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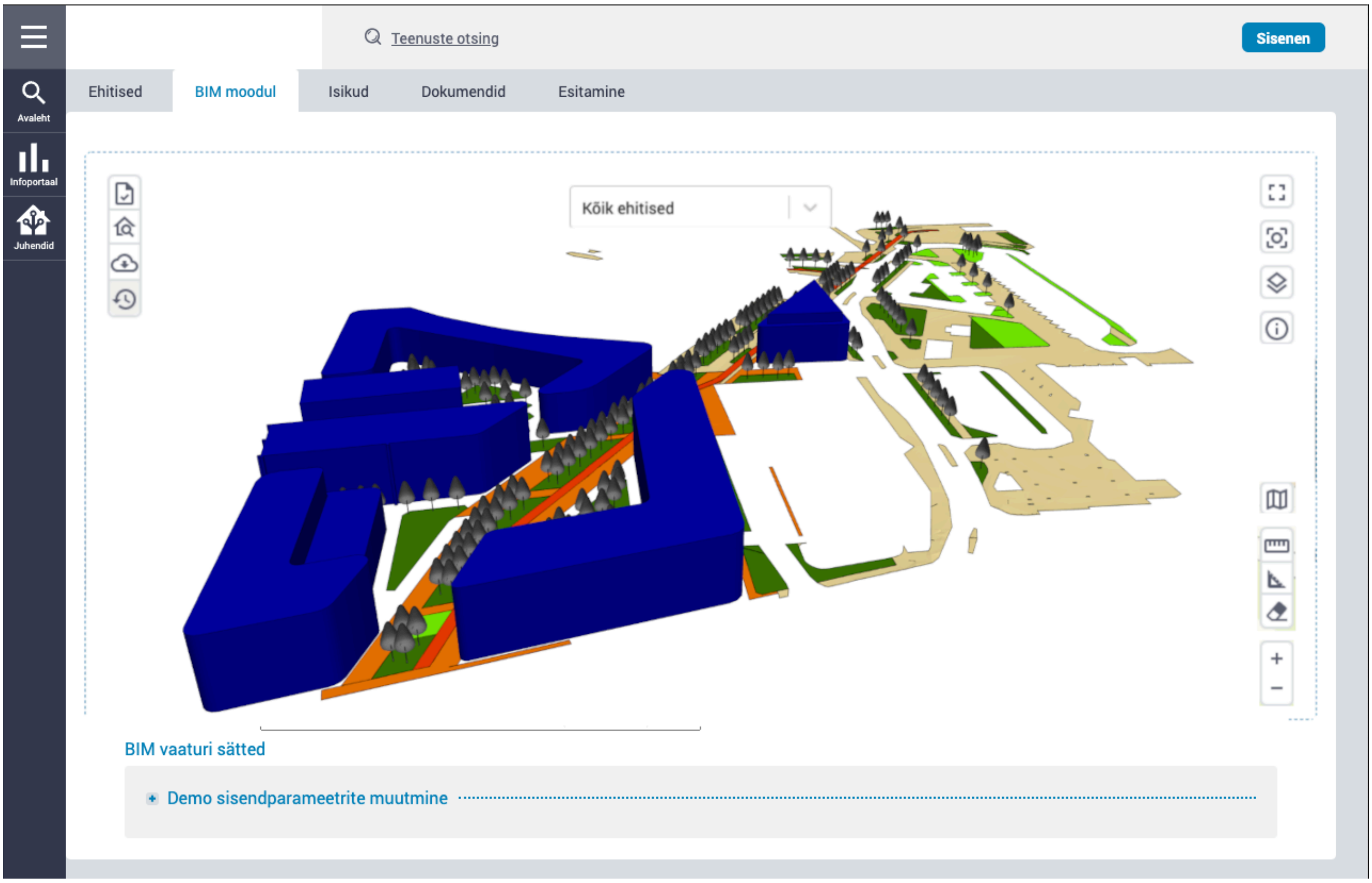
Detailed analysis of the use of the information model of the plan and creation of a prototype solution

Interim Work Report



Future Insight Group B.V.
December 19 2023

1. Introduction

Estonia is one of the world's forerunners when it comes to BIM based permit checking. The first version of such a service, developed in recent years in Estonia, is seen around the world as a good example of how such a system should be set up. An initial test version of the service is currently being rolled out nationwide.

This research project examines the next important steps to see whether and how the approach can be applied one step earlier in the process, namely when submitting and offering detailed plans. These designs cover larger areas and therefore probably require different techniques and types of data.

This interim report describes the results of the first research phase of the project. It provides a comprehensive overview of the current state, challenges, best practices, and recommendations for the implementation of planning information models in Estonia, serving as a basis for further decision-making and future developments in the planning process. Next to that it gives us valuable insights to further define the software prototype solution.

Different kinds of stakeholders from the Estonian practice were interviewed and other global initiatives were examined in the desk research. The results were analysed to come to recommendations. The value case is constructed on the input of the interviews and desk research. Thus, the information gathered in phase 1 through the interviews and desk research will be used in phase 2, developing a prototype. An overview and approach is proposed in chapter four for the development of a first working prototype that will be built in the second and final phase of this project.

1.1 Index

1.2 Management summary

This report describes the results of the first research phase of this project, which examines whether and how Estonian detailed plans can be constructed as planning information models in 3D, and using this input for automated compliance checking. In the first phase, a detailed analysis has been conducted consisting of desk research, interviews and based on the results of these two steps a first solution design has been made for which a prototype shall be built in the second phase of this project.

The desk research was split up in analysing the current planning process in Estonia and investigating the digitalization of planning processes in other countries. Firstly, the Planning Information Models, systems and data used in the Estonian planning process were discussed, after which the layout of the Estonian planning system was studied. Two pilot projects are considered as input for the prototype solution. The Estonian pilots, regarding the National Broadcasting Building and the Tallinn Harbour Area, using 3D detailed plans were analysed in order to understand where Estonia stands at this moment when it comes to using 3D data in the detailed planning. The short conclusion was that there are quite a lot of developments and standardisation around BIM based permit checks, but little around detailed plans. However, there are relevant solutions and standards available from these BIM-based permit checks developments that appear suitable, such as ISO 12006-2:2015[1] and ISO 81346[2]. The approach currently being developed for the European Accord project[3], of which Estonia is already a part, based on open standards and microservices, seems particularly suitable.

The interviews showed a comprehensive understanding of the challenges in the planning process and the readiness of the market. There is a consensus on the need for better standardisation, coordination and version control. The added value of constructing detailed plans in 3D is also endorsed. Some basic standardisation is already happening, however this should be further extended in order to meet the ambitions for automated checking of detailed plans in 3D.

The gained knowledge on the interviews and desk research formed a solid foundation to propose a solution design to automatically check detailed plans. The proposed idea is to base the solution on an online API-based microservice architecture using international open standards, including IFC and CityGML. In this way, the solution can be used in various points of the planning process, gaining the most value.

[1] https://www.iso.org/standard/61753.html
[2] https://www.iso.org/standard/75471.html
[3] https://accordproject.eu/

From the desk research and interviews, the biggest bottlenecks were identified and a list of possible checks made.. From this a list of ten potential compliance checks are identified, of which seven will be realised in the second phase. In the selection of these checks clarity, feasibility and value were determining factors, aiming to address checks that will add the biggest value.

The major challenge here is that traditional BIM and GIS techniques have to be combined in an online microservice architecture. By implementing a so-called 'orchestrator' service, it should become possible to quickly and flexibly combine different types of online analyses in one check configuration. There is little experience with this approach, hence the second phase of the project will be agility realised, focused on innovation and experimenting. In addition to building the prototype solution, the second phase will first focus on setting up a basic architecture and configuring the first checks. Dependencies and points for improvement can be expected from the various components such as the 3D design and reference data, the analysis functions and the basic infrastructure. This second phase will take place between January and May 2024.

1.3 Abbreviations

API	Application Programming Interfaces
BCA	Building and Construction Authority
BEITM	Built Environment Industry Transformation Map
BIM	Building Information Modelling
BRISE	Building Regulations Information for Submission Involvement
CHEK	Change Toolkit for Digital Building Permit
CityGML	City Geography Markup Language
CORENET	Construction and Real Estate NETwork
CP	County Plan
DP	Detailed Plan
EHR	Estonian Building Register
GIS	Geographic Information System
IDD	Integrated Digital Delivery
IDS	Information Delivery Specification
IFC	Industry Foundation Classes
KOV	Local government
MKM	Ministry of Economic Affairs and Communications
MP	Master Plan
NP	National Plan
PBL	Swedish Planning and Building Act
PLANIS	Planning Procedure Information System
PLANK	Spatial Plans Database
RAM	Ministry of Finance
REM	Ministry of Regional Affairs and Agriculture
SEA	Strategic Environmental Assessment
SEIA	Strategic Environmental Impact Assessment
TalTech	Tallinn University of Technology

TLV	Tallinn City Government
UI	User Interface
UX	User Experience
VDC	Virtual Design and Construction

Table 1: Abbreviations

1.4 Estonian terminology in English

Estonian	English
Üleriigiline Planeering	Nationwide Plan
Maakonna Planeering	County Plan
Üldplaneering	Master Plan
Detailplaneering	Detailed Plan
KSH	SEIA

Table 2: Estonian terminology translation

1.5 Methodology

The project consists of two stages, the detailed analysis stage and the software prototype solution stage. This chapter describes the methodology of the detailed analysis stage, which will be used as input for the solution design of the prototype in the software prototype solution stage.
The goal of the detailed analysis stage is to research the existing state, challenges and bottlenecks of the Estonian planning process and outlining the value proposition of the prototype solution. The solution design is based on the results of the desk research and interviews. As input for the solution design, a main research question has been defined:

What are the most prominent bottlenecks in the current Estonian planning process and how can they be improved using automated checks based on Planning Information Models?

To answer the main research question and hence compose a value case, the following steps are defined:

1. A desk research will be conducted, focused on gaining knowledge about planning information models and data formats, the current planning process in Estonia and other countries.
2. Simultaneously with the desk research, interviews will be conducted. The aim of the interviews is also to gain insight in the current planning process in Estonia, however the focus will be on practice and concurrently perceived challenges and bottlenecks. Also, interviewees are asked about their recommendations and which checks they would find valuable or feasible.

The step thereafter is analysing the outcomes of both the desk research and interviews. The results of this analysis will be concluded in the final step of proposing a solution design (Figure 1). These steps will be further described in the paragraphs below.

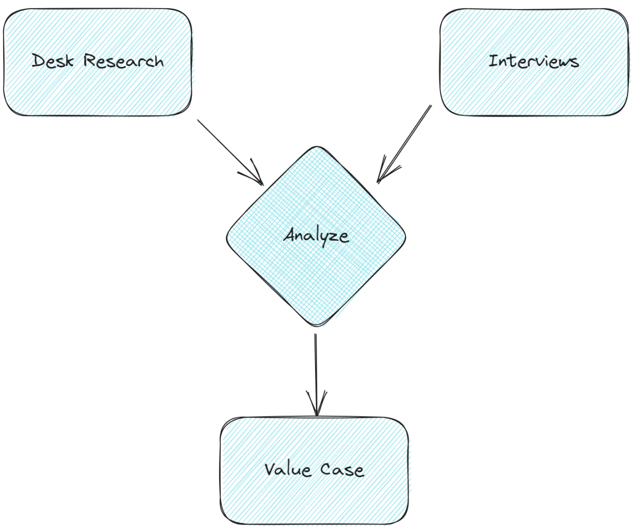


Figure 1: Methodology of the detailed analysis stage

1.5.1 Desk research methodology

The desk research focuses on gaining knowledge about the current Estonian planning system and international best practices. The desk research involves reading academic and industry publications, consulting experts from other countries, and reading government documents. For this, also the previous work of Ministry of Economic Affairs and Communications (hereafter MKM) with the construction related topics represented by the Ministry of Climate, the city of Tallinn, TalTech and the Ministry of Finance (hereafter RAM) with the planning related topics represented by the Ministry of Regional Affairs and Agriculture (hereafter REM) regarding implementing the use of BIM are taken into account. The following subjects will be addressed:

1. Planning information models and data formats used within urban planning.
2. The current state of the planning process in Estonia. This includes the different steps carried out, stakeholders involved, what data is used and which software products are consulted.
3. International best practices.

1.5.2 Interviews methodology

The purpose of the interviews is to gather information about the current state of the planning information model. Besides that, challenges and bottlenecks in that current process need to be identified and more information on them needs to be collected in order to make good decisions on what process to execute the prototype solution for.

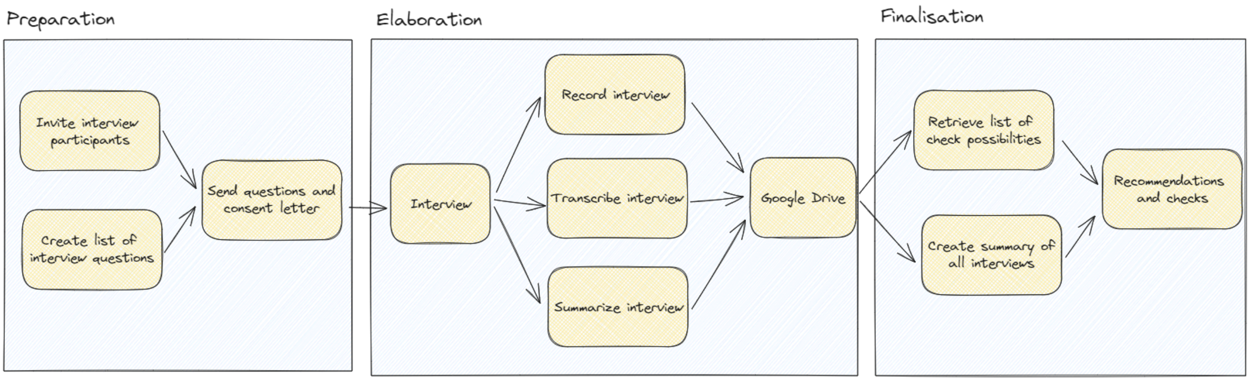


Figure 2: Interviews methodology

For the execution of the interviews, the following materials have been used:

- A consent form, which can be found in appendix A. Permission to record was requested from the interviewees within this consent form. All participants signed this consent form before the interview took place.
- List with interview questions, which can be found in appendix B.
- List with possible interviewees, their contact information and information on when they were interviewed, which can be requested and is not in the appendix due to the protection of personal information.

The questions and whom to interview lists were discussed and improved during our meetings with the Estonian team. The main goal of these questions was to reveal the interests of different stakeholders in the planning processes:

- The interviewees role in the planning process
- The readiness of the market for the introduction of the planning information model.
- The most used software for creating plans (general plan and detailed plan).
- The bottlenecks of the current process from the point of view of the legislation and the effectiveness of the process.
- The bottlenecks in the introduction of planning information models and the changes necessary for introduction from a technological, organisational and legislative point of view.
- The bottlenecks of the three-dimensional visualisation of detailed plans and possible solutions in publicising the plans and involving interested parties.
- What kind of compliance checks have the most potential.

All the interviews have been recorded, transcribed and summarised. The summaries include an overview of the interview, bottlenecks identified within the current planning process, identified check possibilities and recommendations to implement these.

The interviews were held with different experts in the domain of the planning process of Estonia. This included participants working at private companies involved in the preparation of plans, local governments, land administration and architect companies. Check possibilities were obtained after showing the participants a demo of what PlanBIM could be, showing the pilot project data as described in chapter 2, and asking them what they thought this could be used for in the future. This resulted in a list of identified check possibilities.

After conducting the interviews, the list of identified check possibilities have been analysed against the following criteria:

- Clarity: To be able to construct a check, it should be clear and concrete what should be checked. The more concrete of a description, available parameters and to be used data the better a check scores on this point.
- Feasibility: A check should also be technically feasible. This is judged by the description of the check and awareness of the (existing) technical possibilities.
- Value: The extent to which the possibility saves time or money compared to the current planning process.
- 3D advantage: The extent to which this check benefits from the use of 3D data or would only be possible using 3D data.

With the analysis of the check possibilities, a subset of checks that are achievable within the scope of the project and will deliver the most value at this moment are selected (see chapter 4).

1.5.3 Analysis methodology

The outcomes of the desk research and interviews are analysed and summarised, and form the input for the value case and consequently the solution design. Important input for the solution design are:

Which open data formats are suitable for planning information models? The answer to this question is based on the description of currently used and available data formats, and input from international best practices. Concurrently, the available pilot data is analysed on suitability as input for the prototype solution.

Which successes and learning points have to be taken into account based on current systems and previous development regarding the digitization of the construction industry? This will be concluded from the description of the current Estonian planning process and systems and previous research.

Which practices from international initiatives or other countries are recommended to take into account? Which will be answered by researching international best practices.

Which bottlenecks are encountered, can they be resolved with compliance checks and which of them are feasible to address with a prototype solution? To answer this question, input from mainly the interviews, but also from the desk research is taken into account. A list of possible checks is compiled, constructed and judged as described in the interview methodology.

1.5.4 Solution Design methodology

The value case addresses the existing challenges and bottlenecks of the Estonian planning process and outlines the value proposition of the prototype solution. In the value case, the proposed prototype solution will further be described, including a user experience flow and a TO-BE process diagram. The UX flow and TO-BE diagram will be in line with the existing national e-construction platform, and identify possibilities for integration. Additionally, for the prototype solution, a shortlist of 10 compliance checks are selected of which 7 will be chosen in the next phase.

2. Desk Research

2.1 Planning Information Models and data

The definition of the term Planning Information Model in the context of this procurement is defined as follows:

"The planning information model is a spatially (3D) visualised set of planning data, where the data is related to the corresponding elements (For example, the built-up area data is attached to the built-up area element, and the landscaping data is attached to the landscaping elements [trees, bushes, surface layers]). The information model of the plans is in an open data format and can be visualised in digital twins of cities and countries. Based on the information model of the plan, it is possible to check the compliance of the plans with the requirements in the procedural process[4]."

In short, a planning information model is a spatially (2D or 3D) visualised set of planning data, which makes it possible to check the compliance of plans with the requirements in a procedural process. It consists of an open data format and can be visualised in digital twin software of cities and countries. This chapter describes data formats which are or can be used in the planning process. It describes the current usage in the Estonia planning process, and to what extent they are suitable for use in a Planning Information Model in Estonia.

2.1.1 (2D) Computer Aided Design (CAD)

CAD is the use of computer-based software to aid in design processes. A number of CAD tools exist and CAD software can be used to create two-dimensional or three-dimensional digital drawings. It is frequently used by a.o. engineers and designers. An advantage is that one can draw accurately. However, the design is usually graphic oriented instead of object information oriented, with visual representations that are not suitable for further processing. Additionally, drawing styles may differ between drawings, especially if there is no CAD drawing standard in place, dictating guidelines on how a drawing should appear, including colour and symbol usage. On top of that CAD-drawings usually contain a plentitude of information, rendering it densely packed and challenging to decipher. Concurrently, most used CAD-files (.DWG, .DXF) are proprietary formats, you need proprietary software to open the files. Therefore, CAD-drawings are often exported to .pdf, resulting in data-loss.

CAD drawings are often used in current detailed plans, frequently featuring a descriptive table. Recently a standard for these drawings has been introduced in PLANK[5]. For the usage of CAD it is advised that such a standard is followed and CAD drawings are made object-oriented to make them more suitable for further processing.

[4] Majandus ja Kommunikatsiooni- ministeeriumi Ehitisregistri talitus, "Detailed Analysis Of Using The Planning Information Model And Creation Of A Prototype Solution (Translated from Estonian)," *Appendix 1 To The Procurement Document Technical Description Of The Subject Of The Procurement Contract*. 2023.

[5] https://planeerimine.ee/digi/plank/plank-juhendid/cad-formaadid/

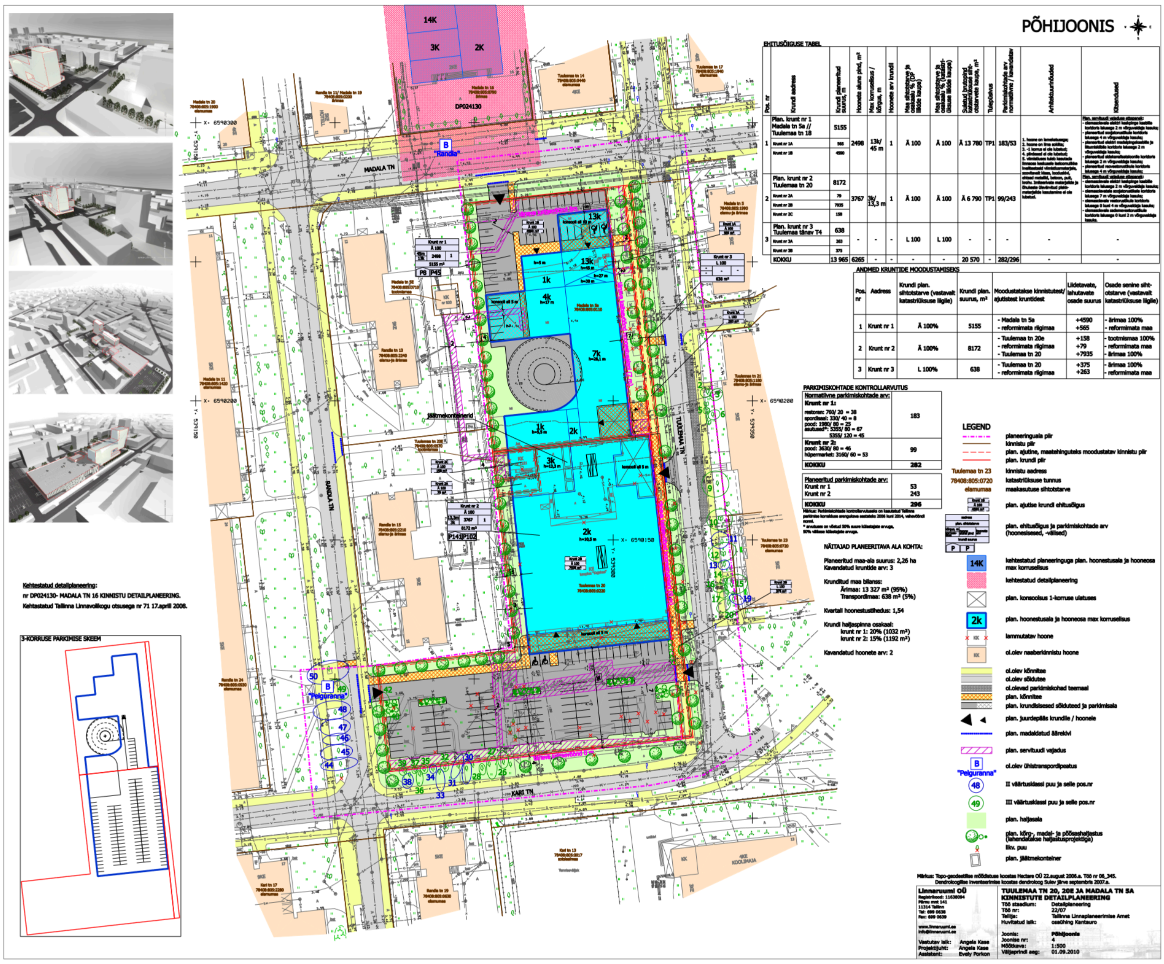


Figure 3: Example of an exported CAD drawing of a detailed plan

2.1.2 Geographic Information Systems (GIS)

A Geographic Information System (GIS) is an information system aimed at storing, managing, analysing and visualising spatial data. GIS is a broad term, encompassing multiple file-formats and software. A distinction can be made between open standard file-formats and open source software and proprietary formats and software. Open standards for file-formats are defined to be freely accessible, publicly available, vendor-neutral, and not constrained by licence fees or patents. They are usually institutionalised by a standardisation body, i.e. the Open Geospatial Consortium (OGC)[6]. Standardisation aids interoperability and interchangeability.

