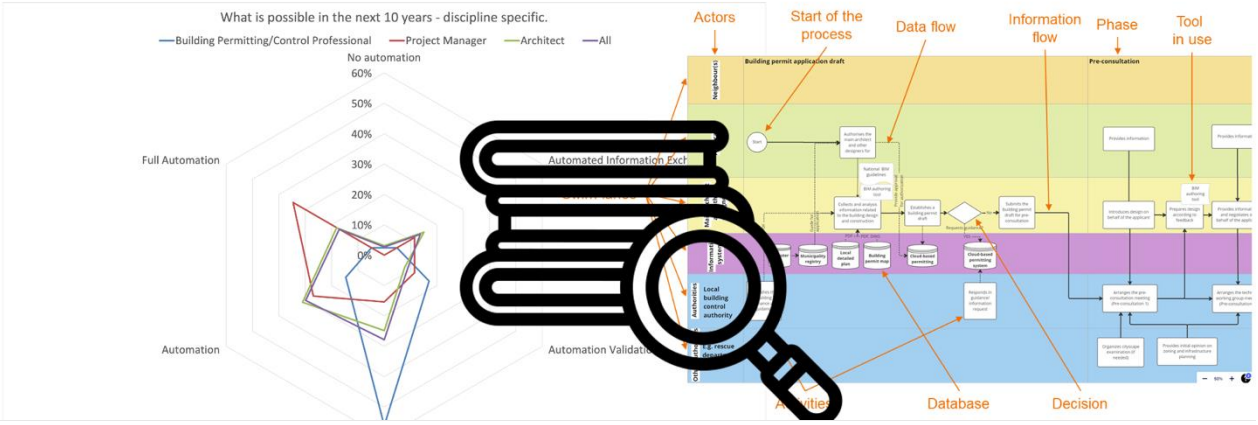
Landscape Review Report

April 30, 2023



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Executive summary

This deliverable document presents the results of Task 1.1 (*Landscape Review of Built Environment Compliance and Permitting)* and Task 1.2 (*Identification of Building Permitting Processes and Regulations*) of the ACCORD Project.

The ACCORD projects' objective is to provide a framework for digitalising permitting and compliance processes using BIM and other data sources, with the end goal of improving the productivity and quality, of design and construction processes, supporting the design of climate-neutral buildings and advance a sustainable built environment in line with the EU Green Deal and New European Bauhaus initiative.

This deliverable is a key element in ensuring the industry relevance of this project work. This deliverable presents the analysis of the complex landscape of built environment compliance checking and permitting across Europe to ascertain the requirements for the future digitalisation of this complex interdisciplinary field.

More specifically, this deliverable will:

1. Conduct a landscape review and analysis of the current adoption of the concept of digitalisation of building permitting and compliance checking.
2. Conduct an EU-wide survey into the attitudes of stakeholders to the prospective digitalisation of this domain.
3. Ascertain the current laws, regulations and guidance that currently drive building permitting across EU consortium member states.
4. Investigate and formally model the existing building permitting and compliance checking processes in the demonstration countries.

Conducting this work has provided the following key outputs that will benefit the remainder of the project:

- A solid understanding of the current state of the field in the areas of academic and EU projects and commercial software.
- Data representing the understanding of the views of members of the industry, specifically their attitudes to digital building permitting and compliance checking along with their views on the obstacles, benefits, and requirements for achieving this ambitious goal.
- A knowledge of standards that may be applicable to the ACCORD project to feed into later developments.
- Detailed understanding of the level of adoption along with pre-selection of the regulations that the project will consider in each of our demo countries.
- Process mapping of building permitting processes in ACCORD demo countries.

This solid basis will pave the way for the development of the ACCORD framework. This framework will have the potential to achieve real change and drive forward the digitisation of this area.

Publishable summary

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More specifically, this deliverable documents the following:

1. A landscape review and analysis of the current adoption of the concept of digitalisation of building permitting and compliance checking.
2. Results of an EU-wide survey into the attitudes of stakeholders to the prospective digitalisation of this domain.
3. Descriptions of the current laws, regulations and guidance that currently drive building permitting across EU consortium member states.
4. Formally modelled existing building permitting and compliance checking processes in the demonstration countries.

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1. Introduction

This deliverable will document the results of Task 1.1 (*Landscape Review of Built Environment Compliance and Permitting)* and Task 1.2 (*Identification of Building Permitting Processes and Regulations*) of the ACCORD Project.

1.1 The ACCORD Project

The ACCORD projects' objective is to provide a framework for digitalising building permitting and compliance processes using BIM and other data sources, with the end goal of improving the productivity and quality, of design and construction processes, supporting the design of climate-neutral buildings and advancing a sustainable built environment in line with the EU Green Deal and New European Bauhaus initiative.

ACCORD is based on the principles that these digitised processes must be human-centred, transparent, and cost-effective for the permit applicants and authorities and, above all, relevant for the industry within which they are to be employed.

To achieve this, ACCORD is developing a semantic framework for European digital building permitting processes, regulations, data, and tools. This framework will drive rule formalisation and integration of existing compliance tools as microservices. Solutions and tools are to be developed, providing consistency, interoperability and reliability with national regulatory frameworks, processes, and standards. It will enable the integration of technical solutions for automating compliance checking of buildings in their design, construction, and renovation/demolition lifecycle phases.

To ensure the industry relevance of the project work, the first work package of the ACCORD project is analysing the complex landscape of built environment compliance checking and permitting across Europe to ascertain the requirements for the future digitalisation of this complex interdisciplinary field. The project partners will conduct a landscape review and analysis of the current adoption of the concept of digitalisation of building permitting and compliance checking. This will focus on:

a. academic projects and methods,
b. relevant software tools and technologies, and
c. national adoption efforts in the field.

The project will also conduct a survey into the attitudes of stakeholders to the prospective digitalisation of this domain in a range of European countries.

This solid basis will pave the way for a framework that has the potential to achieve real change and drive forward the digitisation of this area. Evidence of this will be collected through the implementation and demonstration on construction projects in various EU regulatory contexts: UK, Finland, Estonia, Germany, and Spain.

1.2 Aims and Objectives

This deliverable will document how the first five objectives of WP1 have been met. These objectives and the tasks that have met them are:

1. **Task 1.1:** Conduct a landscape review and analysis of current adoption of the concept of digitalisation of building permitting and compliance checking across:
    a. academic projects and methods,
    b. relevant software tools and technologies,
    c. national adoption efforts in the field.
2. **Task 1.1**: Conduct an EU wide survey into the attitudes of stakeholders to the prospective digitalisation of this domain.

3. **Task 1.2:** Ascertain the current laws, regulations and guidance that currently drive building permitting across EU consortium member states.
4. **Task 1.2:** Investigate and formally model the existing building permitting and compliance checking processes in the demonstration countries.
5. **Task 1.2:** Perform a preselection of regulations/requirements to focus on the future development of prototype implementation within the demonstration projects.

2. Methodology

This section will document the methodology followed by this deliverable. The results of this methodology, will produce the following concrete outputs that will feed into future tasks of the ACCORD project:

1. A landscape review of the domain of digitalisation of building permitting and compliance checking.
2. A set of requirements, and obstacles to be considered in later ACCORD tasks as part of the specification of the ACCORD platform.
3. An initial list of identified standards that may be relevant to the accord project.
4. A list of selected laws, regulations, and guidance to be considered for digitisation by the ACCORD project.
5. A set of as-is process models for building permitting and compliance checking processes in the demonstration countries.

The outputs will be delivered through the methodology shown in Figure 1. With sub elements described in more detail below.

