp_yleujutus	Flood Area or High-Water Limit	Allowed	–	–	–	–	Allowed	Allowed

https://www.riigiteataja.ee/aktilisa/1211/0202/2002/RM_m50_lisa3.pdf#

Table A2 Estonian Master Plan data attribute requirements (Translated to English.)

Layer Name	Attribute (Column Name)	Data Type	Explanation	Mandatory	Condition for Mandatory
yp_EKV	objectID	integer|text	Object identifier.	Mandatory	–
	jaotuskiht	text	Classified distribution layer for GIS formats.	–	–
	nimetus	text	Object name.	Conditionally Mandatory	Mandatory if no distribution layers are used.
	tingimus	text	Conditions.	–	–
yp_jaade	objectID	integer|text	Object identifier.	Mandatory	–
	jaotuskiht	text	Classified distribution layer for GIS formats.	–	–
	nimetus	text	Object name.	Conditionally Mandatory	Mandatory if no distribution layers are used.
	tingimus	text	Conditions.	–	–
yp_juurdep	objectID	integer|text	Object identifier.	Mandatory	–
	jaotuskiht	text	Classified distribution layer for GIS formats.	–	–
	nimetus	text	Object name.	Conditionally Mandatory	Mandatory if no distribution layers are used.
	tingimus	text	Conditions.	–	–
yp_kaldaehitis	objectID	integer|text	Object identifier.	Mandatory	–
	jaotuskiht	text	Classified distribution layer for GIS formats.	–	–
	nimetus	text	Object name.	Conditionally Mandatory	Mandatory if no distribution layers are used.
	tingimus	text	Conditions.	–	–
yp_KOVKultparand	objectID	integer|text	Object identifier.	Mandatory	–
	jaotuskiht	text	Classified distribution layer for GIS formats.	–	–
	nimetus	text	Object name.	Conditionally Mandatory	Mandatory if no distribution layers are used.
	tingimus	text	Conditions.	–	–
	voond	integer|fraction	Width of the protection zone.	–	–
yp_KOVLoodus	objectID	integer|text	Object identifier.	Mandatory	–
	jaotuskiht	text	Classified distribution layer for GIS formats.	–	–
	nimetus	text	Object name.	Conditionally Mandatory	Mandatory if no distribution layers are used.
	tingimus	text	Conditions.	–	–
	voond	integer|fraction	Width of the protection zone.	–	–
yp_maakas	objectID	integer|text	Object identifier.	Mandatory	–
	jaotuskiht	text	Classified distribution layer for GIS formats.	–	–
	tingimus	text	Land use conditions.	–	–

(*Continued*)

Table A2 Continued.

Layer Name	Attribute (Column Name)	Data Type	Explanation	Mandatory	Condition for Mandatory
	tahis	text	Symbol for main purpose.	–	–
	juhtots	text	Main purpose.	–	–
yp_maapar	objectID	integer|text	Object identifier.	Mandatory	–
	jaotuskiht	text	Classified distribution layer for GIS formats.	–	–
	nimetus	text	Object name.	Conditionally Mandatory	Mandatory if no distribution layers are used.
	tingimus	text	Conditions.	–	–
yp_maavara	objectID	integer|text	Object identifier.	Mandatory	–
	jaotuskiht	text	Classified distribution layer for GIS formats.	–	–
	nimetus	text	Object name.	Conditionally Mandatory	Mandatory if no distribution layers are used.
	tingimus	text	Conditions.	–	–
yp_ORME	objectID	integer|text	Object identifier.	Mandatory	–
	jaotuskiht	text	Classified distribution layer for GIS formats.	–	–
	nimetus	text	Object name.	Conditionally Mandatory	Mandatory if no distribution layers are used.
	tingimus	text	Conditions.	–	–
yp_puhke	objectID	integer|text	Object identifier.	Mandatory	–
	jaotuskiht	text	Classified distribution layer for GIS formats.	–	–
	nimetus	text	Object name.	Conditionally Mandatory	Mandatory if no distribution layers are used.
	tingimus	text	Conditions.	–	–
yp_rand	objectID	integer|text	Object identifier.	Mandatory	–
	jaotuskiht	text	Classified distribution layer for GIS formats.	–	–
	nimetus	text	Object name.	Conditionally Mandatory	Mandatory if no distribution layers are used.
	tingimus	text	Conditions.		

https://www.riigiteataja.ee/aktilisa/1211/0202/2002/RM_m50_lisa6.pdf#

Table A3 Estonian Detailed Plan data requirements (Translated to English).