One notable GIS software supplier is Esri. Esri offers a comprehensive suite of tools for handling and displaying spatial information, such as ArcGIS Pro and ArcGIS online. However Esri's software is proprietary, meaning its source code is not openly available. Despite this, ArcGIS allows for interaction through open online viewers.

[6] https://www.ogc.org/standards/

One commonly used file format in ArcGIS is the .shp (shapefile) format, besides that there are gpkg, gdb formats, often considered as a somewhat open format, since even though they are not maintained by a standardisation body, the use is not constrained by licences and other software can handle the formats as well. However, the shapefile format has limitations, including a file-size limit, character limit and lack of relations[7]. Moreover, shapefile is a file format and not a data model.

The versatility of Esri's ArcGIS extends to both 2D and 3D spatial representations. While .shp files are primarily associated with 2D mapping, ArcGIS enables users to create and analyse 3D visualisations. However, when delving into 3D representations, the question arises: what replaces the familiar 'shape' in this context?

Esri's ArcGIS finds application in Estonian municipalities, especially in the field of land use planning and visualisation of master plans. The software facilitates interactive displays, making complex spatial data more understandable to the public. This interactive aspect enhances communication and fosters a broader understanding of the planning process among stakeholders.

Despite its benefits, it has to be acknowledged that Esri is proprietary software. The lack of an open format and standardised data model poses challenges, concerning data interoperability and collaboration. The suitability of Esri's ArcGIS for communication is evident through its interactive viewers; however, the limitations highlight the importance of addressing data interoperability and standardisation.

Next to Esri there are multiple other GIS software vendors, such as MapInfo, and open source alternatives, such as QGIS. For the use of GIS in the planning process it is important that the file-formats chosen do not limit the choice of software for both planners and governments, and promotes interoperability.

2.1.3 CityGML

CityGML is a widely used, standardised city data model, aligning with the Open Geospatial Consortium (OGC) open standard and based on the OGC Geography Markup Language (GML). This data model and format encompass the entire city, including buildings, streets, greenery, and more. The standardised data model establishes agreements on names, promoting consistency if every city or municipality adopts a similar modelling approach. In Addition to the data model, some industries have developed ADE's to the data model to add additional standardised attributes within these industries.

CityGML can be stored as a file (.citygml, cityjson) or stored inside a versioned city database (3d CityDB). CityGML primarily focuses on creating a standardised representation of urban environments. While it supports 3D data, it's worth noting that 2D data is also technically possible within this framework.

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[7]https://pro.arcgis.com/en/pro-app/latest/help/data/shapefiles/working-with-shapefiles-in-arcgis-pro.htm#:~:text=Limitations%20of%20shapefiles,-A%20shapefile%20has&text=Maximum%20field%20name%20length%3A%2010,store%20topological%20information%20or%20relationships

The OGC recently has approved a new version of CityGML, version 3. However it should be noted that many CityGML files or databases are still in the previous version CityGML 2.0, as suitable tools have yet to be developed for CityGML 3.

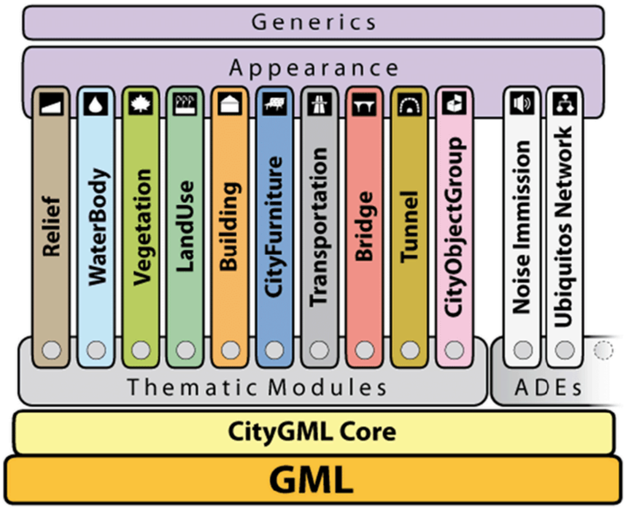

Figure 4: CityGML data model overview[8].

One of the key advantages of CityGML is its support for versioning, allowing for the tracking of changes over time. This feature is valuable in urban planning, as developments and modifications occur frequently. Additionally, CityGML provides the option to convert data to 3D tiles, enabling lightweight visualisation. This capability is particularly advantageous for efficient viewing in 3D applications and digital twin environments.

Currently, CityGML is not yet used in the Estonian planning process. Moreover, 3D data in general is not yet often used in the planning process, and there are no requirements or standards on how to deliver 3D data. Next to IFC, CityGML is a potential suitable 3D data model to be used in the planning process, one distinction being that CityGML is more suitable for 3D data on a larger scale, i.e. on city scale, than IFC. The framework's adherence to an OGC open standard and international compatibility positions it as a suitable candidate for integration into spatial planning packages. Moreover, its compatibility with 3D viewers and potential for supporting digital twin initiatives make it a versatile and forward-looking solution for urban data representation[9].

2.1.4 LADM spatial package

LADM (Land Administration Domain Model) is defined as ISO standard ISO 19152:2012, covering basic information-related components of land administration. It is used for property registration, provides an abstract model with three packages related to parties of people and organisations, ownership rights, obligations and restrictions, spatial sources and spatial representation through geometry and topology.

[8] https://www.researchgate.net/figure/Schematic-representation-of-the-CityGML-20-standard-source-OGC-City-Geography-Markup_fig2_360770855
[9] https://3d.bk.tudelft.nl/ken/files/18_bimchapter.pdf

It also provides a mutual ontology for land administration that is as simple as possible and allows for a shared description of different (in)formal practices and procedures. It enables the combining of land administration information from different sources [10].

Originally developed for Land Administration Systems (i.e. Cadastral) the model allows for broader use in the registration of land use (including restrictions etcetera), and an additional package is being made (LADM Part 5) which focuses on spatial planning. It is called a data model, it is not a data format, the model can be applied to different data formats and does not even have to be in one data format. LADM offers guidelines to support interoperability in the representation of Rights, Restrictions, and Responsibilities (RRRs). The RRRs can be registered and linked to a geometry and parties, so these could be 3 different (existing) databases, highlighting the adaptability of the model. LADM could be linked to CityGML, however this is still in development. It could be applied to both spatial planning and land administration, although this would require a change of use and also it is not used yet in Estonia.

The second edition of LADM (under development by ISO) covers six essential parts, including Spatial Plan Information (Part 5), which plays a pivotal role in integrating land registry and planned land use data. Part 5 specifically addresses the need for a systematic approach to store urbanistic rules, supporting planning hierarchy, codelist values for spatial functions, permit registration, open dissemination, and 3D visualisation of plan information. Integrating LADM into the BIM-based building permit process emerges as a strategic solution, overcoming potential limitations and fostering interoperability within LAS modules, contributing to the advancement of future projects.

2.1.5 Building Information Model (BIM)

A Building Information Model (BIM) is a digital representation of a building. Next to a 3D model it is an extensive information model, containing information about properties, attributes and materials of building entities. The strength of BIM lies in its ability to merge diverse disciplines and phases throughout the building's life cycle management. The different disciplines and phases of a BIM can be managed by a variety of (proprietary) software. Therefore a key feature facilitating interoperability is the use of the open file format Industry Foundation Classes[11] (IFC, ISO 16739-1:2018), maintained by buildingSMART[12]. This enables exchange of BIM data between different software applications, encouraging collaboration among various stakeholders involved in the building process.

Even though the IFC data model dictates a certain information level, the quality of information within BIM models can vary. In that light, determining agreements on the use and contents of properties is needed, so that involved parties have a shared understanding of the contents of a BIM, and the information is predictable and usable as input for automated checks.

[10] https://www.iso.org/standard/51206.html
[11] https://www.iso.org/standard/70303.html
[12] https://www.buildingsmart.org/

These agreements can be specified in an Information Delivery Specification (IDS) and checked by the similarly named IDS-format, developed by buildingSMART [13]. The IDS plays a pivotal role in determining the extent to which the information model is checked and ensuring consistency across the model. BIM is currently used in the (EHR) and besides that, has undergone pilot projects. Automated checks for BIM have been developed previously, particularly in building design and compliance verification. The potential intricacy of BIM files, especially when designed at a detailed level, may result in large and heavy files. This can pose challenges in displaying multiple files, particularly in web viewers. To address this, options such as converting to alternative formats like 3D tiles are considered, albeit with the trade-off of potential information loss during the conversion process.

A technical limitation for the use of BIM in urban planning is the use of local coordinate systems, sometimes lacking a robust geographic reference. This can complicate the correlation of BIM objects with other geographical features. When using BIM in the planning process, it hence should be required to correctly georeference the BIM.

While the BIM IFC-format is predominantly used for buildings, its application extends to other objects, such as infrastructure or utility networks. However, the information models for these entities are less developed. Additionally the use of the IFC-format in the stage before the design of objects, the planning phase, remains underexposed. The use of Spatial Planning Information Models could fill this gap, using the IFC format as a familiar format complementing current building design. Concurrently the IFC format offers other benefits in this regard.

The IFC format is an open standard, it is interoperable, already well known in the AEC industry, has a rich data representation, and concurs with the principles of BIM, including life cycle thinking. IFC as an open standard has made it possible to exchange (building) data among different disciplines and phases, which is visible in a variety of software packages supporting reading and exporting to IFC. These software packages concur with well known software packages creating CAD-drawings, which could aid the adoption of the use of IFC in the planning process. IFC has a rich data format, firstly it supports 3D geometry, which adds a 3d dimension opening possibilities for more complex checks, and an enhanced visualisation. Next to geometry however, IFC includes a rich semantic model of (building) elements, extendable by common or user-defined property sets. The elements are relational, meaning the relationships between different elements are stored.

However it should be noted that the use of IFC in planning differs from the original BIM used for the design of a building. In general, the level of detail of a PIM is far less than that of a BIM-design of a building, representing larger general volumes or areas in comparison to detailed designs of building elements such as walls and doors. Concurrently, whereas building designs in IFC entities are named, for example the IFC entities IFC Door and IFC Wall, there are no distinct entities for planning elements. When using the IFC format for urban planning, these issues have to be addressed.

[13] https://technical.buildingsmart.org/projects/information-delivery-specification-ids/

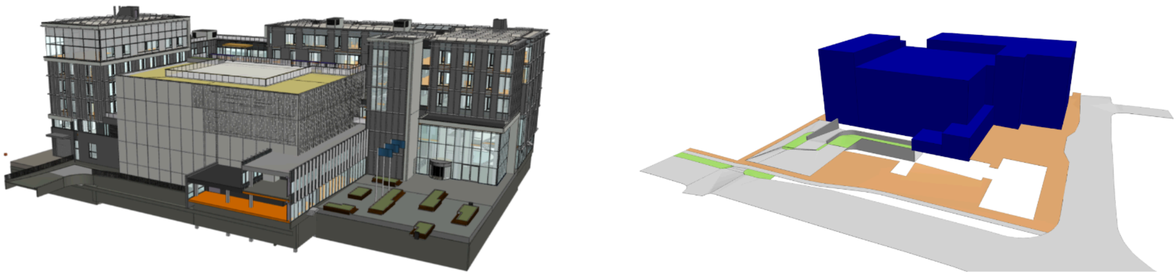

Figure 5: Example of a BIM model of building design (left) and a BIM model of a detailed plan (right)

2.1.6 Databases - WFS and WMS

Geographical data can be stored locally on a file system, however interoperable data formats exist, which allow the use of data without having to have access to local files. This interoperability allows for automation of workflow, i.e. automated checks.

Databases, such as the open source PostgreSQL database, are used to store relational data. With extensions, such as PostGIS and 3DCityDB, they are often extended to store geographical data. Databases offer the option to store, version, and query large amounts of (geographical) data. To make this data interoperable and available, a WMS or WFS can be configured for the database. WFS (Web Feature Server) and WMS (Web Map Service) are used to request and receive data or show map layers. WFS is a standard protocol for serving geospatial data as vector features (points, lines, polygons) over the web. It allows the requesting of specific feature data from a server and performs operations such as querying, inserting, updating and deletion of features. WMS (Web Map Service) is a standard protocol for serving geospatial data as images (PNG, JPEG a.o.) over the web. It allows the requesting of maps and map layers from a server, and one can display them on a client application or a map viewer. (mapscaping.se).

Currently, WMS and WFS are being produced in the Estonian planning process by municipalities, ministries and the Land Board Authority. Planning data stored in the PLANK system for example, is also available through a WMS and WFS. This can serve as a possible valuable input for automated checks. For example, the PLANK WFS service[14] offers an overview of spatial plans in the planning database. It includes the planning boundaries, type of plan and link to the plan. This data can be used to see if a plan area is overlapping with other plans.

2.1.7 Conclusion and recommendations

A planning information model is a 3D planning dataset, based on an information model for planning. Currently most planning data in Estonia is (2D) CAD or GIS, not based on a planning information model. This hinders interoperability and integration possibilities, including the use of this data as input for (automated) planning checks. Moreover not all plans are digitised yet, and only available as pdf or on paper. The lack of standards in old plans makes this harder or unable to use as input for automated checking.

[14] https://planeeringud.ee/plank/wfs

Planning data, to be used as input for automated checks, should be predictable, hence it should follow a standard describing agreements on the use and naming of properties, entities, attributes etc.. To enhance interoperability it is useful to make use of or connect to open existing standards, such as IFC and CityGML. Additionally, In this light the use of LADM should be further researched.

The standard does not necessarily dictate the file format. What is clear is that the file format is recommended to be non-proprietary, and that it is open to use in a variety of software suites, so as to not make planners or governments dependent on one vendor. Additionally it should support 3D data. Currently the data in the prototype models provided for this project is constructed in IFC. The advantage is that this is an open standard and 3D. However, other open formats, such as CityGML might also be suitable for planning data, and have to be further investigated in that light.

2.2 Current state in Estonia

This chapter describes the current state of current planning processes and other related digital innovations in Estonia. First it describes the current planning process, thereafter already existing solutions, thereafter the pilot projects.

2.2.1 The Estonian Planning Process

History of Estonian planning system

Urban planning is the basis of city development. Plans determine for what purpose and under what conditions a certain area of land can be used. Estonia's urban planning history dates back to the early 20th century, with systematic planning efforts gaining momentum before World War I[15].

The first planning law, the Construction Act, was introduced in 1939, primarily regulating planning in cities but ceased to operate when the Soviet Union occupied Estonia in 1940. During the Soviet era, planning in Estonia lacked specific laws but relied on norms and rules, primarily for densely populated areas. Plans were prepared by the National Construction Committee, with limited involvement from local governments.

In the post-independence era, preparations for modern planning and construction laws began before Estonia regained independence in 1991. The *Planeerimis- ja ehitusseadus* (PES), meaning Planning and Construction Act, was enacted in 1995, introducing planning at various levels of government.

In 2003, the Planning Act was introduced, separating planning and construction aspects into distinct laws. This change was mainly driven by the transfer of construction jurisdiction to the Ministry of Economic Affairs and Communications. The planning act outlines the planning process and the content of plans[16]. It cooperates with the Building Code, which provides building regulations and specifies rules for construction close to roads and technical infrastructure.

Layout of the Estonian Planning System

As stated, the Estonian Planning System consists of different types of plans, that are elaborated at different levels of government. The following subsections introduce the layout of the Estonian Planning System, the different authorities that operate in them and the major laws and regulations applicable to the planning system. The several types of plans that exist are structured hierarchically from general to more precise[17]. These four levels are National, County, Master Plan of a municipality and a detailed plan for one or more plots (Table 3). The hierarchy dictates compliance to lower plans (Figure 6).

[15] https://et.wikipedia.org/wiki/Eesti_planeerimiss%C3%BCsteem
[16] https://www.k6k.ee/oskaosaleda/planeeringud
[17] https://www.k6k.ee/oskaosaleda/planeeringud

Type planning	Territorial scope	Organiser planning
National plan (NP)	Whole country	Ministry of the Interior
County planning (CP)	County	County governor
Master Plan (MP)	City or municipality	City or municipality government
Detail planning (DP)	One or more plots	City or municipality government

Table 3: hierarchy of planning levels

In practical terms, a plan consists of two parts - a map (or maps) and a textual part called an explanatory letter. The map shows which plot of land can be used for which purpose with conditional signs or different colours. The explanatory letter explains in more detail whether and which conditions must be taken into account in addition.

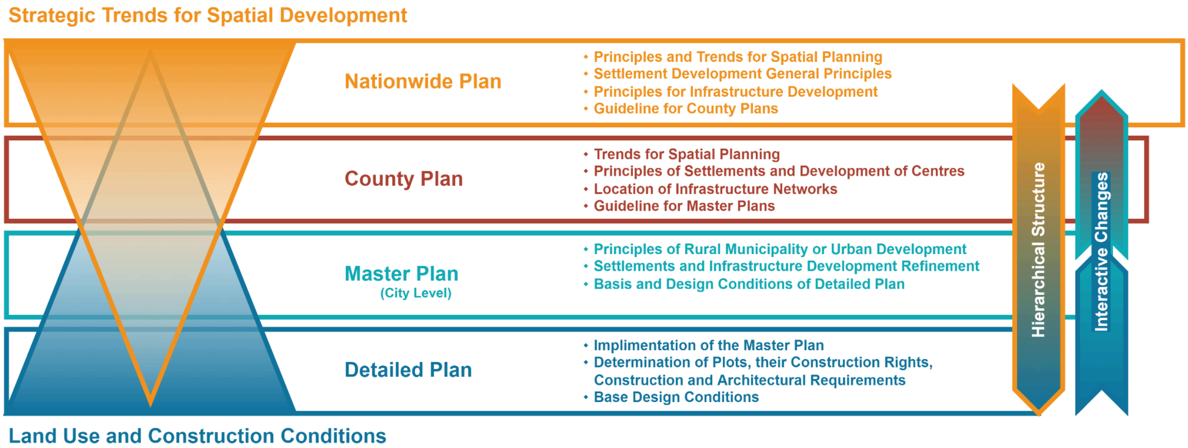

Figure 6: Estonian plan levels.

Responsible authorities

In Estonia´s planning system, different authority roles can be identified. These are the national government, counties and municipalities[18].

The national government:

- Is responsible for the National Plan (NP)
- Influences the spatial and land-use policies of the other authorities through the national plan and indirectly through the sectoral agencies.
- Includes a variety of sectoral agencies, like Road Administration, Environmental Board, Land Board, and Heritage Board. They must approve plans within their area of responsibility.
- Is responsible for County Plans (CPs).

Counties:

- Play a coordinating role in land-use planning on the regional level.
- Ratify Master Plans (MP) and Detailed Plans (DPs) that conflict with existing MPs

[18] https://www.riigiteataja.ee/akt/107032023082?leiaKehtiv

Municipalities:

- Are the main actors in land-use planning
- Are responsible for Master Plans (MPs), Thematic Plans and DPs
- Issue local building ordinances and building permits to developers
- Often outsource the actual preparation of plans to private consultancy companies

Major laws and regulations

The most important law for urban development in Estonia is the Planning Act[19]. It outlines the planning process and content of plans, and the Building Code (contained in several acts), which provides building regulations and specifies rules for construction close to roads and technical infrastructure. The building code may be complemented by Building Ordinances.

Another important law is the Nature Protection Act, which regulates construction in nature protection zones, areas close to rivers and lakes and on the coast. The Heritage Act regulates building activity in conservation sites.

Different planning types and their procedures

In this subsection, the different types of planning solutions of the Estonian planning environment are discussed. As this research has a main focus on the master and detailed planning, these two will be discussed in more detail, while the national and county plan are described briefly. After a general introduction of the master and detailed planning, their procedure is explained together with the involved process participants.

Where the focus of master planning is determining for what purpose different parts of a town or municipality can be used[20], the focus of detailed plans is on how one or more plots of land can be used more precisely[21].

National plan

The national plan (NP) is a long-term plan that defines the most general principles of the spatial development of the entire country[22]. It can also be considered as a long-term strategic plan. The previous valid national plan of Estonia is "Estonia 2030+"[23]. It was established by the Government of the Republic on August 30, 2012, and the preparation was organised and compiled by the Ministry of the Interior. It established which type of settlement is considered preferable, how energy production could look like, and which are the preferred modes of transport. On the 5th of January 2023, the government of Estonia initiated the National Plan ''Estonia 2050'' and its Strategic Environmental Assessment. As the NP is essentially a long-term strategic document, it is not expected that a new plan will be prepared in the near future.

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[19] https://www.riigiteataja.ee/akt/107032023082?leiaKehtiv
[20] https://www.riigiteataja.ee/akt/107032023082?leiaKehtiv
[21] https://www.k6k.ee/oskaosaleda/planeeringud/detailplaneering/dp-alates-juuli-2015
[22] https://www.k6k.ee/oskaosaleda/planeeringud/uleriigiline-planeering
[23] https://eesti2030.files.wordpress.com/2014/02/estonia-2030.pdf

The main established development goal is to ensure living opportunities in every inhabited place in Estonia. For this, a high-quality living environment, good and comfortable movement options and provision of important networks are necessary.
The NP deals with spatial relations with other countries, as well as with different regions of Estonia and the entire land and water area as a whole. Its purpose is to direct the comprehensive development of the settlement structure and nationwide networks, taking into account the particularities of the regions. The national plan provides general guidelines for the preparation of county plans and master plans of municipalities and creates an opportunity for better linking of national level sectoral development plans or strategies.

County plan
The County plan (hereafter CP) is a planning that spreads over a whole county. These plans are prepared by the state by hired private consultancy companies, as county governments and county mayors were abolished in Estonia on the 1st of January 2018. The basis of the CP are formed by the NP and they contain land-use plans for a single county. They cover an average size of 3000 square kilometres and take a wide range of policies into account. They can be supplemented by thematic CPs that have a focus on a specific policy area like transport, environmental or infrastructure.