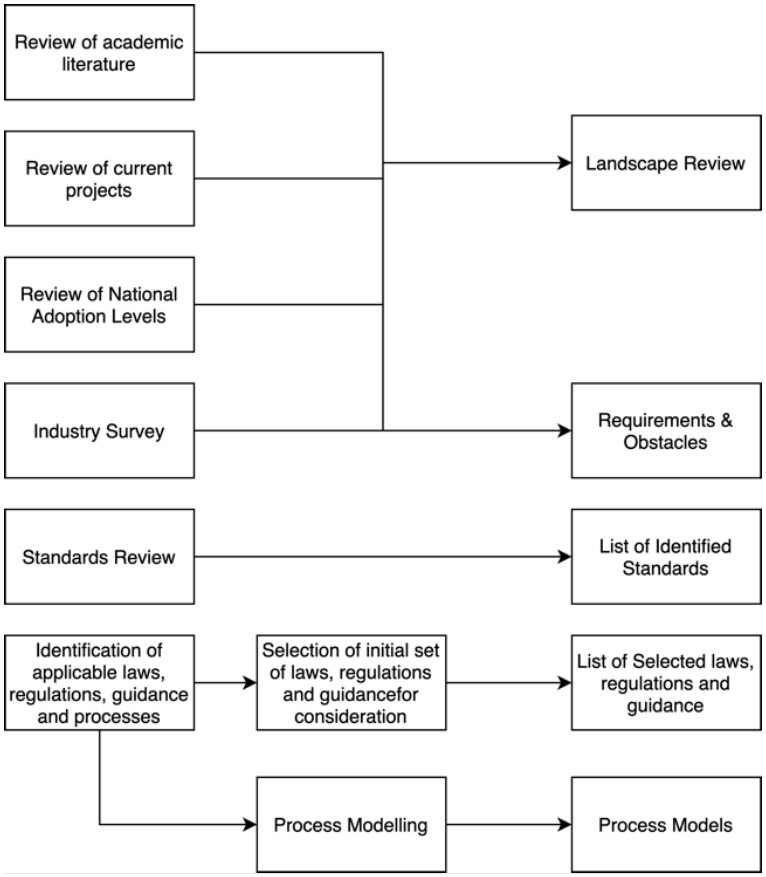

Figure 1. Deliverable Methodology

Review of academic literature and software tools (Section 3.1/3.2): A literature review of academic literature/industry software will be conducted, specifically the scope of this review will not focus on supporting technologies but on academic projects that have implemented and demonstrated approaches of either digital building permitting or automated compliance checking.

Review of national adoption levels (Section 3.4): Each demonstration partner will be asked to examine and document the level of adoption of digital building permitting and automated compliance checking in their country.

Review of current projects (Section 3.2): A review exercise will be conducted to identify current national, EU or international research projects (that have not been identified by any of the previous two elements) of methodology.

Industry survey (Section 4): A survey will be developed and distributed across Europe in multiple languages. This survey will aim to: (a) gather and understand the attitudes of stakeholders to the prospect of digitalisation of digital permitting and automated compliance checking, (b) gather information on the software used and current national adoption to further inform the landscape review, (c) gather a list of possible outcomes, obstacles, drawbacks, and requirements for the adoption of digital building permitting / automated compliance checking and (d) gather contacts for future project dissemination activities.

Standards review (Section 5): All ACCORD partners will be asked to contribute a list of standards that they feel may be relevant to the project. Following this submission, the standards will be categorized and filtered to ensure they are applicable to the ACCORD project. The categorisation that will be used is (a) Semantic Interoperability, (b) Software Interoperability, (c) Managerial and Organisational and (d) Methodological Standards.

Identification of applicable laws, regulations, guidance, and processes (Section 6): The current (as-is) building permit processes in the demo countries will be analysed to identify: a) the actors/stakeholders, b) the activities, and c) the regulations involved. Demo country representatives interviewed three persons that were identified as experts in the country's building permit processes. Usually, these persons work as municipalities' building permit authorities. A consent form was delivered to the interviewed persons. From the information gathered from these individuals, list of laws, regulations and guidance were selected for further consideration in the later tasks of the ACCORD project.

These interviews also provided the background information, along with the partners' own knowledge, to perform process modelling. The process modelling was done using an online collaborative platform that included a template for modelling processes[1]. The template followed the business process modelling notation (BPMN), which is one of the most widely used modelling languages to visualize process workflows. Figure 2 shows an example of a process model. The swim lanes represent the workflow from the perspective of one actor/stakeholder.

[1] Miro platform, available https://miro.com/bpmn-diagram/, accessed 16.1.2023.

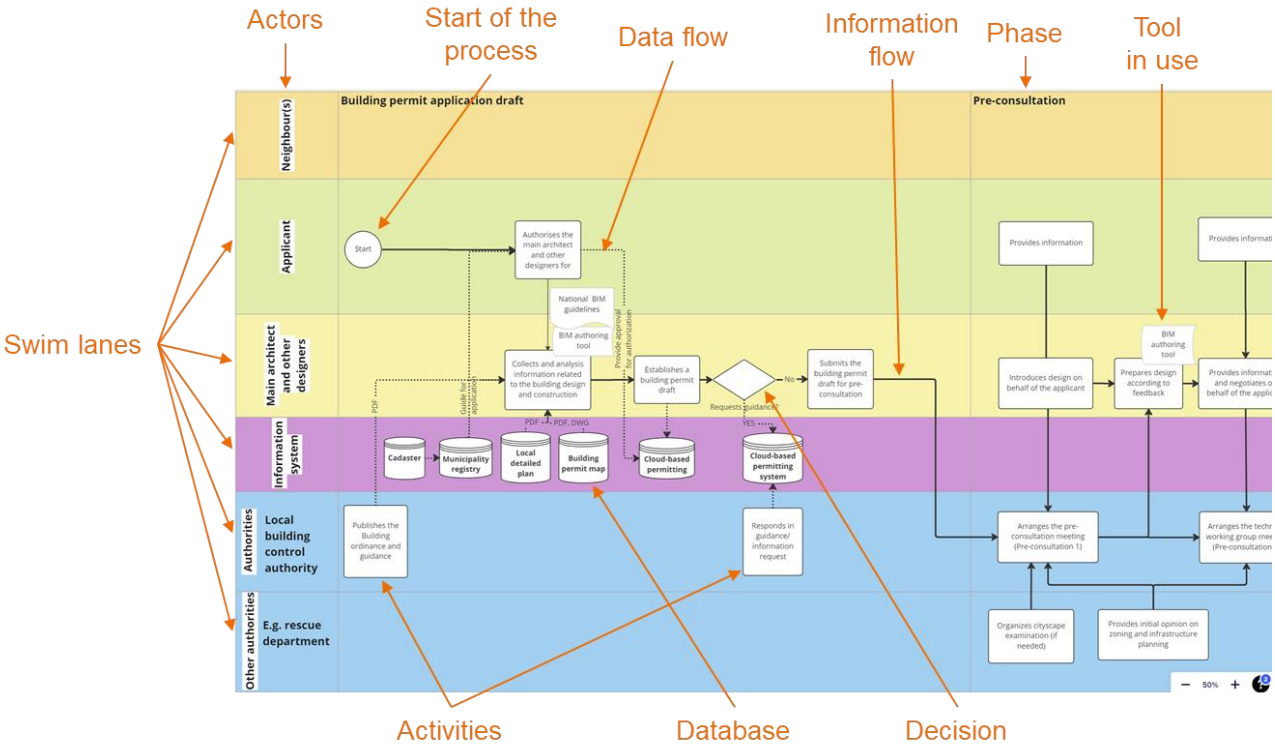

Figure 2. Process modelling notation

ACCORD will also model a future (to-be) building permit process that is based on the ACCORD semantic framework and utilises the tools developed during the ACCORD project. This modelling takes place in WP3 that starts in M9 (May 2023).