Core Layer Name	Name	Division Layers	Mandatory	Spatial Data Requirements	Smart Data	Point	Line	Surface
plan_ala	Planning Area	-	Mandatory	–	Mandatory	–	–	Allowed
dp_arhVoistlus	Area Requiring Architectural Competition	Allowed	–	–	–	–	–	Allowed
dp_avalik	Area Planned for Public Use	Allowed	–	–	–	–	Allowed	Allowed
dp_haljastus	Landscaping and Maintenance	Allowed	–	–	–	Allowed	Allowed	Allowed
dp_hoonestus	Building Area	Allowed	Mandatory	Building area must be entirely within the plot connected to the annotation data	–	–	–	Allowed
dp_juurdep	Access	Allowed	–	–	–	Allowed	Allowed	Allowed
dp_KKTingimus	Environmental Condition Area	Allowed	–	–	–	–	–	Allowed
dp_KOVLoodus	Local Government Nature Conservation Proposal	Allowed	–	–	–	Allowed	Allowed	Allowed
dp_krunt	Plot	–	Mandatory	The spatial shape of an object cannot be a collection of surfaces. At least one geometry per layout.	Mandatory	–	–	Allowed
dp_krundiSihtotstarve	Plot Purpose	–	Mandatory	–	Mandatory	–	–	–
dp_maapar	Land Improvement System	Allowed	–	–	–	–	Allowed	Allowed
dp_servituut	Easement Need	Allowed	–	–	–	Allowed	Allowed	Allowed

(*Continued*)

Table A3 Continued.

Core Layer Name	Name	Division Layers	Mandatory	Spatial Data Requirements	Smart Data	Point	Line	Surface
dp_sund	Need for Acquisition in Public Interest	Allowed	–	–	–	Allowed	Allowed	Allowed
dp_tehno	Technical Construction	Allowed	–	–	–	Allowed	Allowed	Allowed
dp_tingimus	Condition Set by Plan	Allowed	–	–	–	Allowed	Allowed	Allowed
dp_transp	Transportation Construction or Area	Allowed	–	–	–	Allowed	Allowed	Allowed
dp_vaartloodus	Natural Value	Allowed	–	–	–	Allowed	Allowed	Allowed
dp_vaartMiljoo	Milieu Value	Allowed	–	–	–	Allowed	Allowed	Allowed
dp_vaartPollum	Valuable Agricultural Land	Allowed	–	–	–	–		Allowed

https://www.riigiteataja.ee/aktilisa/1211/0202/2002/RM_m50_lisa3.pdf#

Table A4 Estonian Detailed Plan data attribute requirements (Translated to English.)

Layer Name (Worksheet)	Attribute (Column Name)	Data Type in Column	Explanation	Filling Rules	Mandatory	Condition for Mandatory
plan_ala	planLiik	integer|text	Plan type identifier	Values from plan type classifier	Mandatory	–
	sysID	integer	Planning identification number in database	–	Conditionally Mandatory	Required if number is reserved or if changes are submitted
	kovID	text	ID or identifier of the planning activity organizer	–	Conditionally Mandatory	Required if issued by the planning activity organizer
	muutev	text	Modifying a more general plan	yes\nno	Mandatory	–
	planEesm	text	Main objective of the plan, similar to the establishment decision	–	Mandatory	–
	planID	integer	Cadastral administrator's planning identification number	–	Conditionally Mandatory	Required if issued by the cadastral administrator
	planKSH	text	Strategic environmental assessment conducted during the process	yes\nno	Mandatory	–
	planNim	text	Plan name as given in the establishment decision	–	Mandatory	–
	planViide	text	Web link to the plan at the organizer's website	–	Conditionally Mandatory	Required if a public web link to the plan is available
	algatKp	date	Date of plan initiation	–	–	–
	vastuvKp	date	Date of plan acceptance	–	–	–
dp_vaartPollum	objectID	integer|text	Object identifier	Unique within the base layer at least	Mandatory	–
	jaotuskiht	text	Distribution layer for GIS formats	–	–	–
	tingimus	text	Description of conditions	–	–	–
dp_vaartMiljoo	objectID	integer|text	Object identifier	Unique within the base layer at least	Mandatory	–
	jaotuskiht	text	Distribution layer for GIS formats	–	–	–
	nimetus	text	Object name	–	Conditionally Mandatory	Mandatory if distribution layers are not used
	tingimus	text	Description of conditions	–	–	–

(*Continued*)

Table A4 Continued.