Master plan
The Master plan (MP), also referred to as comprehensive plan, lays down the development principles of the area of a municipality or a town[24]. It includes what the purpose is for different parts of the area, like industrial or agricultural. Besides that, construction conditions and locations of roads and streets are determined. That means the MP lays out the development principles of the municipality and land use more generally. The MP is based on the valid country plan and locations of technical facilities as railways, roads, power lines, etc. It is the basis for detailed plans and the corresponding design conditions, which means it is the basis for specific buildings. Master Plans are prepared with help of several detailed steps, that are simplified in the following high-over steps[25]:

1. Initiating planning
2. Planning
3. Public display of the draft plan
4. Public discussion of the draft plan
5. Planning (continued)
6. Acceptance of the plan
7. Public display of the plan
8. Public discussion of the plan
9. Adopting the plan

Figure 7: High-over steps of the Estonian Master planning process.

[24] https://www.k6k.ee/oskaosaleda/planeeringud/uldplaneering
[25] https://www.k6k.ee/oskaosaleda/planeeringud/uldplaneering/yp-alates-juuli-2015

MP Step 1 - initiating planning

The MP is initiated by the local government[26]. This step does not focus on the content of the actual plan, but it establishes the frameworks needed for the decision-making process, such as a schedule, action plan etc. The exact content of the plan will be established during the next steps.

MP Step 2 - Planning

In the Planning steps, the MP is prepared[27]. This means that the content of the MP is developed, which includes determining the principles of spatial development, the locations of roads and streets, as well as the construction and use conditions of land areas. At the same time, the local government must take into account the results of the Strategic Environmental Assessment (SEIA) carried out when preparing the plan.

The output of the planning steps are the maps and text part of the MP, which explains the land use conditions that are determined by the MP. Together with the maps, it forms a unified whole.

This step is executed by the planner of a local municipality or it is outsourced to a private consulting company. Besides that, the local government is obligated to involve interested persons.

MP Step 3 - Public display of the draft plan

In this step, the draft version of the MP is presented to the public[28]. Interested parties can familiarise themselves with the planning tasks and possible solutions on the website of the local government, in the physical location of the municipality or city, and express their opinion about them.

The purpose is to provide an overview of the planned development as accurately as possible and to collect initial views on it.

The solution in this step is neither final nor complete, as a more comprehensive planning solution will be developed after the discussion in the next step. It's also not the last public display, after the planning and acceptance at least one more public display will be organised. The public display of the draft solution could be combined with the display of the SEIA.

MP Step 4 - Public discussion of the draft plan

For the public discussion of the MP draft solution, an event is organised by the municipality or city government, in which (after the public display) the fundamentals of the possible alternatives of the planning solutions are displayed, together with the solution already presented in the previous step[29].

The views and objections presented during the public display and the discussion of the draft solution must be taken into account by the planner when preparing the final plan, but only if they are justified.

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[26] https://www.k6k.ee/oskaosaleda/planeeringud/uldplaneering

[27] https://www.k6k.ee/oskaosaleda/planeeringud/uldplaneering/uldplaneeringu-koostamine

[28] https://www.k6k.ee/oskaosaleda/planeeringud/uldplaneering/lahteseisukohtade-ja-eskiislahenduste-avalik-valjapanek

[29] https://www.k6k.ee/oskaosaleda/planeeringud/uldplaneering/lahteseisukohtade-ja-eskiislahenduste-avalik-arutelu

MP Step 6 - Acceptance of the plan
In this step, the municipality proposes an accepted planning solution, but the final decision regarding the solution of the plan will be made only after the subsequent public display and discussion[30].
Before adopting the plan, the local government must also receive approvals for the plan from other institutions and representatives of public authorities (depending on the case, for example, the Technical Supervision Board, the Rescue Board, the Environmental Board, etc.) that the plan is in accordance with the law.
Accepting the plan does not mean establishing it (making a final decision)! The final planning solution must be clarified only in the discussion between the local government and residents following the adoption (as a result of the public display and discussion).

MP Step 7 - Public display of the plan
In the public display of the MP, the materials of the plan that is adopted by the local government are displayed publicly, on the municipal website and in public places[31].
In this step, citizens can present their written views for the last time before the public discussion and the subsequent final establishment of the planning solution.

MP Step 8 - Public discussion of the plan
The planning solution and its current procedure, as well as the views presented during the previous public display, will be presented once again at a public discussion[32].
At the public hearing, there is an opportunity to ask for additional explanations and to express your opinion regarding the planning solution. If objections were raised to the plan during the public display or they were raised during the discussion itself, solutions will be sought during the discussion.

MP Step 9 - Adopting the plan
By adopting the MP, the local government confirms the principles set out in the plan and the conditions for the use and construction of land areas[33].
With the adoption of a new plan, the previous MP will be replaced, and from its establishment, the MP will become mandatory for detailed plans and design conditions - it must be taken into account both when reviewing new detailed plans and design conditions, as well as when preparing them.
After the establishment, the planning procedure has ended and it is no longer possible to present views on it.

Detailed plan
Detailed planning (DP) determines how one or more plots of land can be used in more detail, including whether and under what conditions it is permitted to erect buildings on the plot[34]. It is a document established by the local government, which consists of a map and an explanatory letter.

[30] https://www.k6k.ee/oskaosaleda/planeeringud/uldplaneering/uldplaneeringu-vastuvotmine
[31] https://www.k6k.ee/oskaosaleda/planeeringud/uldplaneering/uldplaneeringu-vastuvotmine
[32] https://www.k6k.ee/oskaosaleda/planeeringud/uldplaneering/uldplaneeringu-avalik-arutelu
[33] https://www.k6k.ee/oskaosaleda/planeeringud/uldplaneering/uldplaneeringu-avalik-arutelu
[34] https://www.k6k.ee/oskaosaleda/planeeringud/detailplaneering

Building permits for the construction of buildings and facilities are issued on the basis of the conditions specified in the DP. The DP must generally be based on the general plan of the municipality or city , but in exceptional cases it may also contain a proposal to change it. In order to prepare a detailed plan, the local government carries out a procedure, which in certain cases may also include an environmental impact assessment, a Strategic Environmental Impact Assessment (SEIA). If a SEIA is carried out, the DP process follows the procedure of master planning[35]. If SEIA is not carried out, the procedure consists of several detailed steps, which are simplified into the following procedure[36]:

1. Initiating planning
2. (Preparation of) Planning
3. Public display of (draft) DP, if *necessary*
4. Acceptance of the DP
5. Public display of the DP
6. Public discussion of the DP
7. Adoption of the DP

Figure 8: High-over steps of the Estonian Detailed planning process.

Step 5 and step 6 may be waived if all opinions were considered or no one expressed an opinion in writing at the time of the display.

DP Step 1 - Initiating planning

The DP is initiated by the local government[37]. By initiating the DP, decisions regarding the content of the plan are not made yet, but frameworks for the decision-making process are established, like a schedule, action plan, etc. The exact content of the plan will be discussed and established during the next steps.

In this first step, the local government decides whether it is necessary to carry out a strategic environmental impact assessment (SEIA) or not. The SEIA must be carried out if an activity with a significant environmental impact is planned.

Participants in this step are the local government and someone who is interested in planning.

Information about initiated detailed plans should be available on the website of the local government.

DP Step 2 - (Preparation of) Planning

In the second step, the content of the DP is developed[38]. This includes defining more precise conditions for buildings on the plot(s), like the maximum size of the area of the buildings, the permitted height of buildings, etc. If the SEIA is carried out before this step, the local government must take the results into account when developing the DP.

[35] https://www.k6k.ee/oskaosaleda/planeeringud/detailplaneering/dp-alates-juuli-2015
[36] https://planeerimine.blogi.fin.ee/wp-content/uploads/2021/05/2020_12_01_DP_kohane_KSHta_EN.pdf
[37] https://www.k6k.ee/oskaosaleda/planeeringud/detailplaneering/detailplaneeringu-algatamine
[38] https://www.k6k.ee/oskaosaleda/planeeringud/detailplaneering/detailplaneeringu-koostamine

This step is executed by the planner of the local government, but it can be outsourced as well. Local governments have the obligation to involve interested persons in this step, but the law does not contain exact requirements for informing the public in this step. They have to respond within 4 weeks after receiving someone's opinion. Therefore, citizens or interested parties could participate in this step as well.

DP Step 3 - Public display of draft DP, if necessary

In this step, the draft solution of the DP is presented to the public[39]. The proposed DP is presented to concerned persons and bodies for approval and the public in general is invited to present opinions. Based on these opinions and approvals, adjustments to the DP are made if needed. In this step, the three-dimensional illustration of the DP should be paid attention to in the public display stage already.

DP Step 4 - Acceptance of the DP

In this step, the plan is accepted which means the local government proposes to discuss the plan in this form[40]. Before accepting it, the local government must also receive approvals for the plan from other institutions and representatives of public authorities that the plan is in accordance with the law. Who needs to give approval depends on the case, this could for example be the Technical Supervision board, the Rescue Board or the Environmental Board.

Accepting the plan does not mean establishing it. The final planning solution is clarified only after the whole process has been completed.

Participants in this step are the local government and other institutions or representatives of public authorities that should give approval. The public cannot participate in this step.

However, the outcome should be published so it is known for the public when to respond. Acceptance and publication of the plan will be announced on the municipality's or city's website no later than 1 week before the public display.

DP Step 5 - Public display of the DP

In this step, planning materials (like maps, explanatory letters, other materials) that are adopted by the local government (so accepted in the previous step), are publicly displayed (on the website of the local government, in public places) and opinions, suggestions and objections are collected[41].

Citizens can present their written positions for the last time, before going to the last steps of the process. They can address whether they want something different and what (view and objections). This step is only mandatory if written positions have been presented during the display or if the detailed plan seeks to change the basic solutions of the general plan. This step lasts 2 weeks, but 4 weeks in case it changes the master plan.

Documents are presented for the public and displayed at the local government, so in the centre of the municipality or city and on the website. The local government must respond to the written position within 4 weeks after the end of the public display.

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[39] https://planeerimine.blogi.fin.ee/wp-content/uploads/2021/05/2020_12_01_DP_kohane_KSHta_EN.pdf

[40] https://www.k6k.ee/oskaosaleda/planeeringud/detailplaneering/detailplaneeringu-vastuvotmine

[41] https://www.k6k.ee/oskaosaleda/planeeringud/detailplaneering/detailplaneeringu-avalik-valjapanek

DP Step 6 - Public discussion of the DP

In this step, the planning solution and its current procedure, as well as the positions presented during step 4, will be presented once again[42]. At the public hearing, objections are collected and solutions for them are found. Besides the local government and the citizens, the county governor could also take a role as mediator if there is a disagreement.

In the event that the county governor finds that the plan is in conflict with the law or other legislation or with other planning, he may refuse to approve the plan, and in this case the local government cannot establish the plan.

If the views presented by the citizen were taken into account by the local government and therefore the basic solutions of the plan changed, the local government must organise a new public display and discussion . The citizen has the right to take part in them and also present new views if they wish.

DP Step 7 - Adoption of the DP

In this step, the local government confirms the principles and conditions stated in the plan, including the requirements regarding construction[43]. With the establishment of a new plan, the previous DP will be replaced, and building permits and use permits issued for construction on the plot must be based on this DP.

After the adoption, the planning procedure has ended and it is no longer possible to present views on it.

SEIA - Strategic Environmental Impact Assessment

The strategic environmental impact assessment (SEIA) is part of the planning procedure and provides information on what effects may be associated with the land use determined on the basis of the plan[44]. During the SEIA, the expert collects information about the environmental condition of the planning area and assesses how the planned land use may affect the living environment. For example, how would transport flows change, how would noise and air pollution decrease or increase, whether enough green areas would be preserved, how could planning affect the availability of services and economic development, et cetera. The purpose of the SEIA is to identify a balanced and sustainable development-supporting planning solution that takes into account different interests.

How SEIA is performed

Ideally, the SEIA goes hand in hand with the process of the planning solution. This means that when developing different alternative solutions, the environmental impact they may have should be assessed on an ongoing basis, and based on this, alternatives should be changed or choices made between them.

[42] https://www.k6k.ee/oskaosaleda/planeeringud/detailplaneering/detailplaneeringu-avalik-arutelu
[43] https://www.k6k.ee/oskaosaleda/planeeringud/detailplaneering/detailplaneeringu-kehtestamine
[44] https://www.k6k.ee/oskaosaleda/planeeringud/keskkonnamojude-strateegiline-hindamine

In the SEIA procedure, several roles are involved. The organiser of the preparation of the plan is responsible for the procedure. This is the county governor in case of county planning and local government in case of master and detailed planning.
The environmental impacts are evaluated by an expert. This is checked by the supervisor of the Environmental Protection Agency. Besides that, interested persons (like a developer who wants to draw up a plan, or a company that wants to build a commercial building) can be involved.

2.2.1 Software and systems used in the planning process

Different software is or has been used in the Estonian planning process. This subsection describes the relevant systems and how they are being used.

RPIS and PLANIS
RPIS (Ruumilise planeeringu infosüsteem) was the Spatial Planning Information System, built in 2009[45]. The goal of this information system was to unify information systems with planning data, compare plans with map layers, provide a place for open communication and visualise planning work so understandable for everyone.
It was built because of several bottlenecks that were identified in the planning process of that time. One of them was that public display was not popular, because the public has to read long explanatory letters and if they have feedback, an email is expected. A second one is that plans have to be coordinated by several authorities, which often results in a long correspondence and a lot of administration.
Although the goals were clear, the system did not succeed in implementation at municipalities. At the end of 2018, only four municipalities used RPIS. A reason for this could be that although the system was quite complex itself, the planning process remained too complex as well. Another reason was that private sector companies provided systems with the same or more functionalities than this system.
RPIS is currently not used anymore and will be replaced by planeeringute menetlemise infosùsteem (hereafter PLANIS). PLANIS will be part of the new e-construction platform, together with PLANK. A lesson learned from the development of RPIS is that the introduction of a new software solution should make the overall process easier, not more complex.

PLANK
PLANK is the database of established plans in Estonia. It contains plans in their digital form and it is possible for everyone to retrieve all valid plans available quickly and from one place. The goal of PLANK is to reduce the burden on municipalities, ensure the up-to-dateness of plans, and create a solution for the cross-use of planning data with other information systems, such as the Land Board's applications and the Building Register[46]. PLANK was introduced in October 2022 and since November 1 2022 it is mandatory for all municipalities to submit their established plans to PLANK[47].

[45] https://www.err.ee/925762/miljon-eurot-neelanud-infosusteemi-ei-kasuta-peaaegu-keegi
[46] https://rmit.ee/uudised/planeeringute-andmekogu-esimene-samm-valdkonna-digitaliseerimisel
[47] https://planeerimine.ee/digi/plank/

Future of PLANK

E-construction - In the future, PLANK will be part of PLANIS, the planning procedure information system. The development of PLANIS will start in 2024. PLANK and PLANIS have as target groups both planners, municipalities, real estate developers, citizens and other organisations.

Automatic validation in PLANK

PLANK includes automatic validation checking on plans. A plan with errors cannot be submitted. A result of this is that only validated plans are shared and shown in PLANK. For this validation, business rules have been set up that are based on the law.
This automatic check returns a .xlsx file with 6 columns, namely Level, error, Message, Layer name, Object id, Comment.
An example of what the automatic check returns is how much overlap there is with another Master plan and how much overlap there is. Another example is the message that the planning area is not entirely located in the territory of the municipality organising the compilation. The error has come from comparison with the county planning.

Files

The files section consists of different types of files. You can select to download them individually or all at once in a ZIP file.
The following sections in files exist here:

- Explanation letter
- Representations of drawings
- Digital layers
- Legal basis
- Digitally signed plan
- Extra's, like a SEIA report

EHR

The EHR (Riiklik ehitisregister) is the national building register of Estonia. The purpose of the building register is to store, provide and disclose information about planned, under construction and existing buildings and related procedures. The building register is freely usable by everyone and serves as a working environment for local governments when processing documents related to construction[48].
In the EHR, design conditions can be found for the planning. Files for a construction project are uploaded to the building register as .pdf. Some of these file documents are publicly available, but most of them are authorised.
There are manuals available on how to use the EHR, but also on how to use the 3D Twin, how to prepare for loading an IFC model into the 3D twin, and how to upload a construction project to the building register.

[48] https://ttja.ee/ariklient/ehitised-ehitamine/ehitisregister-ehr

2.2.3 Previous Research

For the Estonian e-construction platform, in line with the development of digitised systems such as EHR, PLANK and PLANIS, extensive research has been carried out in light of these developments.

In the research of Kaleem Ullah, BIM is identified as a key element in the digitization of the construction industry, with benefits such as time and cost savings, improved quality, and enhanced collaboration. Concurrently BIM can play an important role in the building permit processes, as currently most building permit processes in Europe are considered to be subjective, error-prone, and time-consuming. Using BIM, part of this process has potential to be automated. For doing this translating laws and regulations into machine-readable form is necessary, although challenging. Next to technological issues, readiness of organisations and the building industry is necessary to adopt the use of BIM in the permit processes. This can be challenging. Education, training and willingness to change are needed[49]. For BIM adoption, technological, organisational and environmental drivers are identified, including perceived usefulness of BIM, management and organisational support, financial resources and clients demand or mandate. However there are also impediments which hinder the adoption of BIM, including the complexity of BIM, a lack of support, a lack of funding and no mandate for BIM[50]. Although the previously referred to research focuses on the adoption of BIM in the construction industry, and for the use of building permits, similar points can be taken into account when designing the prototype solution.

When using BIM in Estonian construction and the permit process the absence of a unified description for building elements is identified. Existing agreements on building element descriptions are often based on stand-alone systems, leading to difficulties in transferring these descriptions through various stages of a building's lifecycle and among different participants. Recognizing this problem, a solution emerged in the form of a Construction Classification International (CCI)[51]. This collaborative effort involved close cooperation with Sweden, Denmark, the Czech Republic, and Finland, aligning with international standards such as ISO 12006-2:2015[52] and ISO 81346[53]. The CCI aims to provide a standardised classification for building elements, offering a seamless and consistent description from design to demolition, across diverse stakeholders, and adhering to international standards. The outcome is an information model, ensuring that each building element, whether material or immaterial, is assigned a code during the planning process and updated throughout its life cycle. It is not covering spatial planning at the moment, although it aims to do that as well.

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[49] https://digikogu.taltech.ee/et/Item/8d451da3-63a5-4ba4-ad2d-7f180a988b8c
[50] https://www.researchgate.net/publication/372505988_BIM_Adoption_Processes_Findings_from_a_Systematic_Literature_Review
[51] https://cci-collaboration.org/
[52] https://www.iso.org/standard/61753.html
[53] https://www.iso.org/standard/75471.html

In 2020 CGI performed an analysis of the current planning process for MKM and RAM[54]. The analysis was focused on possibilities in unifying the planning process, with specific attention to technological possibilities and user friendliness. The analysis emphasised the current variety in planning systems amongst local governments, stating that 26 out of 79 local governments have some kind of information technology solution or self-created information system for processing plans or storing data. Because of the difference (or lack of) information systems a high proportion of e-mail exchange or paper-based administration is noted. Through interviewing and workshops with actors from practice, the current AS-IS flows are presented, and desired TO-BE diagrams are constructed. A cost-benefit analysis was carried out which estimated that improvements according to the description of the TO-BE diagram would increase the satisfaction of participants in the planning process by 59,4%. The largest improvement would be the introduction of a unified planning system, and transparency in the planning process. Additionally possible savings would include 190 working hours, more than €2,600, in the process of one detailed plan by the introduction of a unified planning system, and 370 working hours in the process of the Master Plan.

Concurrently in 2022 a preliminary analysis has been carried out for the functional requirements of the planning procedure information system (PLANIS) and the definition of reuse possibilities of e-construction components[55]. In this document minimal functional requirements, and additionally non-functional requirements, are stated for the introduction of a unified planning system. The need for existing registers to be interoperable are emphasised, with the principle that new services can be used by other e-construction services when needed.

2.2.4 PlanBIM Pilot Projects

Two pilot projects are considered as input for the prototype solution. The National Broadcasting Building and the Tallinn Harbour Area.

National Broadcasting Building

The planned Estonian National Broadcasting Building is located in F. R. Kreutzwaldi 14. The detailed plan is made in relation to already existing buildings. The official detailed plan is registered in the planning registry of Tallinn[56]. The detailed plan registry contains the documents belonging to this detailed plan, including a 2D Map of the detailed plan.

Additionally to the detailed plan documents, a concept 3D Detailed Plan has been made. This detailed plan consists of multiple IFC's, with a distinction in land use, i.e. greenery, buildable area and transportation. It should be noted that these IFC's have considerably less level of detail than more common architectural designs of buildings in the AEC industry.

[54] https://planeerimine.blogi.fin.ee/wp-content/uploads/2021/05/mkm_rm_planeeringud_menetlus_arianalyys_l6pparuanne.pdf
[55] https://planeerimine.ee/wp-content/uploads/Nortali_analyys.pdf
[56] https://tpr.tallinn.ee/DetailPlanning/Details/DP045040

The 3D Detailed Plan consists of volumes of the IFC entity 'BuildingElementProxy', which contain a small amount of attributes, for example, the max building height. The greenery elements are more detailed, although it should be noted that these greenery elements are not planned in that detail, it is a presentation of a possible interpretation of the greenery elements.

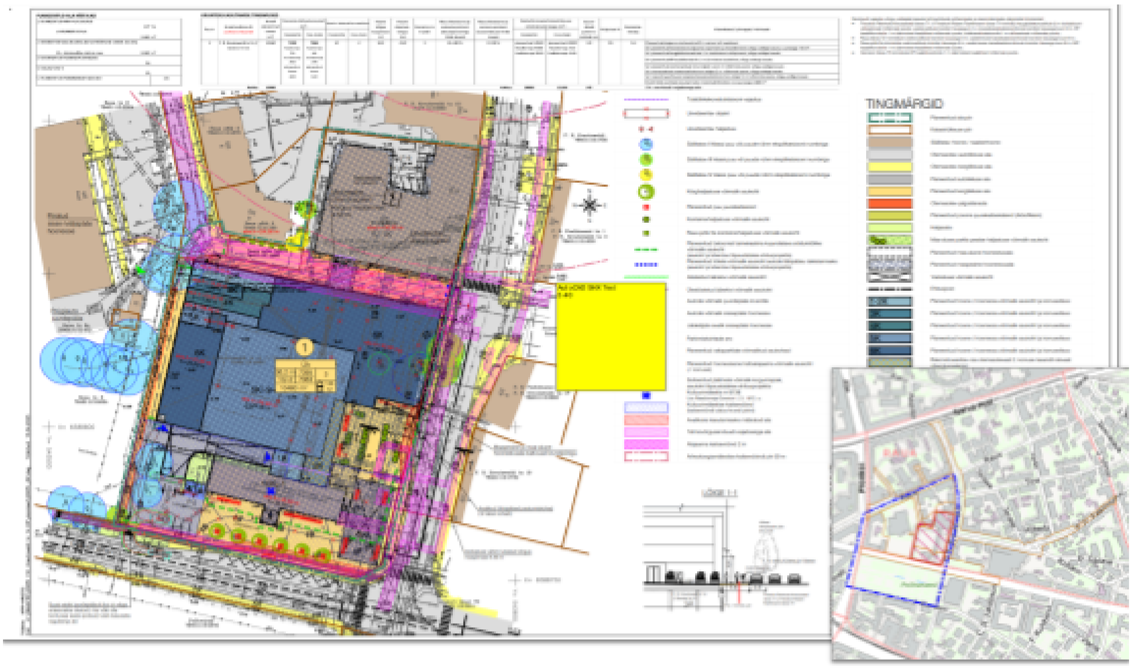


Figure 9: Detailed Plan map of National Broadcasting Building and Detailed Plan Area

Next to the detailed plan IFC's, a design of the planned building is available as an IFC file. The detailed plan has to comply with the underlying master plan. However, currently there is no digitised master plan available.