3. Landscape Review

This section will present the ACCORD landscape review. This will offer a summary of the current research landscape, together with an analysis of existing tools available and in use in this field. Specifically, the review will cover the following topics, which will each by described in the following subsections:

1. Academic Projects and Methods – will specifically focus on academic projects that have implemented and demonstrated approaches of either digital building permitting or automated compliance checking.
2. Relevant Software Tools and Technologies – will examine software tools that are (or have been) available to support digital building permitting and automated compliance checking.
3. Existing EU Projects and Efforts – will examine current and research national, EU or international projects (that have not been identified by any of the previous two elements).
4. Efforts towards national adoption – will document the level of adoption of digital building permitting and automated compliance checking in each demonstration country.

3.1 Academic Projects and Methods

This first sub-section will briefly review the academic research landscape in the field of automated regulatory compliance. Primarily, this focusses on automated compliance checking and digitised permitting.

The first work in this field was conducted by Fenves (Fenves, 1966), who studied the representation of structural design requirements using tabular decision logic. Then, in 1997 Han et al. anticipated the need for automated code checking with a proof-of-concept prototype allowing explicit specification of functional requirements and design parameters (Han et al., 1997).

Then next significant piece of work was in 2006 when DesignCheck, a tool for automated code checking, was developed (Ding et al., 2006). DesignCheck uses Industry Foundation Classes (IFC) models as a bridge between its internal model and third-party Computer-Aided Design (CAD) tools.

In 2007, Boukamp and Akinci conceptualised an approach to automatically extract inspection and quality control requirements from construction specifications, both specific and standardized (Boukamp and Akinci, 2007). Automating the interpretation of construction specifications will enable consistent automation of subsequent tasks such as inspection and/or defect detection. These authors have created a schema for computer-interpretable construction specifications. The approach then consists of two stages: first, identification of the components that would require inspection and associated tolerances and, second, evaluation of the deviations against captured as-built data (such as 3D point clouds). These authors point out that the process cannot, however, be fully automated due to the lack of required information available from the modelling standards and modelling tools, as well as the lack of support for contextual reasoning.

In 2009, Jeong and Lee studied Building Information Modelling BIM-based automated code checking for fire resistance and egress (Jeong and Lee, 2009). They created their algorithm following an iterative method that combines classification of building codes, analysis of codes for automated checking, extraction of requirements for fire resistance, evacuation stairways and fire protection partitions, extraction of relevant information from the BIM model, evaluation of missing information, algorithm refinement and benchmarking against the same checking performed manually. Their conclusion highlights the challenges of extracting information relevant to the codes from the BIM models (particularly due to errors in IFC file parsing), which is a technical issue, and of displaying the results of the checking to the users so to facilitate potential corrections in the design, which is a human-computer interaction issue.

Then, in a 2009 survey, Eastman et al. pointed out the shortcomings of existing rule-based checking systems (Eastman et al., 2009), in terms of rule writing (particularly for a non-programming expert), rule digitisation, rule base management and tool integration. From their review, these authors extrapolated general requirements for rule checking system development: a method to translate natural language statements into logic-based statements and a method to semantically enrich the design model with objects and relations required by the obtained rules. They created their algorithm following an iterative method that combines classification of building codes, analysis of codes for automated checking, extraction of requirements for fire resistance, evacuation stairways and fire protection partitions, extraction of relevant information from the BIM model, evaluation of missing information, algorithm refinement and benchmarking against the same checking performed manually.

In 2010, Greenwood et al. inferred guidelines for future BIM-based compliance checking by reviewing existing implementations of code compliance checking (Greenwood et al., 2010). They extracted the following guidelines: (a) machine interpretable rules should be understandable by regulation authors; (b) rule bases should be CAD implementation-neutral (this is key for localisation of checking systems); (c) consequently open standards should be favoured; and (d) model checking should be integrated with the model authoring processes, to ensure applicability of the checking rules. Also, in 2010, Tan et al. proposed an approach to combine results from the hygrothermal performance simulation of a building envelope with building codes to support compliance checking (Tan et al., 2010). The approach relies on an extended BIM that also contains simulation results, thus extending the XML representations of the IFC schema and data (ifcXML) schema. Building codes are created manually in the form of decision tables derived from the targeted design regulations and their interdependencies. Use of an off-the-shelf rule engine allows the user to define and execute the rules.

In his 2011 PhD thesis dissertation, Lee presented a new domain-specific programming language, the Building Environment Rule and Analysis (BERA) language, to define, analyse and check rules (Lee, 2011). BERA is built on top of the Solibri Model Checker framework and is designed to overcome the shortcomings of the general-purpose programming classically used to develop BIM software. The language embeds an object model that includes building objects and their relationships natively, thus achieving “a human-centred abstraction of complex state of building model”. Thanks to its domain specialisation, the BERA language does not require the knowledge of a general-purpose programming language and does not rely on a pre-established software tool. It enables built-environment users to build their own bespoke applications, beyond the predefined capabilities of existing software. The main challenge of such a language is to extend its object model with new objects or new properties of existing objects in a way that is transparent for the user.

In 2011, Salama and El-Gohary proposed an approach to enrich the knowledge representation and reasoning of underlying compliance checking rules beyond commonly used if-then-else rules (Salama and El-Gohary, 2012). Also, in 2011, Zhang et al. implemented an automated object-oriented rule checker with a view to integrate safety planning in the design process for better project execution planning (Zhang et al., 2011). Lastly, Hjelseth and Nisbet, in 2011, use the RASE concept to capture normative constraints, applying the methodology to extracts from the Norwegian accessibility standard, Dubai building regulation and US court design guidance document (Eilif Hjelseth and Nick Nisbet, 2011).

In 2012, Zhong et al. proposed a meta-model of construction quality inspection and evaluation concepts to overcome the large number of regulations in this area (Zhong et al., 2012). The meta-model is implemented as a Web Ontology Language (OWL) ontology, which allows regulations to be expressed as a combination of OWL axioms and Semantic Web Rule Language (SWRL) rules. These authors used the Code for Acceptance of Construction Quality of Building Foundation (GB50202-2002) as a case study. The design of this meta-model partially follows the Java Inspection Framework (JIF), which provides an abstract specification of software inspection application concepts, such as inspection task and inspection object. Zhong et al. used a simplified Building information ontology based on the ifcOWL ontology (which is a comprehensive OWL representation of the IFC schema, produced systematically by an EXPRESS-to-OWL transformation), and aligned it with W3C’s (World Wide Web Consortium) Semantic Sensor Network ontology to support the building environmental monitoring requirements of the targeted regulations. Information specific to the building were manually populated using Protégé’s graphical user interface, these authors however acknowledge the need for making IFC models available as semantic web OWL resources.

There was an increase in activity in 2013. Firstly, Dimyadi and Amor again assessed the state of automated code compliance checking (Dimyadi and Amor, 2013a, 2013b). Their review highlighted that the availability of both digital representations of building objects and computable representations of regulation texts, as being the main challenge of automated compliance checking.

Subsequently, Hjelseth also proposed a methodology to facilitate the integration of regulation texts in BIM-based code checking tools (Hjelseth, 2013). His methodology relies on three main procedures: “transcribe” (those rules that are computable), “transfer” (those that are not computable) and “transform” (those that can be transformed to be computable). Also in 2013, Melzner et al. performed a case study of BIM-based automated compliance checking, using decision tables, for early detection of fall hazards as part of the safety planning workflow (Melzner et al., 2013). The LicA tool was also proposed in 2013 by Martins et al. This is a tool that automatically assesses the compliance of a building’s water network design with a subset of the Portuguese domestic water systems regulations (Martins and Monteiro, 2012). Finally, Salama and El-Gohary (Salama and El-Gohary, 2016) presented an implementation of an information extraction tool supported by both semantic modelling and machine learning. These authors used rigorously tuned machine learning model (a support vector machine) to classify the clauses of general conditions of construction contracts.