Layer Name (Worksheet)	Attribute (Column Name)	Data Type in Column	Explanation	Filling Rules	Mandatory	Condition for Mandatory
dp_vaartLoodus	objectID	integer|text	Object identifier	Unique within the base layer at least	Mandatory	–
	jaotuskiht	text	Distribution layer for GIS formats	–	–	–
	nimetus	text	Object name	–	Conditionally Mandatory	Mandatory if distribution layers are not used
	tingimus	text	Description of conditions	–	–	–
dp_transp	objectID	integer|text	Object identifier	Unique within the base layer at least	Mandatory	–
	voond	integer|fraction	Width of the protection zone	Unit: meter	–	–
	jaotuskiht	text	Distribution layer for GIS formats	–	–	–
	kujaTing	text	Conditions of the corridor, such as spacing	Unit: meter	–	–
	nimetus	text	If all road and street elements are presented on one layer, it is mandatory to indicate which object it is	–	Conditionally Mandatory	Mandatory if distribution layers are not used
	tingimus	text	Description of conditions	–	–	–
dp_tingimus	objectID	integer|text	Object identifier	Unique within the base layer at least	Mandatory	–
	jaotuskiht	text	Distribution layer for GIS formats	–	–	–
	nimetus	text	Object name	–	Conditionally Mandatory	Mandatory if distribution layers are not used
	tingimus	text	Description of conditions	–	–	–
dp_tehno	objectID	integer|text	Object identifier	Unique within the base layer at least	Mandatory	–
	korgus	integer|fraction	Relative height above ground	Unit: meter	–	–
	korgusAbs	integer|fraction	Absolute height	Unit: meter	–	–
	maxKorgAbs	integer|fraction	Maximum allowed absolute height	Unit: meter	–	–
	maxKorgus	integer|fraction	Maximum allowed relative height above ground	Unit: meter	–	–
	maxSygavus	integer|fraction	Maximum allowed depth in meters is relevant for buildings or significant public interest facilities	Unit: meter	–	–
	minKorgAbs	integer|fraction	Minimum allowed absolute height	Unit: meter	–	–
	minKorgus	integer|fraction	Minimum allowed relative height above ground	Unit: meter	–	–
	minSygavus	integer|fraction	Minimum allowed depth in meters is relevant	Unit: meter	–	–
	sygavus	integer|fraction	If depth in meters is relevant	Unit: meter	–	–
	voond	integer|fraction	Width of the protection zone	Unit: meter	–	–
	jaotuskiht	text	Distribution layer for GIS formats	-	–	–
	kujaTing	text	Conditions of the corridor, such as spacing	Unit: meter	–	–

(*Continued*)

Table A4 Continued.

Layer Name (Worksheet)	Attribute (Column Name)	Data Type in Column	Explanation	Filling Rules	Mandatory	Condition for Mandatory
	nimetus	text	Object name	-	Conditionally Mandatory	Mandatory if distribution layers are not used
	tingimus	text	Description of conditions	–	–	–
dp_haljastus	objectID	integer| text	Object identifier.	Unique at least within the core layer.	Mandatory	–
	jaotuskiht	text	Classified distribution layer for GIS formats.	–	–	–
	nimetus	text	Object name.	–	Conditionally Mandatory	Mandatory if no distribution layers are used.
	tingimus	text	Description of land use and building conditions.	–	–	–
	kujaTing	text	Corridor conditions, e.g. spacing.	Unit: meter	–	–
dp_arhVoistlus dp_juurdep dp_KKTingimus dp_maapar dp_KOVLoodus	objectID	integer| text	Object identifier.	Unique at least within the core layer.	Mandatory	–
	jaotuskiht	text	Classified distribution layer for GIS formats.	–	–	–
dp_servituut dp_avalik dp_sund	nimetus	text	Object name.	–	Conditionally Mandatory	Mandatory if no distribution layers are used.
	tingimus	text	Description of land use and building conditions.	–	–	–
	tingimus	text	Conditions.			

https://www.riigiteataja.ee/aktilisa/1211/0202/2002/RM_m50_lisa4.pdf#