Figure 10: Visualisation of the 3D Detailed Plan combined with 3D Data of the City of Tallinn

Harbour area

The Tallinn Harbour area is a large area to be developed in the City of Tallinn. Next to original detailed plan documents, an elaborate 3D detailed plan is made. This detailed plan consists of multiple IFC's, with distinctions in areas and land use. The large scale of the area makes it interesting, also to use it to check for requirements inside the detailed plan. In comparison to the 3D detailed plan of the National Broadcasting Building, the Harbour area IFC's also contain mainly BuildingelementProxies and a limited set of attributes.

Suitability of the pilot projects

The detailed plan data is suitable for the use as a test case in the solution design, with the following remarks.

There are not yet industry standard IFC-entities that represent planning elements. Therefore BuildingElementProxy is used. However it is advised to use BuildingElementProxy as little as possible, and where possible look or push for alternative entities which better describe the contents of the entity.

The attribute data in the detailed plans is limited, but according to the requirements stated as attachments in the regulation No. 50 "Requirements for planning formalisation and structure"[57]. During the coming development of the solution prototype there should be attention to clarifying needed attributes, in relation to the to be developed checks.

To check if the detailed plan is compliant to the master plan using automated checks structured master plan data will be required. However currently two issues have to be addressed. Firstly the master plan underlying the pilot detailed plans is only partly available, and the downtown planning is in preparation[58]. Secondly it is not yet decided on the requirements of the master plan data as input for the automated checks. The creation of the master plan data, concurrent with a first concept of how tha master data should be structured, is to be addressed during the development of the prototype solution. A building design in IFC of the National Broadcasting Building is available, and can be used to compare a building design against the detailed plan.

[57] https://www.riigiteataja.ee/akt/121102022001
[58] https://tpr.tallinn.ee/GeneralPlanning

2.3 International best practices for planning information modelling

This chapter will give an overview of international best practices regarding the usage of automated checks in relation to 3D and BIM. First the two most prominent European research projects regarding automation in compliance checking are addressed: ACCORD (in which Estonia is also participating) and CHECK. The ACCORD project focus is mainly on buildings and building permits, not on zoning plans, in that regard the CHEK project is of interest. After that an overview of the practices in various countries is given, including mostly European countries. When reviewing the different countries, the information available about planning information models turned out to be scarce. Therefore, the focus in the review part can be found on BIM projects, as often countries use BIM to execute pilot projects.

2.3.1 International developments

ACCORD

The ACCORD project is an EU-funded Horizon Europe Project aimed at automating the building permitting and compliance. The project spans from 2022 to 2025 and includes a variety of european private and commercial partners, including the Ministry of Climate in Estonia and Future Insight.

Main focuses of the project are: creating a rule formalisation tool, allowing formalisation of regulations into a standardised rule representation format; storing the rules in a ruleset database; building Compliance Checking Microservices supporting various use cases. All these elements should be accessible through open standardised APIs to allow integrated dataflows between building permitting, building compliance, and other information services.

To display and test the ACCORD framework four demo projects are set up for the ACCORD project. These demo projects address use cases in the UK, Spain, Germany and Finland and Estonia. Most of the demo projects are focused on automated BIM-based building permits, with special attention to environmental compliance. The German demo however includes the investigation of land use permitting. For this they are investigating the use of XPlanung data[59], an XML/GML-based data format zoning plans, comparable to Estonian Master Plans.

For the planBIM project the ACCORD framework is interesting, especially the web-based approach, communication through APIs and related concept of checking (micro-)services. The concept of a checking (micro-)service is a service, approachable through API, which checks a BIM on one or multiple requirements, using other information services when needed. Using this framework it allows for multiple parties to develop check (micro-)services based on their expertise, for example CO2 emissions. Ultimately all check results will be combined. Additionally the ruleset database can be of interest, to store and approach a standardised rule-format.

[59] https://xleitstelle.de/xplanung/ueber_xplanung

The development of the prototype is advised to be in line with the ACCORD framework, however keeping in mind that the ACCORD project is still running and the framework is not yet realised. Moreover, the ACCORD projects focus mainly on buildings and building permits, not on zoning plans. In that regard other EU-projects such as the following discussed project CHEK are of interest,

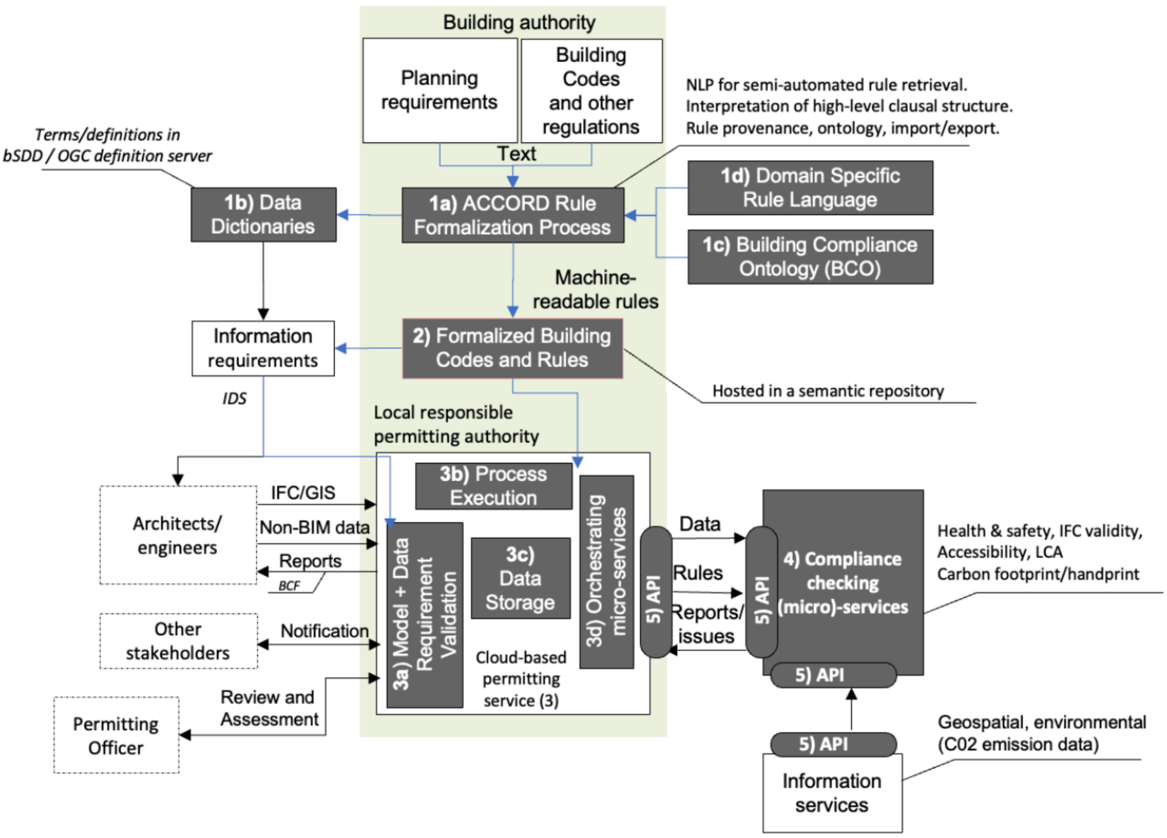


Figure 11: The ACCORD framework[60]

CHEK

The Change toolkit for digital building permit (hereafter CHEK) project is an innovation and research EU-funded project that will provide an innovative toolkit supporting the digitalization of building permit issuing and automated compliance checks[61]. It is a 3 year project that will finish on the 30th of September 2025. The consortium consists of 18 multidisciplinary and multisectoral coverage (research, software development, design, construction, municipalities, and standardisation) entities from 12 countries in Europe.

Building permits ensure high quality in buildings and city development, realised through the compliance to city regulations. Such regulations foster European priorities such as sustainability, beauty and citizens' safety and well-being, in line with the Renovation Wave Strategy.

60 https://accordproject.eu/wp-content/uploads/2023/09/ACCORD_D1.2_ACCORD-Framework-and-User-Requirements-Specification.pdf

61 https://chekdbp.eu/

The aim of CHEK is to take away barriers for municipalities to adopt digital building permit processes by developing, connecting and aligning scalable solutions for regulatory and policy context, for open standards and interoperability (geospatial and BIM), for closing knowledge gaps through education, for renewed municipal processes and for technology deployment in order to reach TRL 7. CHEK will do this by providing an innovative kit of both methodological and technical tools to digitise building permitting and automated compliance checks on building designs and renovations in European urban areas and regions. This will lead to an efficiency improvement of 60% and will lead to the uptake of DBP by potentially 85% of municipalities in Europe. The results will be demonstrated in the working environment of municipalities and designers.

The ambitions of CHEK include: A completely re-designed organisation model will be implemented in the municipalities, in order to shift to a new agile data-driven and digital-based organisation. Secondly CHEK aims to bring a series of innovative tools, coordinated by a web platform with external connection through OpenAPI based, that will support designers and technicians during the permitting process, improving effectiveness, shortening times and costs for the overall process, and resulting in less errors. Additionally a game-changing innovation will also be brought into (up/re-)skilling: it will be the first time that such interdisciplinary knowledge, related to DBP, is systematised, coordinated and structured by a balanced multidisciplinary team. Lastly, an ambition is that CHEK will allow modelling specifically formed BIM and 3D city models starting from a clear definition of Regulatory Information Requirements, translated into IFC and CityGML specifications.

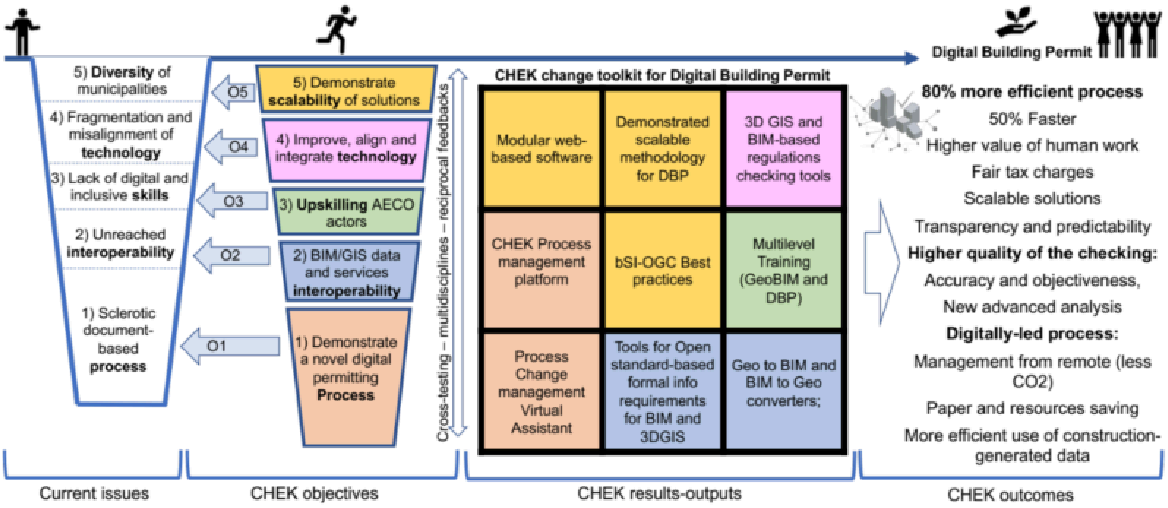


Figure 12; CHEK Methodology[62]

2.3.2 Review per country

This chapter will give a review per country on the developments of international best practices regarding the use of planning information models (BIM and 3D) in the building industry. It differs per country how far they are and what can be learned from them regarding this project. Therefore, taking a look at the practices of these countries will teach us how to best create a prototype and what to think about.

[62] https://vandenbergbouwkundigen.nl/en/expertise/research-and-development/bim-standards

The Netherlands

The Dutch Planning process, similar to the Estonian planning process, consists of a national plan, county plan (provincial plan), and local plans. Additionally thematic plans can be made, and areas for protection, such as nature areas or heritage areas, are in place. Dutch planning data has been standardised according to the Dutch Information Model Spatial Planning (IMRO) standards. Governments are required to register their plans in a national database, available through a public website (ruimtelijkeplannen.nl). Even though this standardisation has highly been adopted, the standard is broad and limited usable for checks. Concurrently it is not being used for checks. The main issue which hinders checking, is the fact that the plan is accompanied by written text, in which the requirements are stated. Hence many requirements are still written. For example, it could be stated that high rise is not permitted in the main street, but this requirement is written text and not geographical data of the street.

National standards manage and provide information regarding open BIM standards. Dutch Revit Standard (DRS), a project of Dutch Revit User Group (RevitGG), is one example of open BIM standards. A BIM agreement will be recorded and maintained through the National Model Document by project partners to ensure that the BIM protocol requirements and conditions are met[63]. Internationally recognized ISO standard is regarded worldwide as the standard for managing digital information and the life cycle of construction works, in combination with BIM.

There is no legal requirement or mandate for the adoption of BIM in the Netherlands. Government support has been provided by establishing a BIM Gateway ('BIM Loket') to provide a single point of reference for a wide range of stakeholders in the industry. Maintaining projects using open BIM standards can be reduced by having a single reference point[64]. BuildingSMART shares a BuildingSmart Benelux with Belgium and Luxembourg. It is important to note that a number of features of the buildingSMART Data Dictionary are similar to those of the IFD International Framework for Dictionaries[65].

A large initiative has been made to change the multiple planning laws and underlying ict-systems into one large law, the 'Omgevingswet'. This law, and its underlying ICT-system (DSO), would require planning data to be more object-oriented, and open doors for automated checking. However the introduction and implementation of this law has been controversial. In 2020 implementation was postponed by the Ministry for Environment and Housing due to the outbreak of COVID-19.[66] In the following years the implementation has been delayed multiple times as the ICT-system was criticised for not being ready for production use, not being tested sufficiently and not having enough support from municipalities who have had trouble preparing to adopt their current processes and ICT-systems to the new law.[67] Now the official date 1 January 2024 is definitive.

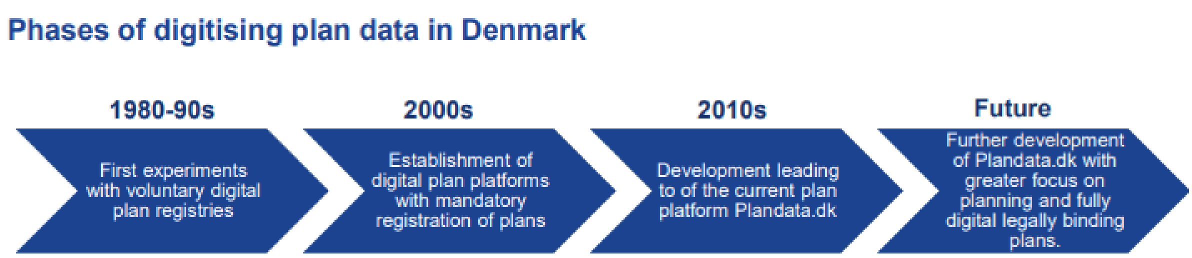
[63] https://vandenbergbouwkundigen.nl/en/expertise/research-and-development/bim-standards
[64] https://www.letsbuild.com/blog/bim-loket-dutch-bim-gateway
[65] https://www.buildingsmart.org/chapter-directory/
[66] Implementation Omgevingswet postponed
[67] Invoering van de Omgevingswet

Concerning the adoption of BIM in the Netherlands, the construction industry is often using BIM modelling, especially with high rise. Some municipalities of bigger cities are also using BIM, mainly for infrastructure projects. Additionally some innovative parties, including housing corporations, hospitals and airports, are using BIM for their asset management.

However, even though municipalities are curious on how to use BIM in for example permit processes, a lot is still unclear and with lack of funding or mandate, a lot of current processes are still paper or pdf-based. Organisations who seek standardisation, and a lot more organisations are finding each other and start making agreements with each other. So there is promise.

Denmark

From the 1980s (starting with Planregistret) until today, Denmark has been developing digital plan data. A common national platform for plan data, Plandata.dk, was established where all official and legally binding plans from the national and local level are downloadable digitally in the form of pdfs or as geodata (direct in the portal or WMS/WFS). It is freely available with access for all in one place (dictated by the Danish Law on planning). This happens on a largely voluntary basis and facilitates municipal workflows, simplifying the submission of plans to the state, assigning geography on all plans in order to identify plan boundaries. The geodata is only used as a cartographic representation of the plan and is not legally binding. As plans differ, the digitalisation ranges from general strategic orientation to cartographic representation of binding and not binding elements, Most municipalities also have their own geoportals showing their digital plan data. There has been a shift to using the data for several purposes in the last years, and showing the benefits of that is important to get as many as possible on board in the digitalisation journey. Earlier the Danish Business Authority was responsible for the planning and development of digital plan data, but on the 21st of January 2021 the planning department was transferred to the newly established Danish Housing and Planning Authority (Da: Bolig- og Planstyrelsen) under the new Ministry of the Interior and Housing (Da: Indenrigs- og boligministeriet). Resulting in a more central place for the planning department, closer to other planning authorities, for example working on building permit processing integration. Hopefully this means the digital plan data's use will be widening to new areas.[68]



[68] DIGIPLAN (espon.eu)

The first country to ever mandate BIM (for their state clients) back in 2007 was Denmark[69], they have since made it mandatory for other projects too. For over a decade, Denmark has mandated its state clients (from Ministries to Universities) to adopt BIM practices both for new construction projects and restoration of already existing buildings. Since 2011 BIM is mandatory for all local and regional projects costing more than EUR 2,7 million and government buildings starting from a volume of EUR 677.000. Since 2011, the Danish Building and Property Agency has been responsible for the ICT regulations state requirements for the use of BIM – Building Information Modeling - and the open source IFC standard. The Danish Building and Property Agency have gathered practical experience with BIM in construction projects in the past 10 years and conclude that the ICT regulations actually have changed the industry where BIM has become part of the daily work routine for many consultants and contractors. It seems BIM pays off, as large Danish contractors are hiring and developing their BIM practice, and it was found that BIM models enable better coordination in projects, especially when combined with an efficient digital quality assurance. Better data for operations and maintenance is both an opportunity and a challenge, and the Agency will focus on this data for the years to come. Open standards are the absolute foundation for usable data, now and in the future.

Some of the most important projects using BIM practices in Denmark, that are worth to be mentioned, are[70]:

- The New Hospital Bisperbjerg in the City of Copenhagen. The new structure is a major merger between the Frederiksberg Hospital and the already existing Bisperbjerg Hospital. The new super hospital, which is scheduled to be in use by 2023, must operate at full capacity during the whole construction works.
- The Ringsted-Fehmarn rail link project was initiated by Denmark and Germany to connect the fixed link across the Fehmarnbelt by 2021. The Ringsted-Fehrman rail link is expected to improve the infrastructure linking Scandinavia to the rest of Europe and will reduce travel time between Copenhagen and Hamburg. The project will be managed by the Danish state-owned railway company Banedanmark.

Finland

Knowledge management has become a central approach by which Finnish society and public administration at all levels seek more efficient and effective ways of providing public services. A change towards information model-based planning is driven by national development programs. There is a transition ongoing towards Information Model based planning to achieve national-level interoperability of plan data, driven by governmental programs, During 2020 a nationally interoperable information model for master and detail plans was developed for use in future municipal urban planning, consisting of a conceptual data model, terminologies and harmonised code lists (e.g. zoning regulations). In addition a national information system for the build environment data is currently being developed.

[69] https://en.bygst.dk/construction/digital-construction/

[70] https://biblus.accasoftware.com/en/bim-in-europe-level-of-adoption-in-different-countries-part-3/

Sitra, the Finnish Innovation Fund, has developed a model for the secure and effective use of data called the "Digital Health HUB". The project built a model for encouraging innovation from public-private partnerships where there is a mixed ownership of parallel and partly competing projects; competing institutional logic and principles; a multiplicity of funding arrangements. The objective of the Isaacus project was to enable the data-secure use of well-being data for various purposes. A study was done on planners' opinions on information model-based planning through questionnaires, and it showed different attitudes towards digitalisation in itself and showed discrepancies between planning practices and digitalisation. Concerns about the change were for example about the effect on the needed skills, the workload and the quality of plans, but it also showed hope for more efficiency and smart tools. It was argued that attention must be paid especially to the usefulness and usability of tools, the necessary changes in planners' roles, the valuation of planning information and the structure of the planning process[71].

Studies[72] indicate that the Information Model-based planning has a strong impact not only on planning outcomes (i.e., land use plans) but also on the planning context (e.g., planning practices and the planners themselves, software and information systems (ISs), and planning law). It is important to pay attention to the needed changes in planning culture and practice and the viewpoints of planners on it all, to achieve successful Information Model-based planning. In addition to the technological aspects, the focus should also be on the social and contextual elements of planning.

Finland is one of the forerunners in BIM use and development[73]. They began planning for innovation in the construction industry in the 1950s. Business Finland, a public funding agency, funded research into ICT development in the construction industry between 1983 and 2015, which allowed Finland's development of national and international standards for BIM implementation.

In 2007, the Finnish construction industry required that all design software had IFC certification. Senate Properties, a state property services agency, has required the use of BIM for its projects since 2001. In 2010, Senate Properties championed the use of coBIM. This is a list of guidelines for BIM implementation at a national level. Since its creation, about 500-600 projects have implemented BIM out of a total of 31,928 average building permits issued per year. From the 1st of January 2025 on IFC becomes compulsory for building permits.

There have been several BIM-based Building Permit development projects in Finland through the years[74]:

- 2018-2020: Requirements of new COBIM2020 survey (buildingSMART Finland) What were the needs for OpenBIM process in Finland (Specific requirements for IFC and Use Cases to describe the information delivery process)

[71] https:// research.aalto.fi/en/publications/
[72] https://www.sciencedirect.com/science/article/pii/S2226585622000978
[73] https://www.ouka.fi/oulu/kaupunkisuunnittelu/kaatio-hanke
[74] https://www.bimspot.io/blogs/bim-adoption-nordic-countries/

- 2018: Kiradigi pilot (RAVA1) funded by the Ministry of Environment of Finland. City of Vantaa and City of Järvenpää made some first pilots for BIM-based Building Permit (Gravicon, Solibri and Sova3D was also in Project-team)
- 2020-2021: RAVA2 Project Ministry of Environment of Finland. First National Propertyset for regulatory (minimum) Building Information form BIM-based Building Permit process and first use cases surveys
- 2021-2022: COBIM2020 part 14 Project Ministry of Environment of Finland. First new COBIM part, First National Use Case for BIM-based Building Permit process
- 2021-2023: RAVA3Pro Project Ministry of Economic of Finland and 23 cities. National Propertysets, Use Cases, Checking rules, BIM-based building permit automatic Checking pilots[75]

The government's KIRA-digi Digitalization KIRA-digi digitalization program with over a 100 projects made it possible to submit BIMs instead of 2D drawings for planning applications[76]. It demonstrated how BIM can speed up and improve the building permit process considerably[77].