In 2013, Sulankivi et al. used BIM-based automated compliance checking to avoid accidental inclusion of safety issues in the construction schedule (Sulankivi et al., 2013). The methodology is

based on a checking algorithm that checks the safety of slabs for each task in the schedule to decide on the installation of guardrails. The method is limited by its focus on slabs and is unable to check slabs in complex situations. More detailed guardrail/safety net models in the IFCs are required to support a comprehensive BIM-based fall prevention system.

In 2013, Zhang et al. developed algorithms for BIM-based automated safety checking (Zhang et al., 2013). The main contribution is a table-based safety rule translation algorithm. Their iterative rule-based checking methodology consists of 3 steps: (a) categorise the rule according to identification of relevant objects and their geometrical attributes; (b) apply safety checking algorithm on the objects using a rule engine, show checking results to inform the user; and (c) update the checking results following the user input and loop on the next object.

In 2014, Chen and Luo developed a BIM-based construction quality framework (Chen and Luo, 2014). Their methodology relies on the construction of a checklist database following the product, organisation, and process (POP) data definition structure, based on control codes and standards. Combined with a BIM-model, the database constitutes a BIM-based construction quality model. During the construction process, information collected on-site is used to perform quality analysis, divided into logical analysis, integrity analysis, deviation analysis and compliance analysis. These authors tested their approach with a BIM model created using Autodesk Revit and Navisworks. As opposed to traditional drawing-based quality management, this approach ensures that information is kept consistent, and that quality control is integrated in the construction workflow. It is however limited by the lack of support for temporary structures in BIM models and by the necessity of onsite mobile computing devices.

In 2014, Cheng and Das presented their web service-based framework for green building code checking and simulation (Cheng and Das, 2014). Their approach, which utilises a rule engine and is based on Green Building XML (gbXML) models, evaluates and updates models iteratively by requesting input from multi-location cross organisational collaborators. Nahangi and Haas investigated automated compliance checking in construction assemblies (Nahangi and Haas, 2014). Their approach combines automated scan-to-BIM registration with a neighbourhood iterative closest point algorithm to detect fabrication defects. Also in 2014, Choi et al present their development of an open BIM-based evacuation regulation checking system, specifically validated against the Korean Building Code for high-rise and complex buildings (Choi et al., 2014).

In 2015, Lee et al. applied automated rule-based checking to accessibility and visibility (Lee et al., 2015). Their approach is based on Lee's BERA language, described previously. Also in 2015, Ciribini et al. presented an innovative use of model checking with a BIM-based e-procurement framework (Ciribini et al., 2015). Their research methodology consisted of converting an existing set of tendering texts into computable rules using Solibri Office (following the RASE methodology) and of tendering drawings into a BIM model using Revit. Macit et al. also presented a hybrid model to represent building code using both the four-level paradigm and semantic modelling (Macit et al., 2015). The four levels derive from the semantic modelling approach of SMARTcodes, they are: the domain level, the rule level, the ruleset level, and the management level. Hjelseth also proposed a classification of BIM-based model checking into four categories (Hjelseth, 2015): validating (i.e., checking the compliance to some requirement/regulation), guidance (i.e., proposing solutions with respect to best practices), adaptive (i.e., automatically adjust a building object to conform to the rules) and content (i.e., examining the completeness of a BIM model against a specific use). Zhang & El-Gohary (Zhang and El-Gohary, 2015) used rule-based semantic natural language processing techniques to automate the extraction and the machine-process-able representation of regulatory requirements from textual regulatory documents. Their method was tested on several clauses from the International Building Code and evaluated by comparison with a manually generated reference. These authors were then able to identify sources of errors, that would allow to improve the automated. Also in this year, Preidel and Borrmann introduced a semi-automated method for compliance checking using the Visual Code Checking Language (VCCL). They demonstrate the method against an exemplary German fire code (Preidel and Borrmann, 2016).

Finally, in 2015, RegBIM (Beach et al., 2015) was developed as an end-to-end methodology for regulatory compliance, underpinned by using IFC as a data model. The methodology behind the software includes; (a) the use of regulation experts to mark-up regulatory documents using RASE (Nisbet et al., 2008), (b) the use of BIM experts to map between the regulations and IFC data models, (c) the use of a rule engine (later a semantic model) to perform the compliance checking, and (d) an innovative user interface to show the complex structure of compliance checking results to end users in an easily understood way.

In 2016, Krijnen et al. published an overview of technologies for requirement checking on building models (Krijnen and Van Berlo, 2016). According to these authors, automated rule checking requires a holistic integration between classification systems, concept libraries, query languages, reasoners, and model view definitions. Also, in 2016 Zhang et al. developed algorithms for BIM-based automated safety checking (Zhang et al., 2013), using a rule-based NLP method to extract information from construction regulatory documents (Zhang and El-Gohary, 2016a). Zhang et al (Zhang and El-Gohary, 2016b) also presented an NLP-based methodology to semi-automate the generation of BIM extensions to support automated compliance checking. The methodology combined: (a) part-of-speech pattern matching to extract regulatory concepts, (b) term-based matching and semantic-based matching to select relevant IFC concepts and machine-learning based classification to identify relationships between pairs of concepts. Another study by Li et al (Li et al., 2016) also applied NLP coupled with spatial reasoning to automate utility compliance checking. In this work, the NLP algorithm translates the textual descriptions of spatial configurations into computer-processable spatial rules. Spatial reasoning executes the extracted spatial rules following a logical order in a Geographical Information System (GIS) to identify noncompliance.

In 2017, Roychoudhury et al. proposed an approach for semi-automated transformation of legal natural language (English) text to Semantics of Business Vocabulary and Rules (SBVR) Model via authoring of Structured English (SE) rules (Roychoudhury et al., 2017). The method relies on a domain dictionary and a clause-based open information extraction technique, a context-free grammar of SE and a framework for translating SE into conceptual regulatory models. SE allows the framework to benefit from interactive input of domain experts.

In 2017, Hakim et al. proposed a classification system for automated compliance checking rules to support their translation from plain language to computable language (Hakim et al., 2017). The classification consists in three main categories, according to the quantity and complexity of BIM data required by the rule, each category being subdivided into two sub-classes according to the level of compliance with IFC. Also in 2017, Dimyadi et al. (Dimyadi et al., 2016) evaluated the adequacy of LegalDocML and LegalRuleML to support automated compliance checking in the construction and facility management domains. They found these approaches to be suitable and developed a proof-of-concept demonstration of the use of them in for the submission of building consent.

In 2018, Zhong et al. designed an ontology-based framework for building environmental monitoring and compliance checking (Zhong et al., 2018). The framework is built upon a BIM ontology (derived from ifcOWL), a sensor ontology (W3C's Semantic Sensor Network ontology) and an ontology of building regulations. SPARQL Protocol and RDF Query Language (SPARQL) queries are used to formalise the rules and constrains from building regulations. Also in 2018, Jiang et al. proposed a semi-automated green building evaluation framework based on an ontology that enriches BIM models with the required multidisciplinary data (Jiang et al., 2018). Their framework consists of a text knowledge extraction process, a BIM information extraction process, and an ontology building and reasoning process (combining semantic rules and a rule engine). Zhang & El-Gohary (Zhang and El-Gohary, 2018) also proposed an approach to differentiate and assess the computability of code requirements and sentences to inform NLP-based automated compliance checking methods. Their approach: (a) pre-processed a corpus of natural language code requirements, (b) performed clustering analysis of the pre-processed corpus, (c) characterised each cluster in terms of semantic and syntactic structure and assessing the computability of cluster elements. Applying the approach to a portion of the International Building Code, the authors identified classes of code sentences that are particularly challenging to represent computationally.