Over 70% of Finnish municipalities have joined the online service Lupapiste (also called Cloudpermit) that enables digital interaction between citizens, companies, and authorities on built environment permissions. We were happy to work together with Lupaspiste on a RAVA3PRO pilot making the first working digital BIMbased permit checks in Clearly.BIM, with integration through our open API. In RAVA3Pro they also worked with 4D, MEP design.

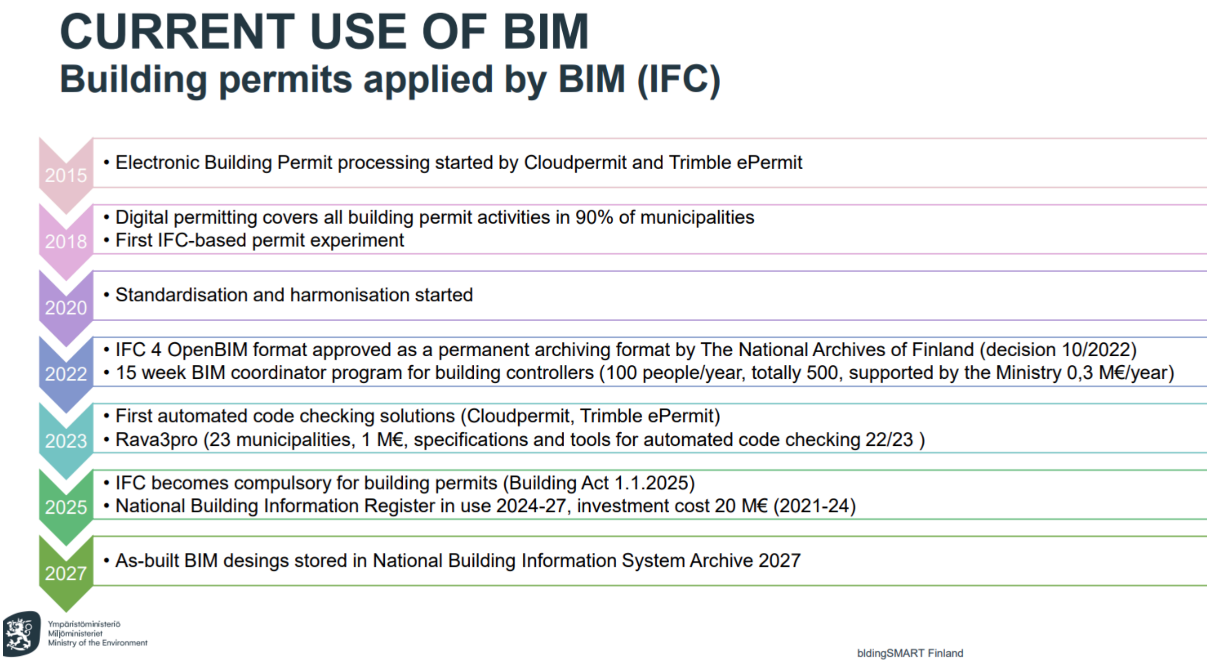


Figure 13: Representation of BIM building permit steps, used for Building Smart 2023 by Rava3Pro [78]

[75] https://kirahub.org/en/rava3pro-en/
[76] https://www.kiradigi.fi/
[77] https://aec-business.com/how-bim-is-revolutionizing-building-control-in-finland/
[78] https://kirahub.org/en/rava3pro-en/

Sweden

In Sweden, municipalities have the main responsibility for planning, and they must have a current comprehensive plan for the whole municipality. Only they have the authority to adopt plans and decide whether a plan is to be implemented. The state & some regions provide frameworks for the municipal and regional level through f.ex. maritime planning, national objectives, claims of national interest and national transportation infrastructure planning. The Swedish planning system consists of the regional plan, the comprehensive plan, the area regulations and the detailed development plan.[79].

Only the detailed development plan and area regulations are legally binding documents; however, the regional plan and the comprehensive plan can be seen as indicating the overall direction of the municipality over a significant time period and as guidance in the development of the detailed development plan and in the permit granting process. The detailed development plan enables the municipality to regulate the use of land and water areas and what the built environment is to look like in a particular area[80]. Detailed development plans are generally prepared when new construction is to be carried out in a dense area and often encompasses one or several city blocks. The detailed development plan regulates what are public spaces, development districts and water areas, and how they are to be used and designed. It may regulate development in more detail — for example, where new buildings must or may be placed, how large or tall they may be, how much distance there must be between a building and the site boundary, and whether anyone may be granted the right to install cables over someone else's land.

Sweden has no cross-sector planning for land on the national level, apart from national-level maritime planning which is regulated in the Environmental Code. Instead, the State provides frameworks for the municipal and regional level through national objectives, identifying claims of so-called national interest and the national transportation infrastructure planning[81]. The regional planning level in Sweden is limited, but does regulate planning in the regions Skåne, Stockholm and Halland. Regional spatial planning is intended to be introduced in additional regions as part of achieving more uniformity in the country.

Sweden's National Board of Housing, Building and Planning is planning to introduce digital permit checks using BIM technology to streamline the permit process and reduce the time it takes to obtain a permit and some relevant studies have been done as to what bottlenecks and possibilities there are.

The Swedish government set up a goal in 2011 of making the best use of digitization opportunities. The digitization of the building permit process has, however, been slow. Application for building permit requires the attachment of drawings and plans, often in PDF format. A number of projects have been done or are ongoing to digitise and automate the planning and building permit process. The *Far jag lov*-project is one of

[79] https://www.boverket.se
[80] https://www.boverket.se
[81] https://www.boverket.se/en/start/building-in-sweden/swedish-market/laws-and-regulations/planning-process/

them whose overall purpose is to develop the general services that the municipalities need to handle the planning and building process digitally. The Auto Control Approach described in *Far jag lov* involves testing rules and requirements from a digital development plan against a digital building BIM-model. The Smart Planning Project (Smart Planering för Byggande) within the Smart Built Environment looked at possibilities to better use 3D models and other 3D data throughout the different stages of the planning and building process[82] was introduced focusing on possibilities to better use 3D models and other 3D data throughout the different stages of the planning and building process. They found three major fields in need of further investigation in the process of transferring from analogue 2D maps to a digital 3D cadastre, and these are the legal matters, the financial aspects, and the technical matters in form of data conversion and visualisation.

Sweden's construction industry has a few small and large companies. Companies that constructed single-family homes were the first to implement BIM up until the mid-2000s. The larger companies started their BIM implementation around 2006 – 2008. Skanska, Veidekke, NCC, some of the largest construction companies in Sweden, have the highest level of BIM competence. These large companies started using BIM for internal housing projects and design and build contracts and they have internal BIM policies and have recruited BIM specialists. Engineering companies are the leaders of BIM adoption in Sweden, they have been open to BIM implementation since 2007. All the major engineering companies have launched projects to define BIM and its use within the construction industry. They provide clients guidance as BIM coordinators and training to other companies. Architect companies began adopting BIM later than the rest of the industry. The larger architecture firms began implementing BIM in 2012. Additionally, clients and project owners have yet to adopt BIM for facility management and maintenance. Some clients demand BIM at a low level, but these are exceptions to the rule.

Norway

The Planning and Building Act (2008) is a tool for safeguarding the public interest and managing land use, ensuring sustainable development and that it is open to all to take part in decisions that concern their surroundings[83]. The Land Registration Act ('Tinglysingsloven, 1935) is about the responsibilities and procedures regarding the registration of documents relating to land. The Cadastre Act ('martikkelloven' from 2005) ensures access to important uniform and reliable land information and to a joint geodetic reference frame in the national register of all real estate in Norway (the cadastre). The Spatial Data Act ('geodataloven' from 2010) on the infrastructure for geographical information promotes good and efficient access to public geographical information for public and private purposes, which is coordinated by a spatial data coordinator. The Ministry may by regulation issue further provisions concerning the duties and organisation of the national spatial data coordinator.

[82] https://diva-portal.org

[83] https://www.regjeringen.no/en/topics/plan-bygg-og-eiendom/plan_bygningsloven/planning/id1317/

Norway has supported the development of BIM standards since 2010 in response to the government's commitment to BIM adoption[84]. Statsbygg published a BIM manual in 2008 outlining the requirements of the Norwegian Homebuilders Association for BIM and IFC compliance[85].

Norwegian standards and guidelines are based on the principle that any requirements defined by Statsbygg for BIMmodels that can be validated automatically should be validated[86]. Numerous national and international standards are available, including a Statsbygg BIM Manual and from the Norwegian Homebuilders Association (advocates housing policies as a national priority). Several ISO standards are in place in the country to manage information during the building lifecycle. Both Statens Vegvesen and Nye Veier (Norwegian directorates of roads and motorways) implement BIM level 3,

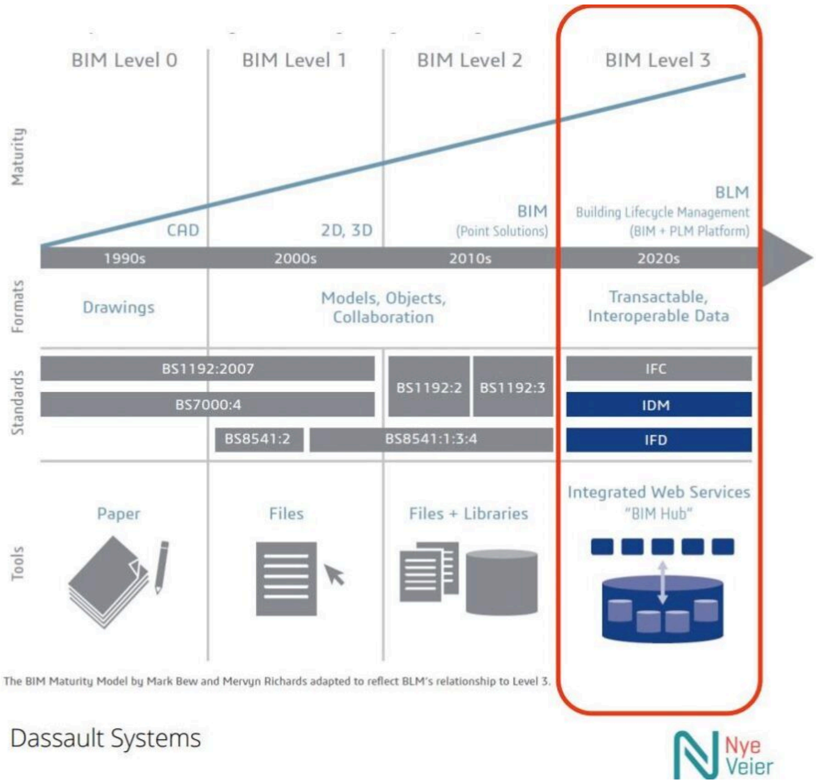


Figure 14: BIM requirements from Nye Veier[87]

Norway used the CORENET research from Singapore to make their ByggSok system, an e-Government system heavily based on IFC Standards, consisting of an information system, a system for e-submission of building applications and a system for zoning proposals. Driven by Statsbygg, DiBK, the Norwegian Building and Construction industry and supported by Standards Norway and Norwegian buildingSMART the work is ongoing and currently focussing on the issues of classification, terminology and standardising rule-checking in construction at an international level.

[84] https://www.iso.org/obp/ui/en/#iso:std:iso:19152:ed-1:v1:en
[85] https://bimcorner.com/9-reasons-why-norway-is-the-best-in-bim/
[86] https://www.labopen.fi/lab-rdi-journal/benchmarking-bim-maturity-level-in-various-european-countries-to-develop-bim-competence-in-finland/
[87] https://bimcorner.com/9-reasons-why-norway-is-the-best-in-bim/

The Direktoratet for Byggkvalitet (DiBK, direktoratet for byggkvalitet) who are working on BIMbased digital permit checks for TEK17 were consulted to give more insight from practice. An important conclusion is that Denmark and Sweden have more qualitative regulations than Norway, and thus Norway should be able to make digital permit checks easier. Also important to mention is that the municipality does the permit checking after the build, but they do want an earlier check to avoid faults and IDS-check. Their goal is that technical requirements for construction must be easy to use and to interpret, they are open for innovation. They see a limited opportunity for automated processes and digital checking of the rules as mistakes are easy and costly and with the current regulatory content it is difficult to digitalise 58000 enterprises. Today TEK is sender focused, they believe it needs more user-focus (building architects). They focus on selecting rules into a menu of: 1. 'Pre-accepted performance levels' (easy to automate), 2. 'A la carte' (standards and design guides), and 3. 'Do it yourself' (analysis of specific requirements to do otherwise but as good as, so flexible). They have been working on how to document requirements (in BIMmodels), creating IDS and to test the BIMmodel. The IDS validation pilots are running now. They are also currently working on changing requirements to make them automatically checkable, for example 'storage food and clothes sufficient' is being turned into must have 'food storage' and 'clothes storage' separately for IFC in a BIMmodel as these storages are rarely in the same room and have to be defined to be able to check them automatically. They have a framework solution for using IFC4 models when delivering digital building permits to the local municipalities[88]. They have to show that it works, using the 'P13' requirements using an app[89].

The Norwegian Directorate of Public Construction and Property, known as Statsbygg is a government client (not a regulator) and project manager for government building projects and facility management of government property[90]. Statsbygg has promoted the use of BIM in all construction projects since 2005, They have put requirements on BIM in all projects since 2011 and have developed their own requirement set for BIMdeliveries. They have been pushing the development by asking for BIMmodel delivery based on a set of requirements (through 'SIMBA 2.1' based on IFC 4 for all new public building projects since 1st of July 2022), using open standards for the validation of BIMmodels against requirements. The standard is well-established and used quite a lot. Building upon their e-PlanCheck pilot projects Statsbygg have experimented with multiple systems as part of their efforts to extend the use of IFC to the entire project life cycle. These systems have been piloted on real projects. They focus predominantly on geometrical constraints. IFC is used for the BIM to be able to digitally check, mvdXML for the requirements to check, and BCF to report differences between requirement and model[91]. They are also following the development of the BuildingSMART standard IDS and whether perhaps this can replace mvdXML[92].

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88 https://www-dibk-no.translate.goog/soknad-og-skjema/vil-du-bruke-bim-i-byggesoknaden?_x_tr_sl=no&_x_tr_tl=en&_x_tr_hl=no&_x_tr_pto=wapp
89 https://github.com/mok-see/valitapp
90 https://www.statsbygg.no/about-statsbygg
91 https://technical.buildingsmart.org/standards/bcf/
92 https://sites.google.com/view/simba-bim-krav/hjem

Statsbygg would be interested in IFC models that can be provided (typically from a service by the central building authority or the local zoning responsible municipality) and that would depict the zoning regulations of the project site, like the volume constraining permitted overall construction heights within the site, permitted construction lines within the site, cadastral border lines (parcels etc), various matriculated zones (cultural heritage) etc. Used in a BIM context one could use such a "zoning models" to check for "100% clash" between the constrained zoning volumes and the designed building, to uncover any deviations (designed building outside of zoning restrictions).

Statsbygg is still using Solibri Office as one of their main BIM expert systems (others being SimpleBIM, dRofus, Anker, BIMQ, BIMcollab, etc), and often also as a BIM viewer. The states infrastructure companies Nya Veier and Statens Vegvesen also use a system that combines 3D models that show above and underground, for tunnels, tracks stations etcetera with dimensioning tools and risk and stakeholders management tools.

Austria (Vienna)

In both Austria and Germany building permits or building approval (AT) are matters for the federal states. However, the state building codes are all different, with nine states in Austria and 16 states in Germany. Nevertheless, they are comparable or even identical in essential points. If an inspection software is to qualitatively check different parameters and requirements, this is only possible with suitable programming that contains all specific inspection parameters and that is always supplemented by updates.

The EU-funded Building Regulations Information for Submission Envolvement (hereafter BRISE) project in Vienna has promising results. Between June and December 2022, 13 planners and architects from Vienna participated in piloting the digital building permission process based on BIM, AI and Augmented Reality, delivering proof that the system is able to achieve significant improvements in real-life building inspection processes[93]. They digitally submitted their BIM-based projects to the relevant authorities in Vienna. The project partners include the Vienna University of Technology, the City of Vienna and the Chamber of Civil Technicians, Architects, and Engineers. BRISE also aims to reduce the bureaucracy of the building inspection process. Approval processes are to become faster and more efficient in the future. The project and completion of the proof-of-concept was in August 2023,

BRISE-Vienna addresses the challenge of accelerating complex verification and permission procedures in city administrations. It can serve as a blueprint for those cities that experience growth and must deal with a high number of building permissions. Vienna has been experiencing continued growth and demand for new housing over the course of the last 20 years. Between 2004 and 2019 the city has been issuing more than 13.000 new building permits per year. Like in other growing cities, today it takes well in average up to 12 months for a planner or an investor to receive a building permission in Vienna. The BRISE-Vienna Project is intended to make full use of the potential of digital technologies to improve the speed of the building verification and permission process. It

[93] https://portico.urban-initiative.eu/urban-stories/uia/piloting-brise-vienna-results-journal-ndeg-3

aims to achieve a strong acceleration and simplification of the entire process by subjecting it to a radical digitization. In short, the following features are brought together to achieve a fast, lean and efficient process:

- Planners and investors will no longer have to submit their building plans on paper, but rather upload their 3D Building Information Model (BIM) in a digital format via the servers of the city of Vienna.
- Based on the application documents the city produces a digital 3D reference model of a generic building which is in congruence with all existing regulations and specifications of the site[94].
- In an automated process the municipal auditor compares the 3D BIM Model of the planner with the digital reference model of the city. By this, he can easily identify deviations from existing regulations and requirements and give direct and quick feedback to the planner.
- Additional features – like AI-based verification routines or AR-based visualisations for citizen engagement – help to make sure that all actors in the process receive the maximum support.

The BRISE project introduces the concept of a Reference Model, a BIM model to compare the design to. Additionally, a division is made between the design Building Application Model (BAM) and the Information Service Information Model (SIM).

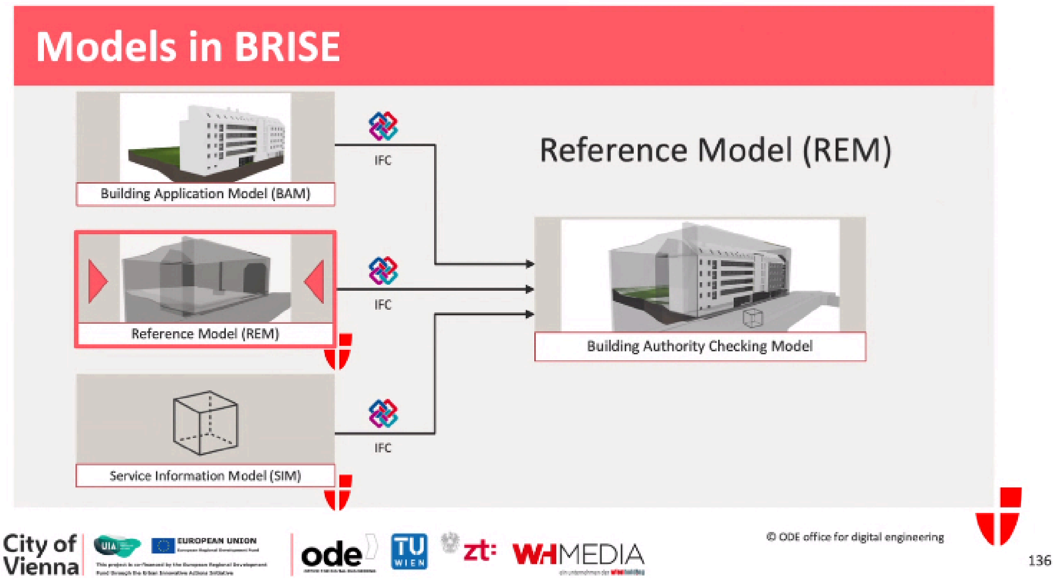

Figure 15: Reference model as presented by BRISE.

The BRISE project has been an inspiring project, however there are still some issues that need to be addressed. Firstly, the BRISE is a Proof of Concept, to gain a legal status many steps need to be taken and hence the outcome of BRISE project are not yet used in practice. The existence of a long history of building laws can be slowing that process down. Additionally, currently the zoning plans and reference model requirements were digitised at the end of the planning process, therefore it could not be used optimally, the

[94] Von Radecki, 2020: „The automated reference models as municipal verification tool"

results of the automated checks are only available after submission. It would be recommended to digitise zoning plans before the final submission, so that planners can already use the digitised zoning plan and checks in the planning process.

As was presented at the BIM World event in Munich in november, a problem they have with the submission process is that the law defines the process in an old-fashioned way. Often, designs have to be delivered on paper, which has to change to digital delivery. In this project both paper and digital (BIM) were done, they checked the BIM model automatically and used the paper version for the 'soft' checks. Also, they found that although AI is remarkable AI had problems in the legal text analysis as the language was sometimes old-fashioned or had too few examples, so its use proved to be limited.
Vienna holds a quarter of the country's inhabitants and has its own planning rules and regulations. If the rest of the country would follow their example to work towards an openBIM Authority procedure, a thought was that it should be on a regional level so that there are specialists to handle it that not every municipality has.

Singapore
The BP-Expert system had been available in Singapore from as early as 1995 for checking 2D drawings for compliance. In 2002 it was replaced by e-PlanCheck, replacing it with the 3D IFC data model, as part of the Construction and Real Estate NETwork (CORENET) project. The tool provides a code compliance checking feature of a digital building model regarding a large extent of the Singaporean regulations in terms of building control, accessibility, fire safety as well as environmental healthcare. Since 2002, it has been possible to submit building permits digitally there. Currently, the Building and Construction Authority (BCA) is re-evaluating the CORENET system and is in dialogue with the software industry to upgrade and rebuild the system based on feedback from the AEC industry. While the use of BIM and IFC is adopted more widely in the AEC industry, there started to arise a mismatch between the data requirements for CORENET checking, and the modelling methods the industry uses to create BIM datasets.

The checking processes within CORENET are based on hard-coded routines and therefore the algorithms, process steps and methods are not transparent for the user. The overall process is structured into three basic phases. In a first step, the model information is checked for availability of the information in the required form to be processed. Subsequently, in a second step, the model is searched for the missing information in underlying information layers. If the missing information cannot be found here, it is created in a last step with the help of information derivation. The processing time for a building project has been reduced to around three weeks thanks to digital checking routines and specifications that have to be observed during modelling and subsequent submission. To be sure, Singapore is a small city-state, but it pursues enormously large construction projects – for which just eight employees are responsible (as of fall 2022.)

Integrated Digital Delivery (hereafter IDD) is one of the key thrusts in the Built Environment Industry Transformation Map (hereafter BEITM), and is aligned to Singapore's efforts to transform the built environment sector by creating a highly-skilled workforce trained in use of the latest architecture, engineering, construction and operations technologies[95]. IDD builds on the use of Building Information Modelling (BIM) and Virtual Design and Construction (VDC), which have been implemented in many projects over the past few years. IDD is the use of digital technologies to integrate work processes and connect stakeholders working on the same project throughout the construction and building life-cycle. This includes design, fabrication and assembly on-site, and the operations and maintenance of buildings.

Figure 16: Explanation of IDD[96].

2.3.3 Summary of international best practices

As summarised from descriptions above, what can be concluded about best practices for the use of planning information models?

In order to noticeably accelerate planning and building in the near future, there is no way around the digital and BIM-based building permit. Nordic countries like Finland, Norway, and Denmark were early adopters of the digitalisation of information and BIM. So, they have had time to formulate educational tools and compile handbooks for implementation. Finland and Norway are often cited as the ideal standard. Here, the permit is issued within a few weeks to months. Even there, the processing time cannot be generalised, because it always depends on the complexity of the building. In Singapore, the processing time for a building project has been reduced to around three weeks.

[95] https://www1.bca.gov.sg/buildsg/digitalisation/integrated-digital-delivery-idd
[96] https://www1.bca.gov.sg/buildsg/digitalisation/integrated-digital-delivery-idd

Formalising requirements concerning data in the law encourages the use of new technologies. The use of open standards is common practice, for BIM the IFC-format is widely adapted, and it is advised to use that. To make BIM mandatory in the permitting process in stages (first state clients/bigger projects moving on to regional and local projects) is something that could be followed. This is related to giving BIM a higher legal status to help improve the use of BIM over 2D PDF. In the interviews (see chapter three) the legal status of BIM and other legal requirements not being in tune with current digital developments also came forward as a challenge. Changing the legal requirements to be more supportive of BIM and more in tune with current digital possibilities could help improve the status and use of BIM in the planning process.

The development of the prototype is advised to be in line with the ACCORD framework, however keeping in mind that the ACCORD project is still running and the framework is not yet realised.

Using standards (including information delivery specifications) accelerates the planning process. Several countries are piloting with IDS as the value of it is acknowledged more and more, having validated BIMmodels with all the required information in them benefits all parties in the planning process. Estonia can learn from the results from these pilots on the use of IDS. Investing in innovative solutions can accelerate the efficiency of the planning process.

The digitisation of zoning plans is an issue in many countries. Initiatives to digitise zoning plans are seen. Next to digitization the question is how to use them as input for automated checking in planning information models. In Sweden, Germany and Austria there have been pilots, but these projects are experimental, and none of them are operational. Estonia could be the frontrunner showing how information modelling usage in planning could work with this project's prototype.

3. Interviews

This chapter shows the insights gathered by conducting the interviews. First, an overview of the interviews that took place is given, after which an overall summary of all interviews is given. This summary shows valuable insights into the bottlenecks of the current Estonian planning process and the readiness of the market for the introduction of PlanBIM.

3.1 Overview of the interview participants

In total, 11 interviews were conducted. The table below shows for each interview with which organisation it was and what the function of the interviewee was. Their names have been anonymized but they are known by the researchers and the Klimaministeruum. To get a broad perspective, interviewees with different roles and backgrounds were selected. Both private and public organisations were approached.

Interviewees were first asked about their view on the current planning process, their role in it and their perceived bottlenecks. Thereafter they were asked about their view on the future, based on a planBIM example, what possibilities and hurdles they see.

Nr.	Organisation	Function
1	Lääne-Harju Municipality	Architect & planner
2	Hades Geodeesia & Estonian Digital Construction Cluster	CEO & Board member
3	Estonian Architects Union & PLUSS	Head of project management & PLUSS
4	Hendrikson & Ko & Estonian Association of Spatial Planners	Head of comprehensive and regional planning department
5	Skepast & Puhkim	Planning department manager & project manager
6	City of Tallinn	Head of planning department & architect & Head of planning board
7	Port of Tallinn & Estonian Digital Construction Cluster	Head of development department & board member
8	City of Tartu	Spatial planner
9	Ministry of Climate	Head of client service help desk
10	K-Projekt	Leading Expert
11	Ministry of Regional Affairs and Agriculture	Digital Division of Spatial Planning

Table 4: Overview of the organisations that took part in the interviews.

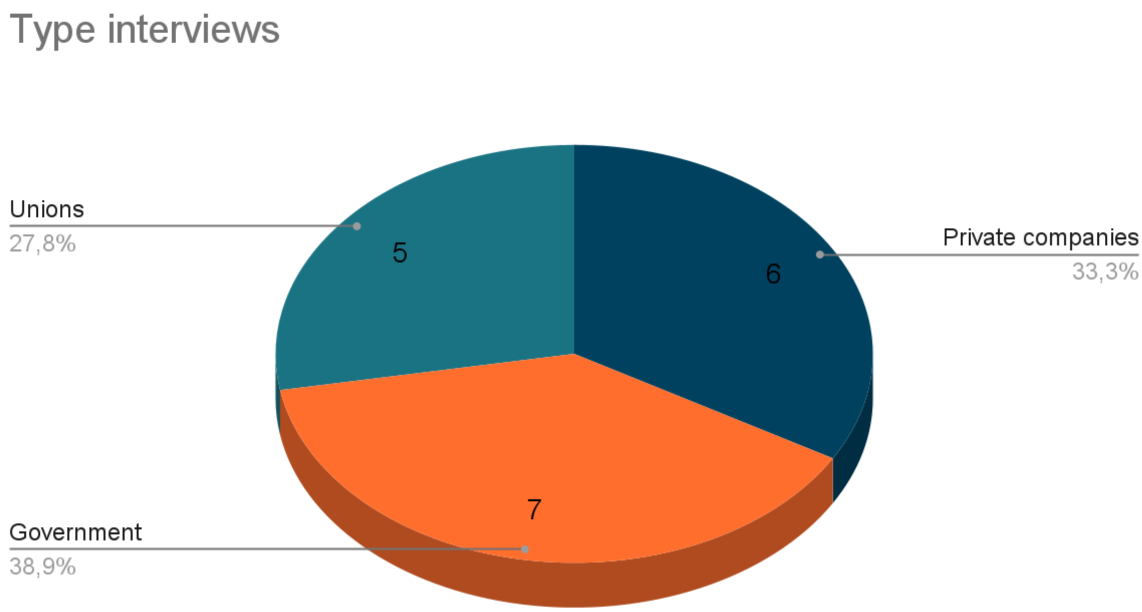

Figure 17: Division of the interview types.

3.2 Interview summary

The interviews with various professionals involved in the Estonian planning process in Estonia reveal common challenges, insights into the used software products, insights on PlanBIM readiness, potential checks, and valuable recommendations. This summary highlights key findings from the discussions.

3.2.1 Identified Bottlenecks in the Current Planning Process:

Common identified bottlenecks in the Estonian planning process, as conducted from the interviews, are stated below:

Lack of Coordination
Multiple interviews emphasise the challenge of different departments providing solutions without proper coordination, leading to inconsistencies and incoherent feedback.

Data Quality
Issues with insufficient data quality, master plans lacking sufficient details, and due to legal obligations, paper is still used which does not correspond with the current society.

Data Flow
The different steps in the process require different data solutions, which results in data getting lost during the planning process. Reasons for this are that the quality is not good enough, it is not digitalized or it is not handed over correctly. This makes it hard to re-use data.

Data standardisation
A lack of, or not followed data standards, make it hard for planners to compare different (detailed) plans.

Transparency and public involvement
To convey a solution the visualisation of the solution-to-be is currently hard to convey to the public for the detailed plan, as there is not yet a concrete building to show. Still the inclusion of every involved party is very important. Additionally detailed plans are often not understandable by the public, since the maps are crowded with information and there is no standard.

Version control
Considering feedback: There is no place for discussing designs in the current 2D and 3D products. Concurrently reviewing if all feedback has been processed in a revised version is hard to check as different data formats are being used. Approval checking takes a lot of time and all involved parties work in their own way and identifying the latest version of plans and documents poses a significant problem in the planning process.

Balance
Finding the balance between the national and local level is a bottleneck for multiple municipalities, especially smaller ones. Balancing different interests is an inherent problem of planning in general. This comes back in finding a balance between the feedback of different departments/authorities as well.

Legal bottlenecks: Bureaucracy
Formal bureaucracy of the law is misaligned with modern society. This results in redundant steps, long procedures and a gap between paper-based processes and the digital solutions available nowadays.

Legal bottlenecks: Legal status of 3D data formats
BIM and 3D don't have a legal status by law. If this would be changed in the law, the initiative would be coming more from top-down as well, instead of bottom-up as it is now.

Legal bottlenecks: Differences between local governments
National plans are better structured and standardised but when it comes to plans of local government, big differences exist in the sense of format types. The law does not state anything about the structure of for example observation corridors and sectors, boundaries of areas of environmental value.

3.2.1 Overview of Most Used Software in the Planning Process

Used software in the planning process has been identified, conducted from the interviews. The software and use is listed below:

GIS products

- Used for Master Plans.
- Not for making detailed plans, but for showing them to the public.

Autodesk AutoCAD Map 3D and ArchiCAD

- Widely used by planners for detailed plans.
- Utilised for obtaining 3D shapes of buildings and checking legal conditions.

Estonian Building Register (EHR)

- Commonly used for accessing 3D building shapes, legal information and visualisation.
- Not possible to collect the correct building heights.
- Plans are more rural.

PLANK

- Used regularly for planning purposes.
- Because it is quite new, not all the information needed is there yet, especially for smaller municipalities.

Land Board Geodata

- Often accessed daily for geospatial information.
- A valuable resource for planners in obtaining data about infrastructures and other geospatial information.
- Offers small tools that are useful as well.

SketchUp

- Used for Building Information Modeling (BIM) by some planners.
- Important for creating 3D visualisations and BIM models.

BIM

- Some already use it, some not. If they use it, it is at a later stage, when the actual building is being designed or the construction phase is happening.

Other local data platforms or geowebs

- Tallinn Planning Portal was appointed a few times, to get protocols and receive drawings and plannings.
- Sometimes only excel or paper documents are available by a municipality.
- Tartu has their own PLANK planning database.

3.2.2 Readiness of the Market for Introduction of PlanBIM

Reactions and perceptions of the readiness of the market for the introduction of PlanBIM, according to the interviewees are summarised and listed below:

Positive Perceptions

- Many express positive views about the potential of BIM.
- Recognized as a valuable tool for improving accuracy, efficiency, and collaboration in planning.
- Although it will take more time in the beginning to get used to the process change, it will save time and money by preventing mistakes.

Challenges in Adoption

- Resistance from smaller municipalities due to limited information systems.
- Architects' and planners resistance to new standards and perceptions of rigidity.
- Needs a good introduction with proper training.
- Models need to be accessible by the target audience, who have the right hardware and software.

Standardisation

- Standardisation transition is happening in the planning process, mainly because of the PLANK introduction. Standardisation of the detailed plans will help process practitioners adopt the use of BIM.
- All participants should be open to sharing 3D models, which is not the case at the moment.

Selective Use of BIM

- Recognition that the goal of having all plans produce 3D data may not be immediately feasible.
- Emphasis on focusing efforts where BIM is most beneficial in the planning process.

Concerns

- BIM is too detailed for detailed planning.
- 3D tools shouldn't be too expensive, their benefits have to be shown and taught to local authorities to increase use.
- BIM models take up a lot of space in local databases.

3.2.3 Identified Check Possibilities

Part of every interview was to show a demo of PlanBIM and ask the participant what their ideas are regarding automated checks. This resulted in a list of 27 identified check possibilities, which can be found in Appendix C. An analysis was made in overlap between the mentioned checks, as some participants suggested similar checks. This resulted in a list of 18 unique check possibilities. These checks will be further discussed in chapter 4.

3.2.4 Other use cases for BIM in the planning process

Next to possible check possibilities, additional benefits mentioned by interviewees have been summarised:

BIM as visualisation for the public
Public Involvement: Estonia places a strong emphasis on participatory planning. Public participation can be improved by showing the public the (detailed) plan as a BIM model. This would allow the public to improve their input and feedback.

BIM instead of 3D illustrations
Now renders are used, but BIM would give a more realistic and interactive view than currently popular renders, which are often outsourced, expensive and time consuming.

BIM to compare planning versions
Feedback on plannings are given in different data formats. By standardising this feedback and using a BIM model for it, a check could be created to highlight the differences between the versions to see if all feedback has been incorporated in the newer version.

BIM and simulation
Automations in BIM would help the public and politicians understand the BIM model in the environment and take away concerns.

3.2.5 Recommendations given

Recommendation given by the interviewees, both concerning PlanBIM as general recommendations, are listed below:

General Recommendations

- Making the detailed plans more standardised and in 3D and easy accessible through will definitely make them more understandable
- Involve practitioners in standardising the input and/or prototype.
- Keep it flexible
- Education
- Web-based: the new solution should be web-based.
- Improve the legal status of BIM, now it has the least important legal status.

PlanBIM Recommendations

- Performance: It should be stable and fast, especially regarding 3D data.
- User Experience: The solution should be simple and intuitive, so less digital users understand how to use it as well.
- Structured and standardised data: choose a neutral format so different software products can be utilised.
- Highlighting the need for accurate ground models, impact areas from noise studies, viewing sectors, and green corridors for effective use of PlanBIM.

- Feasibility Assessment: Recognizing the challenges in achieving universal 3D data and suggesting careful consideration by local governments regarding its feasibility.
- Take into account the level of detail needed for the BIM model and make this very clear for all participants.
- Standardisation is needed to be able to work with automatic checks.

3.2.6 Conclusion

The interviews collectively paint a comprehensive picture of the challenges faced in the Estonian planning process, the prevalent software landscape, identified check possibilities, perspectives on PlanBIM readiness, and recommendations for improvement. The identified bottlenecks form the basis for the value case of the proposed solution design, which can be found in Chapter 4.2. There is a consensus on the need for better coordination, version control, and enhanced data quality. The insights gained from these interviews provide valuable input for shaping future planning processes and the potential introduction of innovative solutions like PlanBIM.

4. Analysis and Solution Design

In this chapter, the outcome of the interviews and desk research will be analysed to create a value case. With the insights that come out, a solution design will be proposed. This also includes information on the next steps which will be executed in the second part of this research.

4.1 Summary and bottlenecks of planning process

To give a summary on the current state of the planning process in Estonia, both the findings of the desk research and interviews are incorporated to create a solid base for the value case and solution design. After that, an analysis of the available data and its structure will be discussed.

The lack of standardisation is a key bottleneck causing disruptions in the data flow, reducing the data quality, and impeding effective comparison between the different plan types and versions. Recognizing the need for greater public participation, there is a clear demand for 3D tools to better visualisation and understanding of the plans.
Moreover, the reliance on manual checks introduces a risk of human error, which makes the introduction of automated systems necessary for greater accuracy. The current planning process consists of time-consuming approvals from different stakeholders, underscoring the need for improved and smarter collaboration. Efforts to do so are crucial to break down silos and foster a more cohesive planning approach.

Embracing efficiency and digitalisation is paramount, and the strategic (re)use of 3D data is emerging as a promising solution to address these challenges, offering a path to a more streamlined and effective planning approach in Estonia.

Chapter 3 describes in more detail the identified bottlenecks in the current planning process. It is shown that Estonia is working towards a central e-construction platform, from which we conclude that the solution proposed in this research should fit into that. This means the solution design should be integrated or should have the ability to be integrated into the e-construction platform,
The introduction of PLANK has created a starting point towards this integrated platform idea and this was also the start for standardisation throughout the planning process. PLANK includes validation checking on the submitted plans and although this is a start with introducing automated checks, it only applies to 2D and validation checks. Therefore, there is a need for a check mechanism being able to handle both 2D and 3D data and automatically check on regulations. Additionally, plans are only registered in PLANK after the planning procedure, while there is a need to have (detailed) plan data in the planning system throughout the planning process.

The interviews gave us a better understanding of which and how data is used in the planning process. We see that this is partly PDF, partly CAD, and partly GIS. Sometimes standardised according to PLANK standards or other requirements, but not always. We have also seen what is used in other countries from the desk research. The usage of BIM is growing, but it can be seen that IFC has been used the most. Our recommendation is to develop a standardised IFC standard in Estonia and to make requirements on the information for the Master plans, detailed plan and designs to make them more suitable for automated checking and to prohibit current problems in the data flow, quality and comparison. The legal status of BIM and IFC can be changed as for example Finland has done, making IFC a requirement in the permitting process. The required level of detail of BIM should be clear and predictable. This will be further analysed in the second stage of this research.

Stages in the planning process where 3D has a prominent value, based on the interviews, are with the public's involvement and in comparing the detailed plan versus the master plan.

Based on the outcome, we can conclude that the interface of the prototype has to be user friendly. As several stakeholders need to be able to use the prototype, it should be taken into account that no specific knowledge or experience is needed in order to automatically check the plans. Another point of attention is that proper training should be given, in order to make the acceptance as high as possible and it will be properly used.

This applies especially to smaller municipalities with less human resources and access to the right software and hardware. They can achieve great benefits from the implementation of automatic checks as it would save time and resources for them. Therefore, their opinion and experiences should be taken into account, next to those of other stakeholders in the planning process. A concern of those smaller municipalities was that 3D tools are too expensive and the proposed solution would therefore not be feasible for them. This highlights it's important to propose a solution that includes availability for each stakeholder in the process and not only the ones with the most resources.

Another concern that came out of the interviews was regarding the level of detail that 3D visualisations often have. When talking about the detailed planning phase, details are not needed to convey necessary information. Just a simple 3D visualisation, like a 3D block in a 2D environment could be enough for this phase. Although this is something to further define in the second part of this research, we can already conclude that the amount of information used in 3D in the design phase is not needed. This should be made clear to the users when implementing the prototype, as it will determine a large part of the will to adopt the solution design by the stakeholders. When creating the standard used for the automated check, the practitioners should be involved as well to make sure that it suits the reality and not only the theory.

4.1.1 Analysis of the plan data suitability according to the requirements

There is a description of the required attributes, as stated in attachments of the Regulation No. 50 "Requirements for planning formalisation and structure"[97]. These include a clear distinction in discipline, provide unified codes and also some attributes which are potentially useful as input for automated checks, for example, the maximum building height. The use of these requirements can be seen in for example the PLANK database, and the PLANK geoservices[98], although this data only partly covers Estonian land area, including only a part of the city of Tallinn. The pilot detailed plan data in IFC is also according to the namings of the requirements, although the requirements do not state specifically in what way and which location in the file the attributes have to be named.

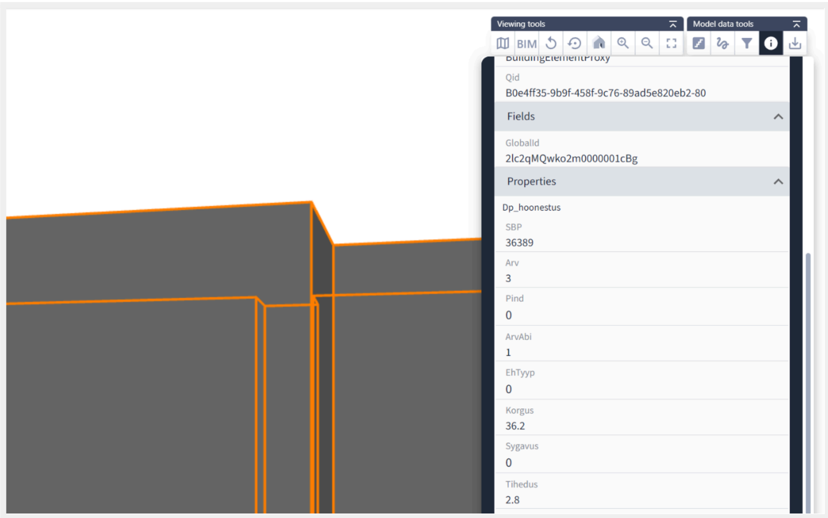

Figure 18: Properties of the Pilot Project IFC of the National Broadcasting Building, equivalent to the requirements

For automated checks it is a necessity that data is standardised and predictable. Not only the naming, but also the place of properties and wording has to be correct. In this light it is important that not only requirements, but additionally the data model is clear, and that adherence to the requirements in data can be validated. For the use of the requirements in IFC this should be determined, and could be validated through buildingsSMARTs IDS.

Additionally, even though the requirements offer a basis of attributes with values that could potentially be useful as input for automated checking, during the development of the checks it will become clear if the requirements as stated are sufficient, or that additions to the requirements have to be advised. In this light in addition to the current requirements, connection to international standards will be explored. For master plan data to be used for the development of automated checks, it should be noted that there is a dependency of available master plan data, and the availability according to the requirements.

[97] https://www.riigiteataja.ee/akt/121102022001
[98] https://planeeringud.ee/plank/wfs?SERVICE=WFS&REQUEST=GetCapabilities&VERSION=1.1.0

4.2 Value Case

A study conducted in 2018 showed that there were approximately 15,000 detailed plans valid in Estonia[99]. At that time, 34% of the letters were still on paper and 30% of the drawings were on paper (see the figures below). In 2018, there were still municipalities that did not use information systems nor prepared their plans digitally. With the introduction of PLANK, a new way of working started which has helped digitising the overall planning process and therefore digitalizing the detailed plans.

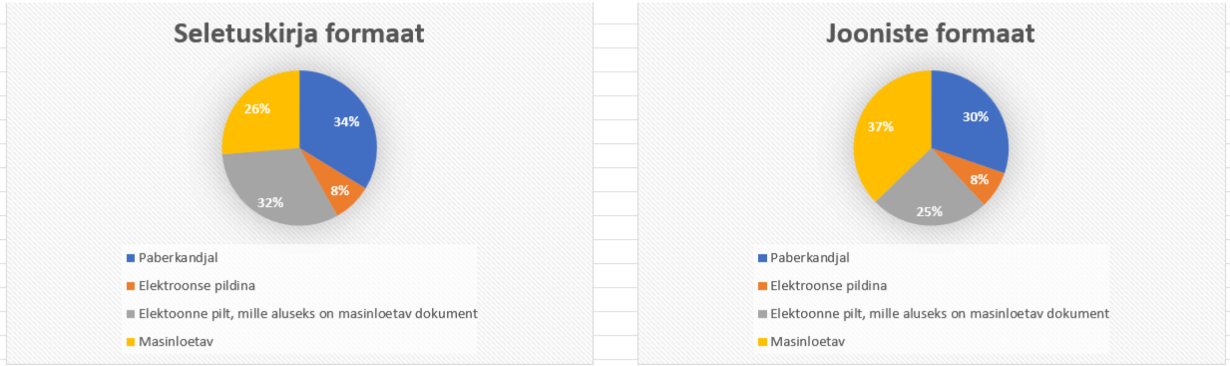

Figure 19: Division of file formats in the detailed plannings in 2018[100].