In 2019, Nawari (Nawari, 2019a, 2019b) defined a conceptual and theoretical framework to standardise the extraction of regulatory requirements from textual regulations for design review and propose a modular architecture for the implementation of automated design review. The framework classifies regulation clauses into four categories: content (definitions), provisory (explicit rules), dependent (on provisory clauses) and ambiguous (fuzzy knowledge). The formal language proposed by the paper is based on an object-driven representation of rules that can deal with uncertainty. The framework is flexible and can adapt to various engineering design disciplines. This work specifically focuses on checking of compliance of IFC models against regulations expressed their formal language.

Bus et al. (Bus et al., 2018) experimented with an approach based on semantic web technologies for compliance checking, using the IfcOWL ontology. Their approach consisted of: (a) homogenising the modelling style among different stakeholders of a project using a reference BIM Execution Plan, (b) creating regulatory terminology by enriching the IfcOWL vocabulary with explicit and inferred regulatory concepts, (c) simplifying the semantic representation of geometrical features by computing IFC object bounding boxes, (d) and generating machine processable regulatory requirements by semi-automatically converting natural language rules into SPARQL queries. They tested this approach with French fire safety and accessibility regulations. Zhang (Zhang, 2019) focused on the possibility of using current open standards for capturing requirements in the building industry to automatically check building models. Based on this, an approach was developed together with the ability to query related semantic and geometric information in building models. A research prototype was constructed, and this approach was validated.

Nawari et al. (Nawari, 2020) proposed the Generalized Adaptive Framework (GAF). GAF is a process for computerizing regulatory compliance checking based on an object-based representation of building regulations. It enables the translation of regulations into efficient computable expressions. Using the GAF approach, they (Messaoudi et al., 2019) presented the development of a virtual permitting process for the state of Florida. Based on an analysis with local stakeholders, a virtual permitting framework is proposed using building information modelling. This computable model, generated using the GAF approach, is then linked with a building information model using MVDs. This work was subsequently further expanded and deployed in the post disaster recovery use case (Messaoudi and Nawari, 2020).

In 2020, Sydora and Stroulia (Sydora and Stroulia, 2020) presented a domain-specific language for computationally representing building interior design rules only (non-regulation) and a method for evaluating rules in this language against a BIM model.

In 2021, Hjelseth and Li (Eilif Hjelseth and Beidi Li, 2021) investigated a dedicated spatial reasoner, ASP4BIM, against several New Zealand Building Code provisions. The spatial reasoner is intended to be complementary to current approaches and the authors are vocal that they do not advocate for the elimination of ambiguity and vagueness, but the co-existence of prescriptive and descriptive codes.

The year 2022 saw increased interest in this area with Jiang et al., (Jiang et al., 2022) proposing a grey-box checking technique and a BIM-based automated code compliance checking methodology that leverages ontology. The authors implement an automated code compliance checking platform against Chinese Building Codes. Moult et al, (*EG-ICE 2020*) proposed the use of the Gherkin language for automated compliance checking, enabling them to leverage on technology from the domain of software development continuous integration. Furthermore, Zheng et al (Zheng et al., 2022) use a mix of NLP and semantic alignment techniques to extract regulations from text documents, align the semantics found in the documents to those in an ontology that relates to IFC models. This then advances to an attempted automated generation of SPARQL queries based on this alignment. Doukari et al., (Doukari et al., 2022), demonstrate bottom-up object centred approach for automated model checking and the corresponding plugin prototype. The authors present two case studies, one of which was a fire safety check against fire doors. Finally, Fauth et al. (Fauth et al., 2023) was one of the first papers to take a primarily process orientated and not technology

orientated view of the problem, identifying that digital solutions do exist, but at the sub-process level, not for wider “meta” processes.

In 2023, Zhang et al, (Zhang et al., 2023) reviewed different rule representation approaches and defined a framework for the capabilities needed to represent the rules that are required for automated compliance checking. Finally, Zhang and El-Gohary (Zhang and El-Gohary, 2023) propose a deep learning method for IFC-regulation semantic information alignment, these attempts to automatically align the semantics used in the IFC schema (and documentation) with those found in the regulatory texts.

A summary of the papers reviewed in this section that resulted in tangible demonstrable prototypes are summarised in Table 1. It should be noted that the “Allows for Digitisation” column refers to the ability of the work to facilitate the digitisation of new regulations in some convenient way (i.e., excluding manual coding or modelling).

Table 1. Summary of Academic Literature Landscape Review

Name	**Subject of compliance checking**	**Allows for Digitisation**	**Checking Methodology**	**Input Data Format**	**Output Data Format**
Singapore CORENET ePlanCheck (Liebich et al., 2004)	Regulations from Singapore related to building design, fire safety, water, energy usage, barrier-free access	No	Submission of Building Model to Server	IFC building models enriched with calculations made with FORNAX engine.	Compliance report displayed in 3D view of CORENET web interface
DesignCheck (Ding et al., 2006)	Disabled Access Regulations	No	Checking against single IFC Model	IFC models enriched with code-related properties.	Interactive report page and print-friendly report page
Tan (Tan et al., 2010)	Building Envelope Design	No	Single Model Check	Expanded Object Model	Report
Zhang (Zhang et al., 2011)	Site Safety	No	Single Model Checking	Tekla API	Report
Melzner (Melzner et al., 2013)	Site Safety	No	Single Model	IFC	Report
LiCA (Martins and Monteiro, 2012)	Water Distribution Systems	No	Single Model Check (via a process of conversion)	IFC	Report and Visualisation
Sulankivi (Sulankivi et al., 2013)	Guard rails for Slabs	No	Single model check	IFC	Report, visualisation, and insertion in model
Cheng and Das (Cheng and Das, 2014)	Energy Simulation	No	Single Model Check	gbXML	Report

Choi (Choi et al., 2014)	Evacuation	Yes	Model check via InSightBIM–Evacuation	IFC	Report and visualisation
Lee (Y. C. Lee et al., 2015)	NA	Yes - Domain Specific Language	Single Model Check	IFC	Report
Ciribini (Ciribini et al., 2015)	Tenders	Yes - RASE	Single Revit Model	Revit	Report
Macit (Macit et al., 2015)	Izmir Municipality Housing and Zoning Code	No	Single Model	Not specific	Not specified
RegBIM (Beach et al., 2015)	UK Building Regulations	Yes - RASE	Submission of single model	IFC	IFC + JSON Report
Zhang (Zhang and El-Gohary, 2016a)	International Building Code	Yes - via NLP	Single Mode Check	IFC	Report
Preidel (Preidel and Borrmann, 2016)	German Fire Code	Yes - via VCCL	Single Model Check	BIM (unknown)	Visualisation
Li (Li et al., 2016)	Utility compliance	Yes, via NLP	Single Model Check	GIS	Visualisation
Dimiyadi (Dimyadi et al., 2016)	New Zealand Building Code	Using LegalRuleML	Single Model Check	ifcOWL	Report
Zhong (Zhong et al., 2018)	Environmental Monitoring	No	Single Model Check	ifcOWL	Report
Zhang and ElGohary (Zhang and El-Gohary, 2018)	2015 International Building Code	Presents a methodology for identifying the different types of building code requirements in terms of computability and if they can be automated	NA	NA	NA
Bus (Bus et al., 2018)	French Fire Safety, Accessibility Regulations	No	Single Model Submission	ifcOWL	Report
Nawari (Nawari, 2019a, 2019b)	Florida Building Code	Yes, proposes a framework for automating code compliance	Single Model Checking	ifcXML	Report
Zhang(Zhang, 2019)	Multiple Use Cases (Norway, US, South Korea)	No	Single Model File	ifcOWL	BCF (BIM Collaboration Format)