With the implementation of our proposed solution design, value is added in various places in the current planning process. We would like to name specifically:

Standardisation

The lack of standardisation is currently causing problems in the data flow, quality and comparison. With the introduction of a standardised way of using 3D plan data in the planning process, the overall cooperation will run more smoothly and will be improved. It will not only have an impact on the ability to be able to run automatic checks, it will also improve the overall planning process by being able to quicker compare plans, digitalise data and use data over different software products

3D Visualisation.

By using more 3D plans, the public will be able to understand the proposed detailed plans as well. The current drawings are often technical, which makes it hard for someone without technical knowledge to understand what is being pointed out. The transparency of the plans in the living environment will therefore increase.

99 https://planeerimine.blogi.fin.ee/wp-content/uploads/2021/05/2018_0083_DPde-hulk-ja-andmekandja_aruanne_20190403.pdf

100 https://planeerimine.blogi.fin.ee/wp-content/uploads/2021/05/2018_0083_DPde-hulk-ja-andmekandja_aruanne_20190403.pdf

Automated checking

Running checks automatically on a 3D plan will prevent human errors when looked at manually. There is always a chance that details are missed when checked manually, but with the introduction of an automatic check mechanism this will be excluded.

Time savings

A bottleneck often referred to in the interviews was that the current detailed planning process can take quite some time as different departments have to approve and criticise a plan. By introducing automatic checks in this process, the estimation is that less work has to be done by the individual departments. For example a department that checks the greenery requirements for a certain plan and calculates that manually. This will result in a reduction of human resources needed, which is especially important for municipalities with not enough human resources available.

Interoperability and re-use of data

By already using 3D data in the planning process, this data can be reused for automatic checking later in the planning process or in the visualisation of the country in the digital twin. This will increase the overall efficiency and digitalisation of Estonia.

As shown by these value points, the proposed solution design will not only have an impact on its own part of the planning process, but will improve the overall planning process of Estonia.

4.3 Analysis of the identified check possibilities

Eighteen check possibilities have been identified. They are analysed on four criteria: Clarity, feasibility, value and 3D advantage. Next to the analysis, the check possibilities are discussed with the working group. Based on the outcomes of the analysis, a list of 10 checks is compiled as possible checks to be developed. The criteria are further elaborated upon below, thereafter per check the description and analysis are presented.

4.3.1 Check analysis criteria

The four criteria against which the identified checks are analysed are:

Clarity
To be able to construct a check, it should be clear and concrete what should be checked. The more concrete of a description, available parameters and to be used data the better a check scores on this point.

Feasibility
Next to clarity, a check should also be technically feasible. This is judged by the description of the check and awareness of the (existing) technical possibilities.

Value
The value depicts the added value the availability of the check will add. This is decided by the analysis of the interviews and the outcome of the discussions in the working group.

3D advantage
A distinction is made for which checks will highly benefit or might only be possible with the use of 3D data.

4.3.2 Check analysis elaboration

The final list of checks includes a list of 18 checks. In this subchapter, we will elaborate these checks to work out all parts properly. First, a description of the check is given, after which the intended outcome is described. After that, an analysis with the four criteria is made, which decides together with the possible risks the result of the analysis. The result "Do" means the check will be further analysed in the next stage. The result "Don't do" means the check will not be taken further in the process.

In our analysis comparing the different possible checks for the four criteria (clarity, feasibility, value and 3D advantage) we used symbols to show how they were evaluated. Table 5 shows the symbols used for this. So for instance a V in the table under feasibility means we found this particular check to score as positive/high regarding feasibility.

Besides that, each check is placed in a phase of the planning process. The three phases identified in the checks can be found in Table 6. Although the focus of this research is on the DP-MP phase, other phases are considered as well.

Symbols used	Meaning
VV	Very positive/very high
V	Positive/ high
X	Negative/low
XX	Very negative/very low

Table 5: Explanation of the symbols used in the check analysis.

Phase	Meaning
DP-MP	Detailed plan versus Master plan
DP-DP	Detailed plan versus Detailed plan
DP-DS	Detailed plan versus Design phase

Table 6: Explanation of the phases used in the check analysis.

1. Version comparison of detailed plans

Description
DP-DP - Compare two versions of detailed plans and highlight the differences.

Outcome
Informatic: differences between versions highlighted

Analysis

Clarity	Feasibility	Value	3D advantage
VV	V	VV	V

Possible risks
An effective visualisation of differences should be investigated

Result

Do

2. Maximum building height

Description
DP-MP - Check if the height of the buildable area is within the maximum building height requirements.

Outcome
Warning

Analysis

Clarity	Feasibility	Value	3D advantage
V	V	VV	VV

Possible risks
Allowed height of buildings might not be clear: Maximum building height is often described by number of building stories, rather than actual height in metres.

Result

Do

3. Building distance

Description
DP-MP - Calculate the distance of buildable areas against buildings in the digital twin and/or other buildable areas in the DP or nearby DPs. The distance between buildings has to be compliant with minimum distance according to fire requirements.

Outcome
Informatic: Visualise distances and highlight possible errors

Analysis

Clarity	Feasibility	Value	3D advantage
V	V	VV	VV

Possible risks
Distance calculation method and distance visualisation have to be researched.

Result

Do

4. Cadastral border distance

Description
DP-MP - Calculate the distance of buildable areas against its cadastral border. The distance from the buildable area to the cadastral border has to be compliant with minimum distance according to fire requirements.

Outcome
Warning

Analysis

Clarity	Feasibility	Value	3D advantage
V	V	VV	X

Possible risks
Entrance point of cadastral border unclear.

Result

Do

5. Fire hydrants

Description
DP-MP - Calculate the distance of buildable areas against fire hydrant data from the digital twin. The distance from the buildable area to fire hydrants has to be compliant with minimum distance according to fire requirements.

Outcome
Informatic: Visualise distances and highlight possible errors

Analysis

Clarity	Feasibility	Value	3D advantage
VV	V	VV	V

Possible risks
Distance calculation method and distance visualisation have to be researched.

Result

Do

6. Greenery demands (%)

Description
DP-MP - Calculate the percentage of greenery in the plan area, to compare to the requirements of the master plan.

Outcome
Warning

Analysis

Clarity	Feasibility	Value	3D advantage
VV	VV	VV	X

Possible risks
Master plan data with percentages is not structurally available.

Result

Do

7. General access to the plot

Description
DP-MP - Check if the entrance of a plot is accessible by a road.

Outcome
Warning

Analysis

Clarity	Feasibility	Value	3D advantage
X	X	VV	X

Possible risks
High amount of unclarity.

Result

Do

8. Protected area requirements

Description
DP-MP - Check if the detailed plan overlaps with protected areas, such as protected heritage areas or flood areas, and give a warning or error if there is overlap.

Outcome
Depending on the type of protected area: Warning or error

Analysis

Clarity	Feasibility	Value	3D advantage
VV	VV	VV	X

Possible risks
Master plan data with percentages is not structurally available.

Result

Do

9. Check area measures

Description
DP-MP - Calculate the area per land use type, such as the building area, to give an overview.

Outcome
Informatic: Area measurements per land use type.

Analysis

Clarity	Feasibility	Value	3D advantage
VV	VV	VV	X

Possible risks
Detailed plan may not cover the entire planning area.

Result

Do

10. Design in buildable area

Description
DS-DP - Check if the design of a building falls within the buildable area.

Outcome
Warning

Analysis

Clarity	Feasibility	Value	3D advantage
VV	VV	VV	VV

Possible risks
Only check which checks design against detailed plan.

Result

Do

11. Accessibility requirements

Description
DP-MP - Check if the plot meets all accessibility requirements given in the master plan.

Analysis

Clarity	Feasibility	Value	3D advantage
XX	XX	XX	X

Result

Don't do

12. Impact of buildable area on noise

Description
DP-MP - Check if the impact of the buildable area in sense of noise is not too much.

Analysis

Clarity	Feasibility	Value	3D advantage
X	XX	V	VV

Result

Don't do

13. Impact of buildable area on light

Description
DP-MP - Check if the building does not block the sun for other buildings, and what the impact of the building is on shadow formation.

Analysis

Clarity	Feasibility	Value	3D advantage
V	XX	V	VV

Result

Don't do

14. Road inside limits

Description
DP-MP - Check if the planned road area is inside the transport area of the master plan.

Analysis

Clarity	Feasibility	Value	3D advantage
V	V	V	X

Result

Don't do

15. Parking spaces requirements

Description
DP-MP - Check if the measurement of the parking lots are within the standards of the parking requirements. The amount of parking lots depends on how big the building is going to be and the usage of the building. Different rules apply to different uses for the area.

Analysis

Clarity	Feasibility	Value	3D advantage
X	X	X	X

Result

Don't do

16. Tree conditions

Description

DP-MP - Check the measurement of a tree or the growing conditions of a tree. Developers have to represent the real tree and take into account their growing scheme.

Analysis

Clarity	Feasibility	Value	3D advantage
X	XX	X	V

Result

Don't do

17. Utility requirements

Description

DP-MP - Check if there is no intersection between the plan and utility networks. Check if the connection of utility networks is correct.

Analysis

Clarity	Feasibility	Value	3D advantage
X	X	X	V

Result

Don't do

18. Building permit

Description

DS-DP - The detailed plan can be used to check building permits.

Analysis

Clarity	Feasibility	Value	3D advantage
XX	XX	V	V

Result

Don't do

4.4 Solution Design

Based on the existing systems, the location of the prototype can be determined. To automatically check the detailed plans, it needs to be placed in the current process just before the PLANK system, in which established detailed plans are registered in 2D. When carrying out the automated checks, it will mainly have to be able to use available 2D geo information such as master plans, thematic plans, other policy maps or asset management information.

At the same time, the new 3D detailed plans can also be used later on to test architectural designs when applying for a building permit. At this time, the BIM checks that are already available in the BIM checking service will be important. The solution must therefore connect these two worlds and be able to combine techniques and data from both the BIM and GIS world in a flexible and scalable manner.

The most suitable data format also depends on the checks to be performed and will therefore be further tested during the development phase. IFC and CityGML appear to be the most promising, with LADM (Land Administration Domain Model) also appearing relevant as a data model.

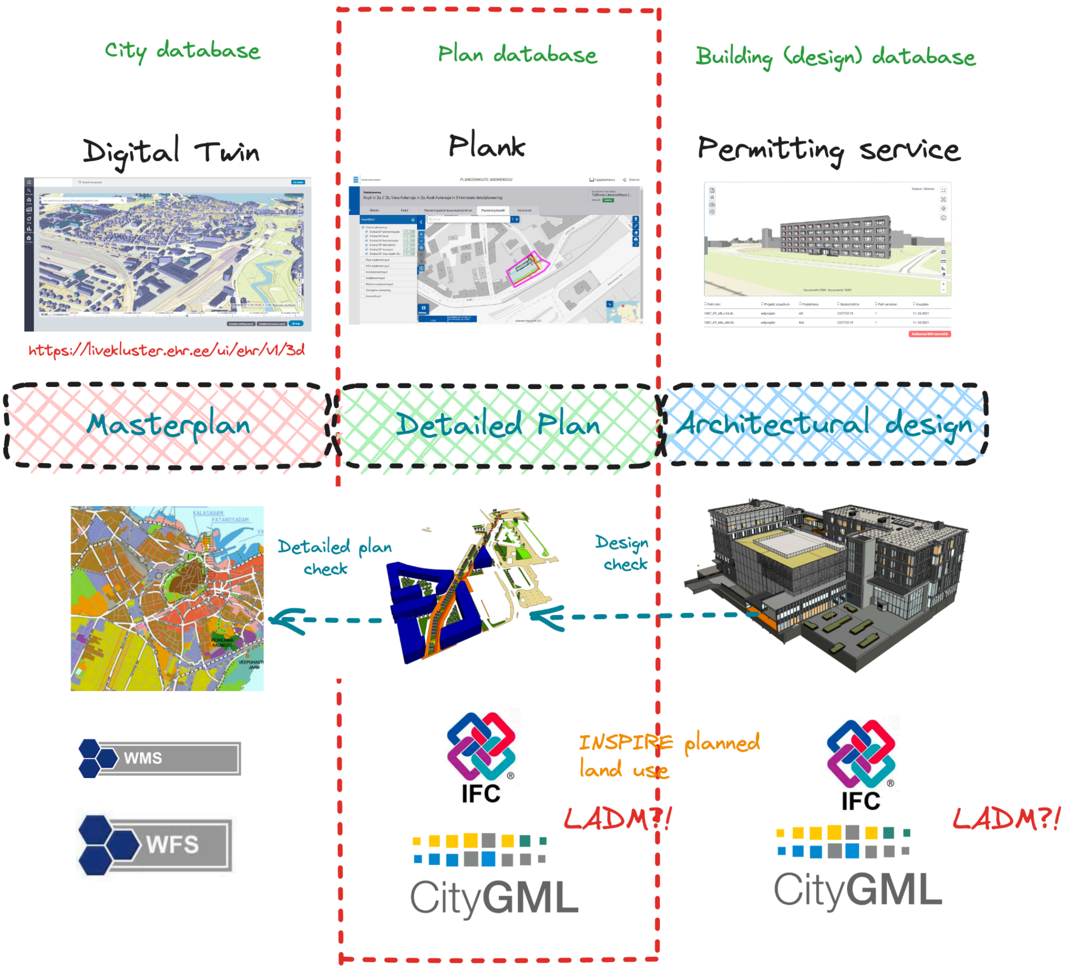

Figure 18: Phase of the proposed solution design.

4.4.1 TO-BE diagram

Within the complete detailed plan procedure there are several places where working with more standardised 3D plans will have added value. Below is a global overview of these steps and the possibilities. For the prototype the focus will be on setting up a working check example, which demonstrates that different types of data and checks can be combined in the planning phase and how that could look like. The prototype solution fits inside the planning process, which is drawn in the TO-BE diagram (Figure 20). The main focus is on the planning steps, in which the detailed plan is drawn, updated and (automatically) checked. The diagram should be seen in line with the proposed TO-BE diagrams as proposed in the CGI analysis.

The process starts with the planning initiator. This can be a municipality or a private party. In the latter case, sufficient permission has to be acquired before starting the drawing of the detailed plan. From here on, either the initiator or a party acting on behalf of the initiator starts the drawing of the detailed plan. This party is addressed as the Planning Officer.

During the initiation request, basic data and requirements for the detailed plan are collected by the automation. This includes requirements which can and should be automatically checked. When approval has been granted to start the planning, the planning officer further defines the conditions and requirements of the detailed plan, adding requirements that can not be automatically checked. Concurrently, the municipality will look at the requirements, and change them when deemed necessary, keeping in mind the formal processes if the stated requirements are not according to other plans or regulations, such as the master plan.

During the entire planning phase, the draft detailed plans can be stored in the prototype solution. Additionally, the planning officer can trigger the automated checks unconditionally, in order to see to what extent the current draft is compliant to the requirements, or if things have to be changed.

After a final draft is made, the detailed plan is submitted and has to be approved by the municipality. If the municipality approves the detailed plan, the planning officer publishes the plan and after a waiting period, in which comments on the plan can be made, if no limiting comments have been made the detailed plan is established by the municipality. If there are comments, they should be answered and if needed the planner has to adjust the plan.

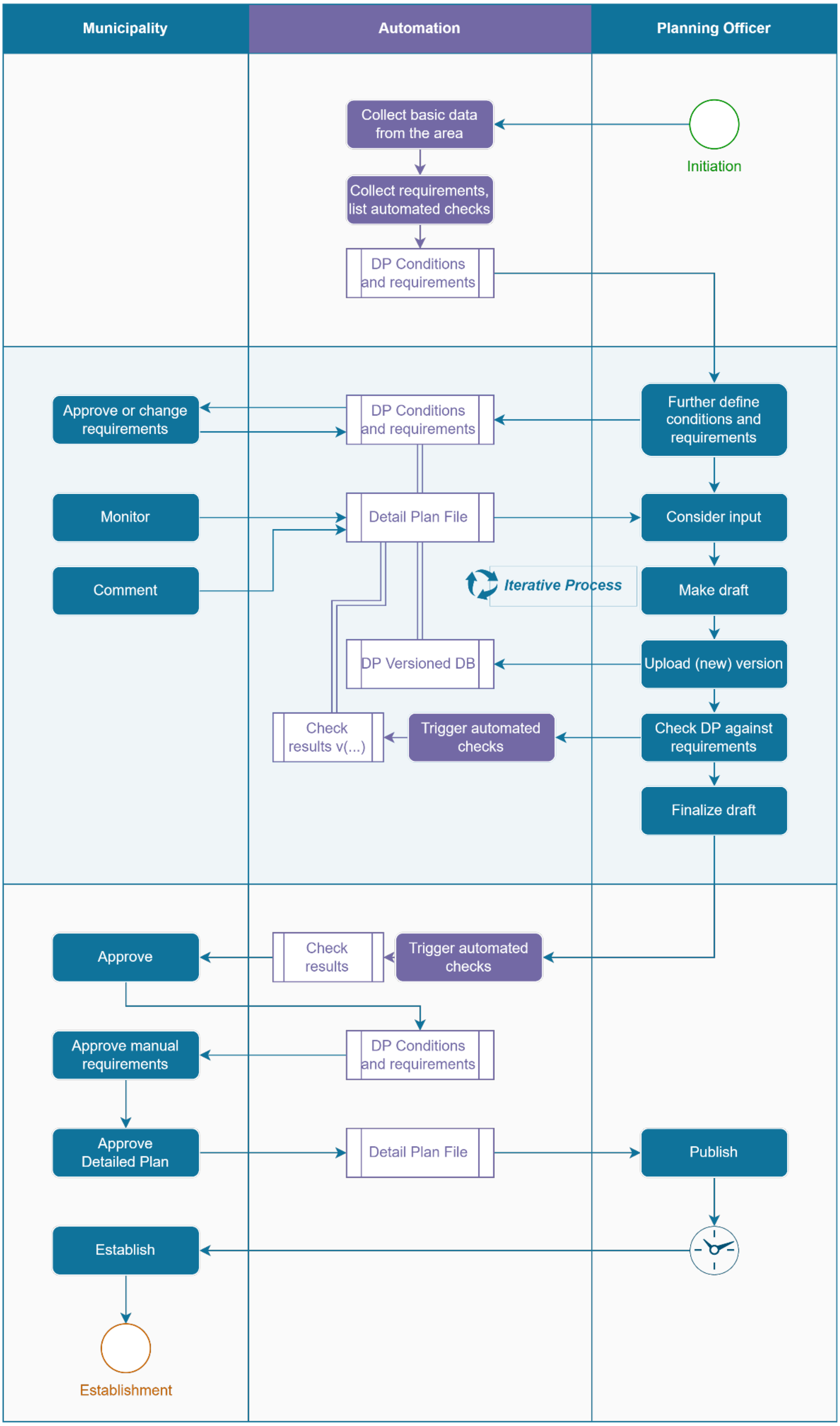

Figure 20: TO-BE Diagram

4.4.2 Proposed solution

Based on the results of the research phase and our previous experiences, the proposal is to base the solution on an online microservice architecture using international open standards. This is also in line with previous initiatives, the design of the e-construction platform and other international initiatives that have been investigated, such as Accord and CHEK. At the same time, it also appears that there is still very little experience with standardising and automatically checking detailed plans, which means that there are actually no operating examples available yet.

The basic components for this approach are already available in the Clearly.Hub. This is Future Insights digitally connected ecosystem that anyone can connect to. From one central facility, data and apps are made available in a secure manner for various applications using various international standards and APIs. 2D, 3D and BIM data and functionalities are already supported by the platform.

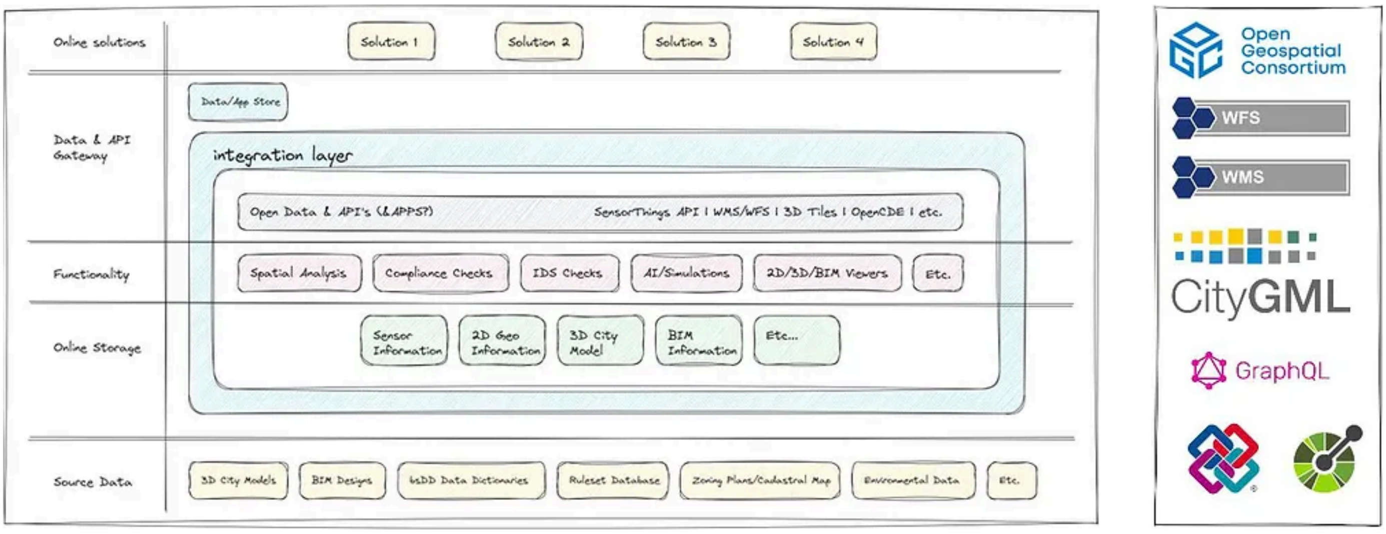

Figure 21: An overview of the Clearly.HUB.

One of the most important parts that will be added to this and that is still missing is an 'orchestrator service'. Such a service should be able to combine different analysis, questions, edits, etcetera. from different online sources. This could, for example, be a combination of a pure BIM check that is carried out via an API by the BIM checking service, and a spatial analysis that is done in the Digital Twin. Or in theory, ultimately a more complex simulation could be done, the outcomes of which can also be used in the check results. The possibilities seem limitless and at the same time there is limited experience with these types of techniques in this field of application. This 'orchestrator service' is also an important missing part of the envisioned standard checking framework in the earlier mentioned Accord project in which both the Ministry of Climate and Future Insight participate. It is now clear how most components can be filled in, but the orchestrating service remains a big unknown.