Nawari (Nawari, 2020)	Construction Regulations	Generalised Adaptive Framework - A framework to convert regulations into computable models	NA	IFC	NA
Messaoudi (Messaoudi et al., 2019) (Messaoudi and Nawari, 2020)	Permitting for State of Florida	No	Single Model Submission	IFC	Report
Hjelseth (Eilif Hjelseth and Beidi Li, 2021)	New Zealand Building Code Provision	Dedicated spatial reasoner ASP4BIM	Single Model Check	IFC	Report
Jiang (Jiang et al., 2022)	Chinese Building Codes	Implementation of automated code compliance checking via BIM leveraging an ontology	Single Model Check	IFC	Report and visualisation
Zheng (Zheng et al., 2022)	Fire Safety	Yes, via NLP and semantic alignment	Single Model Check	IFC	Report
Doukari (Doukari et al., 2022)	Fire Safety	modular 'if-then else' XML rules encoding	Single Model Check via SYNEG plugin	IFC	Report and visualisation
Zhang (Zhang and El-Gohary, 2023)	International building code, international energy conservation code, Americans with Disabilities Act Standards for Accessible designs	Deep learning method for IFC-regulation semantic information alignment	Single Model Check	IFC	Report and visualisation

3.2 Relevant Software Tools and Technologies

This subsection summarises the currently available tools offering digital building permitting / automated compliance checking functionality. This analysis was performed by identifying the tools currently available and determining if it is in scope. Each tool deemed to be in scope for this study was then analysed, where a license was not available academically, its documentation was reviewed. The software identified and analysed are summarised in Table 2. It should be noted that individual custom portals developed for individuals' nations/municipalities are not mentioned here, instead they will be discussed in Section 3.4.

Table 2. Summary of Industry Tools Landscape Review

Name	Subject of compliance checking	Allows for Digitisation of Regulations	Methodology	Input Data Format	Output Data Format	Status
AEC3 Require1	No inbuilt regulations	Yes, any regulation using markup.	User performs an automated check of design model against all digitised standards.	IFC	Textual Reports, XML and IFC	Pre-Commercial
Autodesk Model Checker	Multiple rulesets available	Manual specification or customization of rulesets	User performs an automated check of design model against selected rulesets.	Revit	Visual	Commercial
BriefBuilder	Client Requirements	GUI requirements capture at building room level	Checks rooms or buildings against attached regulation	IFC+Revit	Report (PDF)	Commercial
CARS	Design Manual for Roads and Bridges	Specified via a structured word processing tool	No checking but rules access via an API	NA	NA	Not Public
GliderBIM	Custom Rulesets	GUI-based validation ruleset editor	Automated model validation against rulesets	IFC	Reports or RFIs (Request for Improvement)	Commercial
Verify3D	Rules for a variety of local accessibility and fire safety standards/regulations	No	Checking of entire model against predefined regulations	Revit	Visual Analysis	Commercial
UpCodesAI	Rules for a variety of US state building codes	No	Run code check on entire current Revit model.	Revit	Report (PDF)	Not currently available

SMART review	Predefined checking rules for the International Building Code	No	Allows architects to check compliance of entire building design.	Produces detailed textual checking review in navigable HTML.	Revit	Commercial
Jotne EDMmodelchecker	None	Define rules and constraints as an EXPRESS schema.	Selected Rules on entire model	IFC	Violations from constraints visualised in a HTML format.	Previously available
Solibri Office/Site	Many sample rulesets including accessibility and intersections.	Generic Rule Templates customize using the GUI-based Ruleset Manager	Selected Rules on entire model	IFC	Visual	Commercial
BIM Collab Smart views	Smart views are filters to dynamically show, and color-coded components based on their properties	No	none	IFC	Visual	Commercial
CYPE Urban	Tool developed specifically for the Spanish Urban regulations.	Various national and international codes are built in	CYPE programs have a wide range of national and international codes available which are applied to carry out the analysis, design, and check	Various CYPE formats and IFC	Visual	Commercial
ACCA	Modules available to manage BIM/IFC data, create data dictionaries.	For documents and reports associated with BIMs	Not explicit but is able to define exchange information and associate with IFC elements	IFC	BIM and documents	Commercial
BlenderBIM	Open-source software based on IFCOpenShell.	BIM and BCF	Can validate IFC data types, find difference	IFC	BIM, JSON.	Alpha software –

	Can author and edit BIMs		in IFC models, modify BIMs with predefined recipes, execute data model checks (Information Deliver Specification schema)			Open Source
BIMspot	Web based open BIM platform, has predefined rulesets for data enhancement and asset information requirements. regulations	For documents and reports associated with BIM	Can check geometry and clash detection, but not predefined. User can define rules and upload those created in Solibri.	IFC	BIM and documents. BCFzip for model checks	Commercial
Future Insight – Clearly BIM	Collaborative BIM Platform	Voxel / Distance / Geometric Rules hardcoded currently.	A variety of rule checking functionality can be executing integration BIM and city-wide data.	IFC	IFC	Commercial
Cloud Permit	Workflow management / submission system for permits	None	Submission and management of inputs / documents and models	Documents + IFC Files	Documents + IFC Files	Commercial
PlanX	Platform for creating and publishing digital planning services	Allows presentation of UK planning rules via the "Yes/No" user interface.	Hardcoded rules.	None	None	On trial with UK local authorities
Trimble E-Permit.	Workflow management system for permits	None	Submission and management of document and user inputs	Documents	Documents	Commercial
Blocktype	Provides information on UK land plots including characteristics of a site and policy requirements.	Unsure, but policy requirements appear to be hard coded.	Land plot lookup	None	None	Commercial.

3.3 Existing EU Projects and Efforts

This subsection details current and ongoing efforts through EU networks and projects. Firstly, it considers the overarching work by the buildingSMART Regulatory Room, and the EUnet4DP network. It will then cover relevant Horizon Europe projects, along with any national networks / projects that are currently in progress within the countries of the ACCORD consortium.

3.3.1 buildingSMART International Regulatory Room

The buildingSMART Regulatory Room is an industry domain within buildingSMART International and was formed to help project owners and regulatory authorities benefit from the use of openBIM (BIM processes based on open data formats). The vision of the Regulatory Room is to achieve an automated regulatory process using openBIM technologies. This must be through supporting gradual change in workflow from manual to automated, to safeguard the legal perspective.

The key goals of the Regulatory Room are to:

- Standardize processes, workflows and procedures for regulators based on openBIM and support them with tools, guidelines, and manuals.
- Support interoperability between Regulatory, Requirements and Recommendatory (RRR) content
- Provide an open discussion room for each government's building regulators, researchers, and implementers to promote openBIM based processes and collaborative issues.
- Be an arena for government regulatory bodies to share information, inspire and implement automated code checking using openBIM standards including ISO 16739 in real life situations.
- Lead and manage projects and initiatives to facilitate and influence adoption by stakeholders.

Significant contributions of the Regulatory Room to date include:

- Publishing a report on open standards for regulations, requirements, and recommendations content.
- Conducting an industry survey on the role of openBIM in the regulatory process.
- Holding "open house" events, where projects can be presented and discussed.

The ACCORD project already has significant links with this Room, consortium members were involved in co-authoring their reports and the project has already been presented at an open house event on 26th of January 2023.

3.3.2 Horizon Europe Projects

There are currently 4 EU projects (including ACCORD) relevant to the scope of this work ongoing or recently concluded. These are: (1) Chek Digital Building permit (CHEK DBP), (2) Digichecks and (3) Future City Pilot.

Chek DBP (2022->2025) is a three-year funded project (commenced on the 1st of October 2022) with the objective of enabling the development and uptake of digital method for building permitting via a toolkit of methods and technology. CHEK will develop new DBP processes, technologies, and open standards-based data exchange. CHEK is ACCORD's sister Horizon Europe project, funded from the same call.

DigiChecks, (2022->2025) is a three-year funded project it aims to create a new Digital Framework to facilitate the management of construction permits. The project will build a solution to provide flexibility, ease-of-use and efficiency to the permit validation and approval system in construction projects. The second step towards achieving the goal of DigiChecks, which aims to facilitate

digitization in the construction industry. DigiChecks is also ACCORD's sister Horizon Europe project, funded from the same call.

Future City Pilot (2016) is OGC's (Open Geospatial Consortium) pilot project aiming to demonstrate how the use of CityGML and IFC data can together provide stakeholders with information, knowledge, and insight, enhancing financial, environmental, and social outcomes for citizens in cities. Specifically, this project is relevant because one of its initial use cases is the integration of IFC and CityGML data for urban planning.

3.3.3 EUnet4DP

EUnet4DP is a network of researchers and stakeholders aiming at the definition of a common strategy for the digitization of the building permit issuing process, with advantages to interoperability, procedures and data optimization, standardization, and good implementations. The primary focus of the group is the adoption of digital building permitting and automated compliance checking in European member states. In total there are 75 organisations across 16 countries that are members of the network.

3.3.4 XBau in Germany

The primary project within Germany is the XBau project which seeks to standardise the machine to machine communication for permitting processes. A project has also been conducted to determine the possibility of extracting information from an IFC Model into the XBau data standard, with a view for submission for building permitting. In the city of Dortmund, a pilot project has been conducted which aimed to put BIM-based building permitting into practice and showed many advantages but also the difficulties of implementing BIM-based permitting.

Further projects have developed a so called "one for all" solution for the building permit process. This solution utilises the national process and data exchange standard for permitting process XBau and can be reused by states and local authorities. This is known as BauPortal.

A follow up project aims to advance further, creating a uniform basis for the automated checking of building code requirements with BIM-based testing tools. Furthermore, requirements for BIM models will also be developed to make the necessary information for the permitting process available digitally.

3.3.5 D-COM Network in UK

The primary advancement of the field in the UK has been through the D-COM Network. The D-COM network is led by Cardiff University and was formed to drive forward the adoption of the digitization of regulations, requirements and compliance checking systems in the built environment.

To further increase adoption, show the viability of the automated compliance checking approach, and conduct research into; (a) digitizing and subsequently managing requirements and regulations drawn from a variety of contexts and sources, (b) automatic and semiautomatic compliance systems, (c) underpinning data formats to store and subsequently analyse the result of regulatory compliance checking the D-COM network, together with the Construction Innovation Hub developed a set of prototype software tools, which are openly available on GitHub.

These software tools include:

- A document server capable of serving the UK construction regulations in a machine-readable format with embedded rule data.
- A rule engine that enables the compilation and execution of these documents in the DROOLS rule language.
- A results server capable of storing compliance checking results.

3.3.6 RAVA3Pro in Finland

Another project RAVA3Pro is currently in progress, running from 2021 to 2023, is led by the city of Helsinki and financed by the ministry of finance. The project aims to further develop and automate the electronic permit process of municipal building control, with 23 municipalities involved. Helsinki's Urban environment department is the main applicant and administrator. The project uses IFC models and firmly kicks off the automation of building permit inspections within the municipalities.

3.3.7 Other EU Countries

Several other countries have also initiated projects in digitalising building permitting / automated compliance checking. These include:

France: Article 62 of the ELAN law stipulates that as of January 1, 2022, all municipalities with more than 3,500 inhabitants must be equipped with a system allowing for the capture and instruction of building permits in a dematerialized manner. The national Plan BIM 2022 followed on from the Digital Transition in Construction Plan (PTNB), which has been working since 2015 to set up a framework for a digital transition in the construction sector. The Plan BIM 2022 aimed to generalize the use of digital technologies in construction by 2022.

In this context, public authorities have set up the kroqi collaborative web platform, this facilitates the submission of digital permits in the construction sector.

Norway: eByggesearch has been created as a digital guide that guides users on what permits are needed for a particular building project, it also aids the user in filling out digital permit applications.

Austria: have recently completed the BRISE project. This aims to digitise and improve administration in Vienna, including the application and issue of building permits, using openBIM technologies.

Slovenia: have developed the e-prostor service that provides digital access to geodetic data.

Italy: The Structural E-Permit project was carried out in 2019 by ACCA software (Section 3.2), in collaboration with the Campania region in Italy, the University of Napoli Federico II, the public office responsible for structural projects in the city of Avellino, and the Municipality of Montemarano in Avellino. The project focused on the development and application of a framework for automatically checking and verifying if a structural project complies with a certain regulation for issuing an authorization. The project involved the study and systematization of structural design data consistent with the Open BIM process, the IFC standard format and the MVD specification, since the entire process is based on the use of a BIM model of the building in IFC format as primary data exchange between applicant and public body, with three distinct phases.

3.4 National Adoption Efforts toward Digital Building Permit Processes

This section will outline the current national adoption efforts toward digital building permit processes in the ACCORD demonstration countries of Finland, Estonia, Germany, Spain, and UK.

3.4.1 Finland

Finland has conducted various research and development projects (2001-2014) to create the basis for digitalizing public governance and services, such as the SADe program[2] and the KRYSP project, which created the KuntaGML providing a schema to transfer data between systems. It is not an

[2] SADe program to digitalise public governance and services 2009-2014, available https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/75089/SADE-ohjelma_ilman_liitteita.pdf, accessed on 5.12.2022.

official standard, but, e.g., Cloudpermit uses it to move applications and building data from its service to four different back-end systems/registries[3].

In 2016 the municipalities were allowed to use digital archiving for official long-term archives without the requirement of archiving paper documents. This has sped up the digitalisation of permitting procedures. Nowadays, most municipalities also have a web-based interface for applicants to provide documents and input data directly in forms in the user interface.

Around 70% (215) of the municipalities use a cloud-based service provided by Cloudpermit for permit application input and communication between the applicant and authorities. Around 13% of the municipalities use a building permitting service provided by Trimble. The uptake of these two cloud-based permit services has been effective. In 2018, around 150 municipalities used a web-based service. The rest of the municipalities (17%) do not yet use a web-based building permitting service.

The current permitting applications have tremendously benefited from three adaptions in Finland: 1) a national building registry, 2) a national property registry which includes ownership data, and 3) open WMS (Web Map Service) and WMTS (Web Map Tile Service) data sources. For example, when an expansion is being made, having the existing building data and property ownership information readable from an API is crucial to the upkeep of a reliable building registry in a digital process.

The city of Järvenpää has already conducted one successful pilot where a building permit was applied with an IFC-file via Cloudpermit.[4] The IFC model needed to include information on the structure, materials, and facilities of the building, as well as overall areas/volumes. The architecture followed the national common BIM requirements[5] and the municipality's building control's BIM guidelines[6]. The cityscape review and location of the building in the environment were carried out on the municipal 3D service of Järvenpää,[7] developed by Sova 3D. Regulatory compliance was manually checked in the Solibri Model Checker program.

One part of the building permitting procedure is the cityscape assessment to check the suitability of the building for the environment. Several cities have prepared a 3D city model either as a photogrammetry-based mesh model with photo texture or laser scanned model with photos converted in CityGML, usually with Terrasolid Ltd tools. Also, the National Land Survey of Finland is scanning the whole nation with 5 point/m^2 accuracy and is converting the buildings in CityGML meeting LOD2 requirements (a LOD2 building includes differentiated roof structures and thematically differentiated surfaces). This information is available in the public National Topographic Database and can be used to present a city model without photo textures.