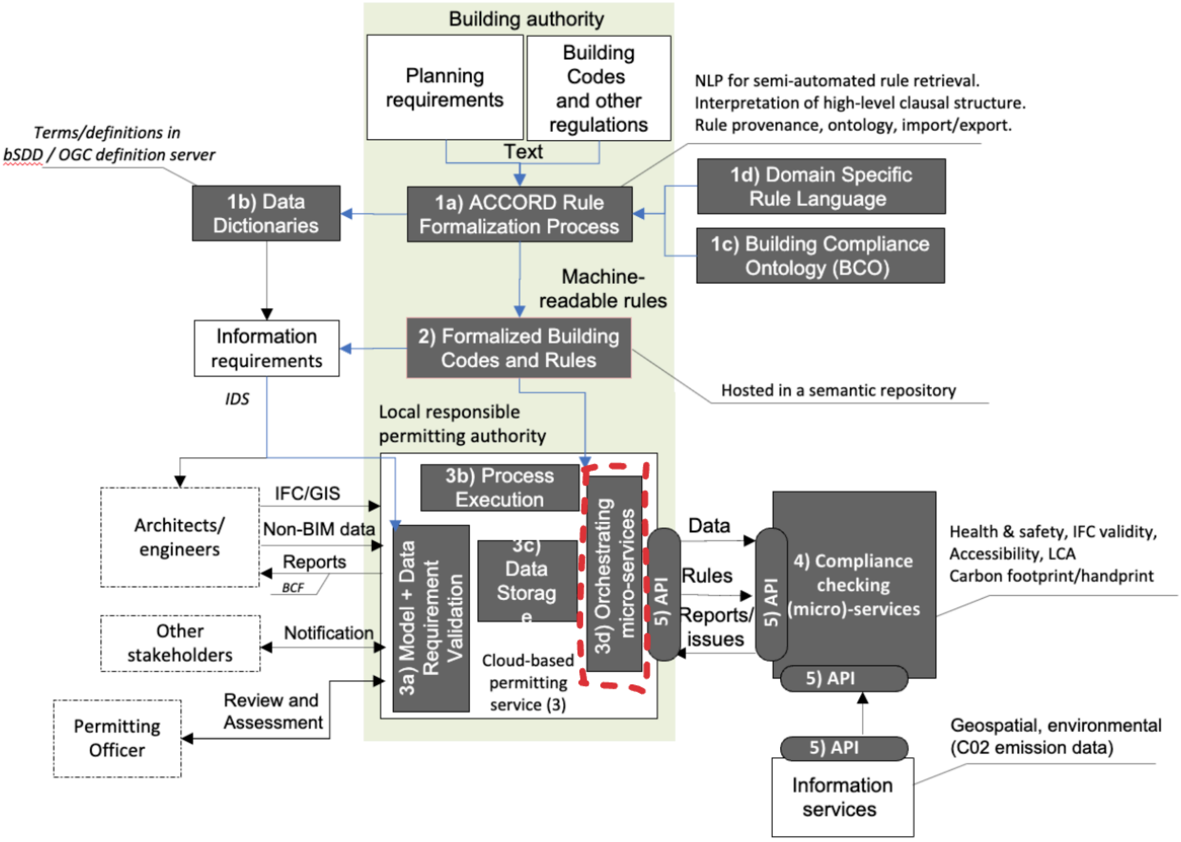

Figure 22: An overview of the architecture of ACCORD.

The proposal is therefore to set up such an orchestrating service for the construction of the prototype and to test it with different checking services and types of data. Although not as visible in the final user interface and therefore to the final user, this is probably the most challenging technical innovation in this project. As it can add a lot of flexibility and scalability to the checking framework, it is an extremely important potential extension compared to the current checking functionality.

The actual checks will therefore be a combination of different check and analysis services. In addition to the existing BIM checking services, experiments will be conducted with the operation, combination and results of various other services and techniques, such as FME, QGis server, GDAL API and OGC API.

One of the questions that still arises is how the results can best be shown to the user interface. Since detailed plans generally cover a larger area than traditional BIM techniques, it may sometimes be better to use a 3D Digital Twin-like representation. However, the current BIM checking service is completely based on real BIM techniques. Speed, stability, flexibility and scalability of the services are also matters to be assessed, as a basis for future choices.

The main data flow is based on a client/code process, and makes use of checking services. These checking services check one rule, and give back results. The advantages of such a system is that different checking engines can be used, based on the need. For example there can be a difference in BIM-based checking engines, GIS-based checking engines or environmental checking engines. Checking services can use other data sources if needed. To align and guide the checks in an effective way, a checking orchestrator will be proposed.

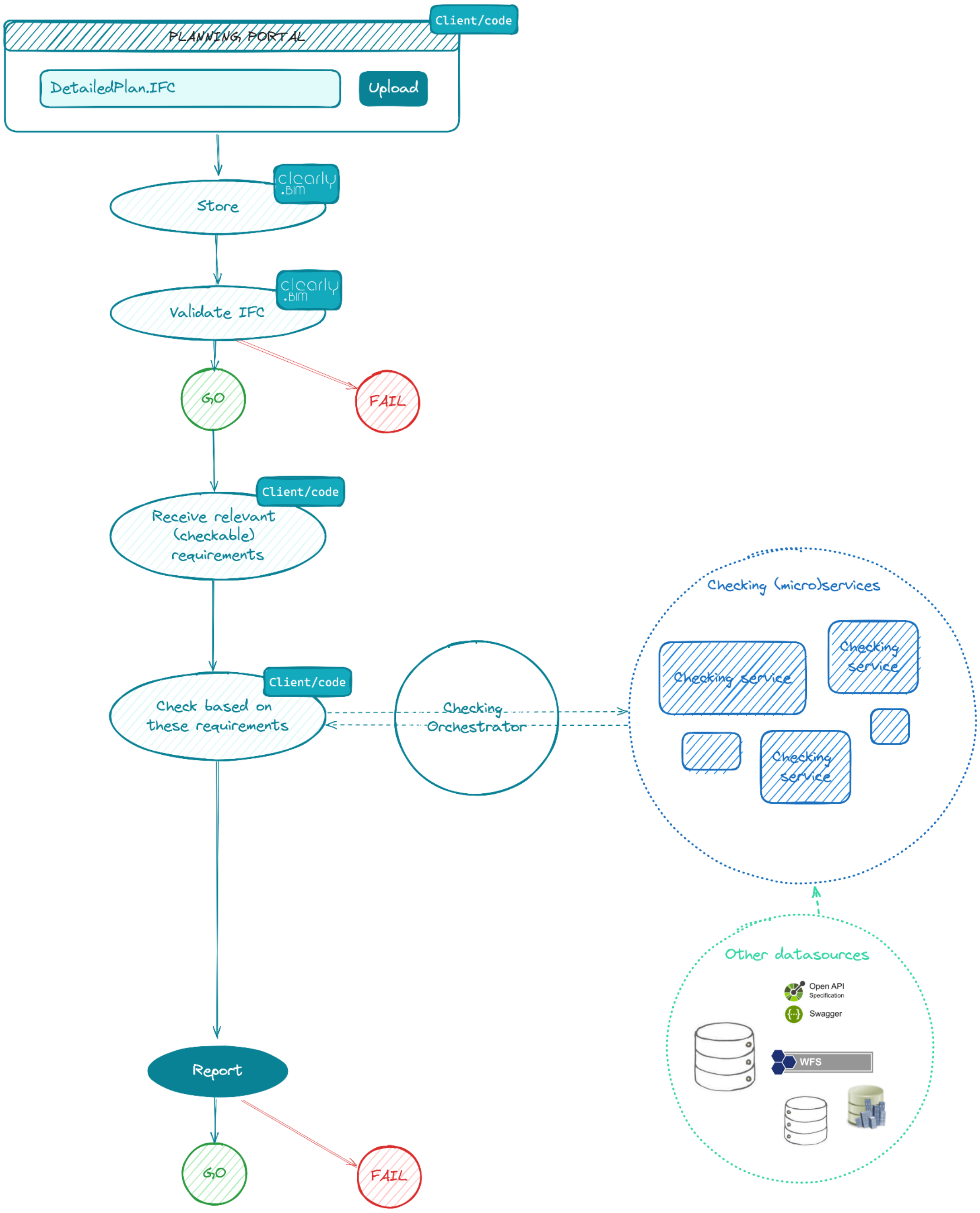

Figure 23: Data flow of the proposed solution design.

4.4.3 Data standardisation

In addition to technology, structured and standardised data will also be an important part of the solution. To start with, this concerns the structure of the detailed plan. The proposals submitted for this were in IFC, which is a logical option and fits well with the existing BIM service. For the implementation of spatial checks on a larger scale or combined with other scales, including CityGML to the process, might be a more convenient option, especially with eventual broader access to all accepted detailed plans at national level towards the national Digital Twin.

In line with this, the main question is what information exactly needs to be recorded in such a detailed plan, in order to be able to carry out the requested checks, among other things. The standardised information needed from a detailed plan is not yet t included by default in both IFC and CityGML, as currently there is no standardisation to add this for this use case. Therefore, it should be added. What information is needed and how this should be structured and standardised, will be further elaborated on the basis of the concrete checks to be developed. This will be done in the second phase of the project, while at the same time focusing on understanding the current data formats and how they should be made available to carry out checks on. To prevent Estonia from choosing a completely new and unique path, existing standards that are previously mentioned in this document will be followed. One of the open standards that appears to be relevant and which will be investigated is LADM (Land Administration Domain Model)[101]. Another example is the German Xplan, which is somewhat complex but perhaps contains useful elements. In the final rapport our findings from phase two on this matter will be included.

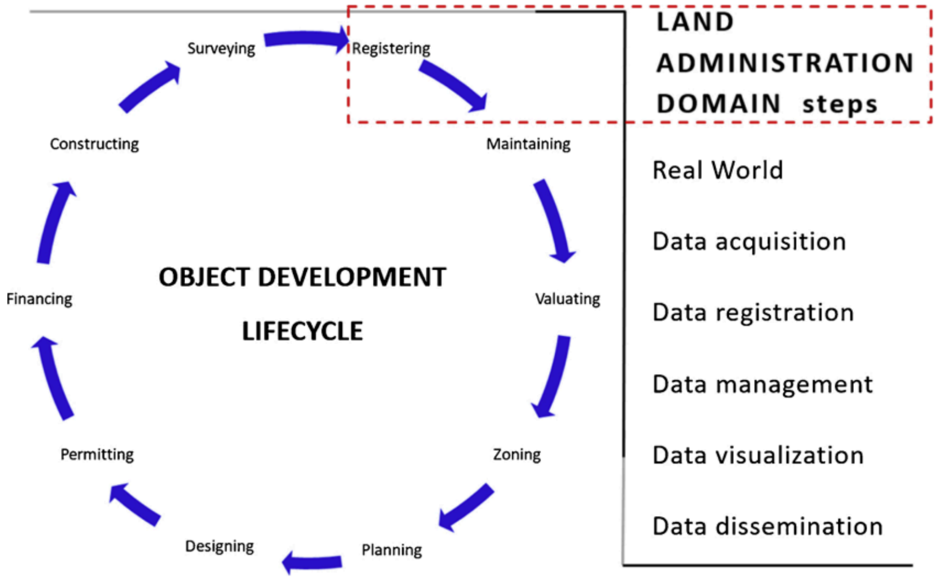

Figure 24: Explanation of LADM steps.

All kinds of 'reference' data will also be needed or have to be prepared. Consider the master plans to which additional data may need to be added to make checks feasible. But it could also be a dataset with fire hydrants or the protected cityscape of Tallinn that are relevant as input for checks.

[101] https://www.iso.org/obp/ui/en/#iso:std:iso:19152:ed-1:v1:en

4.4.4 UX design/flow

The results of a more standardised 3D detailed plan can, as previously indicated, be used at various places in the process and therefore in the e-construction platform. Consider the national Digital Twin in which current plans can be shared or as a basic layer in the permit check when applying for a building permit. However, the prototype will focus on showing how the tool could work when submitting and automated checking of the plan by the submitter. This functionality is ultimately what needs to be demonstrated and shared and is also the biggest challenge in terms of development. In a mockup combined in the current EHR, a potential layout is shown in the figure below.

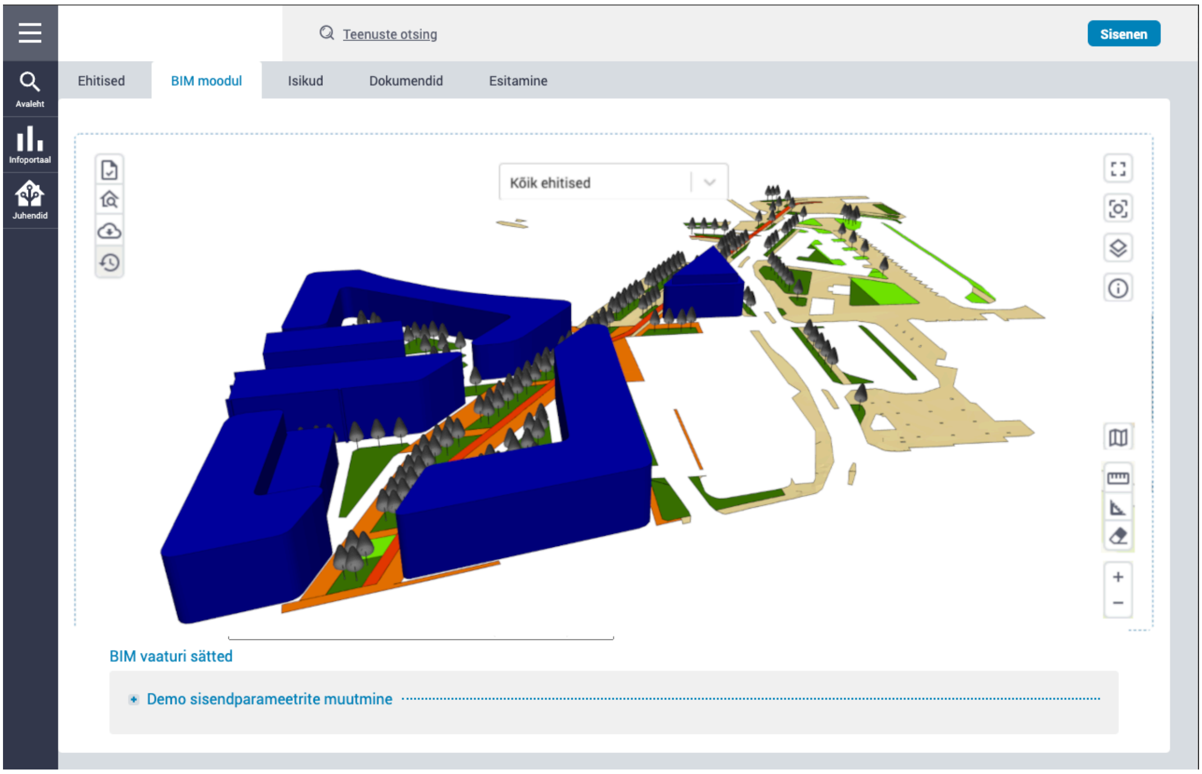

Figure 25: Example of prototype design.

The prototype will only consist of the embedded 'viewer' functionality in which the visualisation and check results are displayed in combination for now. During an eventual actual implementation, all kinds of other 'supporting' functionalities must be added such as logging in, file management, various process steps, adding notes, etc. However, these are all functionalities that simply have to be done later in the implementation, but which are not the biggest challenge right now.

4.4.5 Planning second project phase

Now that the detailed analysis is ready, the question and solution direction for the prototype solution have become more clear. With this direction, we decided on the required activities for the second phase of this project. As can be seen in the planning figure (Figure 26) an agile approach has been provided, in which there is a clear interaction between setting up the basic technology, preparing the required data and setting up the checks. A shortlist of ten possible checks have been agreed on and this will be used as input to develop seven checks within the second phase.

This will involve close collaboration and coordination with the client, both in terms of elaboration of the checks, provision of the required data and choices to be made on a technical level. The exact products of the second phase are a prototype of the given solution design, a clear direction for the planning data to be standardised in order to be used for automatic checking and seven checks that can be used within that prototype. Besides those products, the scalability of the prototype will be taken into account during the second phase, as the goal is that the development of the prototype is not the end. It can be seen as the beginning of a new 3D revolution.

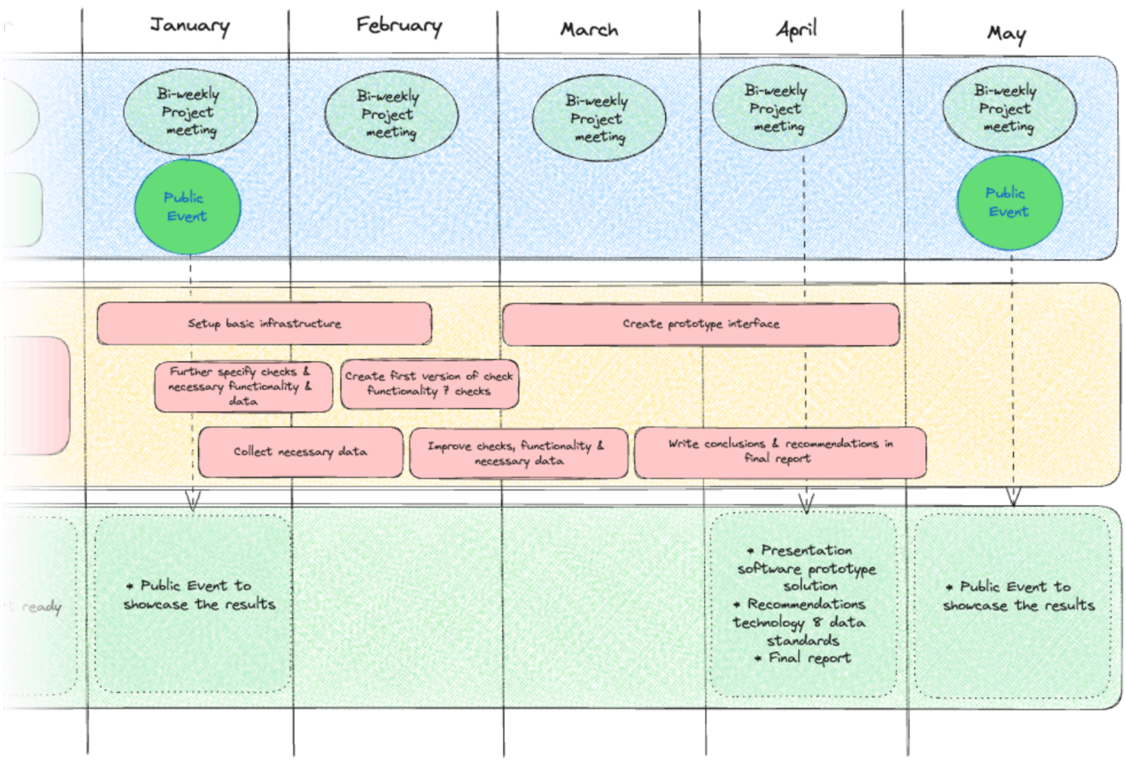

Figure 26: Planning second phase of the project.

Appendices

List of separate appendices

Appendix A - Interview Questions

Interview questions

1. Introductions: Name, company, function, consent
2. What does the current planning process look like from your point of view?
3. What is your role within this process?
4. Which software do you use in this process?
5. Are you using any of the following products in the planning process?
   a. EHR 3D Twin
   b. PLANK
   c. Land-Board Geodata
   d. BIM product
   e. Any local municipality data platform or a geoweb
   f. Other products not mentioned yet

6. Which data do you use in this process? And where do you get this data?
7. Which data would help in the planning process but is not available/takes too much time to gather at the moment?
8. What part of the process takes the most time?
9. Are there any parts in the process that are prone to human error in your opinion?

[Demo]

10. Are there certain steps in the process for which you think this would be suitable?
11. What data (2D/3D) would be needed to make this feasible and is this data already available?
12. What would be the effect (in sense of time/money) of the addition of a BIM check on this step in the process?
13. How ready do you think the market is for the introduction of BIM checks in the planning process?
14. How could the BIM checks be integrated into the current processes?
15. What do you think are the bottlenecks for using the BIM checks in practice and in legislation?

Appendix B - Consent Form

REPUBLIC OF ESTONIA
MINISTRY OF ECONOMIC AFFAIRS
AND COMMUNICATIONS

Interview consent form

Project title: Detailed analysis of the use of the information model of the plan and creation of a prototype solution
Name interviewers: Marjan Broekhuizen and Hilde Jongeling
Organization interviewers: Future Insight

Name interview participant:
Organization interview participant:

Thank you for agreeing to participate in the research for this project. The aim of this project is to analyze the use of the planning information model in order to create a prototype solution. For this analysis, several interviews will take place to research the current use of the planning information model. This interview is part of that analysis and will take one hour. The participant will have the right to stop the interview or withdraw from the interview at any time.

This consent form is necessary for us to ensure that you understand the purpose of your involvement and that you agree to the conditions of your participation.

The following actions will be taken regarding to the interview:

- The interview will be recorded and transcribed automatically with software.
- A summary of the interview will be made by Marjan or Hilde.
- You will be sent the transcript and the summary of the interview, which will give you the opportunity to correct any factual errors.
- Access to the recording, transcript and summary will be limited to Future Insight and the Estonian Ministry of Economic Affairs and Communication.
- The recording will be kept for the duration of the project.

With agreeing to this interview, your words may be quoted directly for the purposes of the research. Please select one of the following options that fits best the statement that you agree with regarding being quoted:

	I agree to be quoted directly

	I agree to be quoted directly, only if my name is anonymous.
	I wish to review the transcript and summary that followed as a result of my interview.

All or part of your interview may be used;

- In the rapport as result of this research
- At one of the public events in which the (final) results are shared
- In news articles
- On our website and in other media that we may produce such as spoken presentations.

By signing this form, I agree that:

- I am voluntarily taking part in this research. I understand that I don't have to take part, and I can stop the interview at any time;
- I understand what is written down in this consent form and agree with it;
- The transcribed interview, the summary or extracts from it may be used as described above;
- I understand that I am free to contact the researchers at any time with any questions I have and may have in the future.

Participants Signature   Date

Researchers Signature   Date

Appendix C - Checks Interviews

Appendix C: Identified checks per interview

Number	Interview	Check Name
1	2	Fire requirements
2	2	Accessibility requirements
3	2	Impact of building on light and noise
4	4	Greenery demand of 10/20%
5	5	If a road is inside the desired limits
6	6	Compare draft plan versus adjusted plan
7	6	Heights of buildings
8	6	Distances to cadastral
9	6	Distance to neighbouring buildings
10	6	Check area measures
11	6	Parking spaces requirements.
12	6	Trees. However trees are not a standard 3d Model as in reality they differ and grow.
13	7	Access to the plot
14	7	Greenery requirements
15	7	Height requirements
16	8	Enough greenery for a certain building (Janne thinks it is very doable as they have the detailed plans in GIS or in CAD, so you could measure the greenery).
17	8	Building height
18	8	Parking lots: the amount depends on how big the building is going to be and the usage of the building. Different rules apply to different uses.
19	9	detailed plan can be used to check building permit
20	9	i.e. buildable area (roof is certain angle)
21	9	buildable area of the house
22	9	some areas of the protected

23	9	shadow information during the year
24	9	Cadastral units
25	9	Access to the land plot
26	9	Conditions for the connection of utilities
27	10	Check the planning in relation to classified protected areas, not everyone has access to information about locations of endangered species.