A national KIRA-digi program (2016-2019)[8] included three development projects on digitalizing building permitting in Finland[9]. For example, they further developed building control's inspection

[3] Association of Finnish municipalities' Github, available https://github.com/kuntaliitto, accessed on 23.11.2022.
[4] The world's first 3D BIM model-approved building permit in Järvenpää? available https://www.sova3d.fi/i/uncategorized/the-worlds-first-3d-bim-model-approved-building-permit-in-jarvenpaa/, accessed 18.11.2022.
[5] COBIM – Common BIM Requirements 2012, available https://asiakas.kotisivukone.com/files/en.buildingsmart.kotisivukone.com/COBIM2012/cobim_6_quality_assurance_v1.pdf, accessed 5.12.2022.
[6] Järvenpää building control's BIM guidelines, available https://www.jarvenpaa.fi/files/1f830f7f99bfb89be79d7d4da709836890c78be1/tietomallipohjainen-lupakasittely-asuinrakennukset.pdf, accessed 5.12.2022.
[7] Järvenpää's 3D service, available https://kunta3d.com/, accessed 5.12.2022.
[8] KIRA-digi project, available http://www.kiradigi.fi/en/experiments.html, accessed on 5.12.2022.
[9] Building permitting development projects, available

rules and digital archiving of IFC models. Also, interoperability between the needed information systems were developed.

RAVA2[10] project, financed by the Finnish Ministry of Environment (2020-2021), defined the first national propertyset and use cases for the regulatory (minimum) BIM-based Building Permit process.

The Renewal of COBIM2012 part 14 requirements, also financed by the Finnish Ministry of Environment (2021-2022), is a continuum of RAVA2 project. The renewal project updates the BIM guidelines to support BIM-based regulatory building permitting.

Project Ryhti (2020-2024) has two parts: 1) Semantic data interoperability in the built environment[11] and 2) The built environment information system "RYTJ"[12]. The semantic part focuses on defining logical information models and vocabularies/codes for enhancing data interoperability in the built environment. It concentrates on data types needed in the authorities' processes. For example, information on zoning plans and building permits will be compiled and processed into a coherent and accessible form.

A development project, BIM-based building permit – scaling clinic[13], in 2021, developed and unified BIM-based building permit practices in several municipalities. The project was funded by the Finnish Ministry of the Environment, Finnish Property Owners, and project partners.

A current building permit development project, RAVA3Pro[14], is led by the City of Helsinki and funded by the Ministry of Finance to automate step by step the building permit processes of municipal building control. The project includes 23 Finnish municipalities.

3.4.2 Estonia

Since 2016, building permit processes have gone through the digitised environment of the National Building Registry[15] (*ehitisregiser* – EHR). The mandate for using the Building Registry is set in Building Code § 40. This means that all 79 municipalities in Estonia must use the procedural environment of the Building Registry to process building permits even if the construction design documentation is brought on paper. In that case local municipalities must scan the documents, add them to Building Registry and start the process of the building permit. The Building Registry is a central registry controlled by the Ministry of Economic Affairs and Communications. Data in the registry is owned by users – homeowners, utility networks owners and local municipalities.

The digitised permit process is very similar in all municipalities with only some minor exceptions in the process. The applicant (either owner or someone in the contractual relationship with the owner like architect or project manager) starts the building permit application process in the Building Registry: selects what kind of permit they need (building permit, construction notification, design conditions, certificate of occupancy, notice of using the building), fills in the form about technical data about the building (height, depth, areas, volumes, sources of heating/cooling/water, types of

- http://www.kiradigi.fi/media/hankemateriaali/loppuraportit/kira-digi_raportti_28.3.2019.pdf
- http://www.kiradigi.fi/media/hankemateriaali/loppuraportit/kiradigi_-loppuraportti_26032018-002.pdf
- http://www.kiradigi.fi/media/hankemateriaali/loppuraportit/sova3d_gravicon_vantaa_bim-mallit-rakennusvalvonnan-tarkastuksessa-ja-vuorovaikutusprosessissa_loppuraportti.pdf

[10] RAVA2 project, available https://kirahub.org/rava2-kehityshankkeen-julkinen-lausuntokierros-on-kaynnistynyt/, accessed 7.12.2022.

[11] Project Ryhti, steered by the Ministry of the Environment, available https://ym.fi/en/project-ryhti, accessed on 5.12.2022.

[12] The built environment information system, available https://ym.fi/en/project-ryhti/the-built-environment-information-system, accessed on 5.12.2022.

[13] Rakennuslupa tietomallilla -skaalausklinikka, available https://www.rakli.fi/rakennuslupa-tietomallilla-skaalausklinikka/, accessed on 2.1.2023.

[14] RAVA3pro, available in Finnish https://kirahub.org/rava3pro/, accessed on 5.12.2022.

[15] User interface of Building Registry https://livekluster.ehr.ee/ui/ehr/v1 , accessed 13.03.2023

constructions etc), uploads digitally signed construction design documentation (at the moment in PDF format), pays state fee and submits application. The processor from local municipality starts the permit process by taking application, adding parties who either; (a) coordinate the process (state institutions like Rescue Board, Environmental Department, Health Department etc) or (b) who must give their opinions (utility networks owners), neighbours and other interested parties by Administrative Procedure Act[16]. All added parties give their remarks in the Building Registry and the application is sent back to the applicant to correct the remarks. After correction of the remarks the next process round starts, and all parties of process can see if their remarks are corrected. This loops until there are no more remarks. Then the building permit is signed digitally by the representative of municipality in the Building Registry. In every step of the process automatic messages are forwarded to people who are doing their tasks in the registry (for example if application is sent back to applicant or if building permit is signed).

In 2022, the Building Registry went through a major upgrade in user experience and user interface. New services were added (processing design conditions) and the ability to add IFC files was created. In the first half of 2023, BIM-based building permit processes will be introduced to everyone in Estonia. BIM-based building permit processes adds the ability to look around the submission in 3D (using an IFC viewer embedded within the Building Registry) including surrounding area of the building (integration with National Digital Twin[17]). The BIM-based permit process has 47 automatic checks against the Building Code that are shown to both applicants and processor in a simple UI solution. Further checks can be added with simple IT development, that will be done centrally in the ministry. Local municipalities don't need expensive hardware/software and high BIM specific user skills for adopting the BIM-based permit process. In addition to automated rule checking, technical data about the building, that is needed to be inserted into the Building Registry, will be extracted from the IFC BIM model, and sent to building permit application automatically. This feature will save time and reduce possible errors encountered by double insertion of the data. The user interface of BIM based building permit check results is shown on Figure 3. This is a web-based solution, that does not need any additional software from applicant or permit processer.

Figure 3. An IFC model with automated check results, located in its correct geographical coordinates, surrounded by layers from National Digital Twin.

[16] Administrative Procedure Act https://www.riigiteataja.ee/akt/123022011008?leiaKehtiv , accessed 18.11.2022.

[17] National Digital Twin https://livekluster.ehr.ee/ui/ehr/v1/3d , accessed 18.11.2022

In addition to BIM based permitting software, common BIM requirements[18] needed to be developed on the national level to make automated rule checking possible. Process was guided by the Ministry and then delegated to the Standard Committee. National BIM requirements first version was published in the Summer 2022.

3.4.3 Germany

With the gradual introduction of Building Information Modeling (BIM) in Germany, more and more construction projects are being planned and executed with the help of three-dimensional digital building models (so-called BIM models). The digitization of the construction industry also includes the introduction of digital processes for handling administrative procedures under building planning and building regulations law. In the future, the exchange between the players involved must take place digitally. To this end, the IT Planning Council's project "Exchange standards in the construction and planning sector - XBau" has been implemented since October 2014 to create uniform national specifications for the exchange and processing of information in administrative procedures under building regulations law[19].

As part of the federal government's online access law ("Onlinezugangsgesetzes"), a large proportion of administrative processes were to be offered to citizens digitally by 2022, including the digital building application. The working group under the leadership of the North Rhine-Westphalia Chamber of Architects organises the processes towards digital building permits in cooperation with the federal state and local governments.[20]

The reference implementation for the digital building permit was developed in the federal state of Mecklenburg-Western Pomerania.[21] The first parts of the online service have been in use since the beginning of 2021 and are available to other federal states for subsequent use according to the so called "One for all" principle (German: "Einer für alle"). A total of 25 online services have been implemented. With the service catalogue "LeiKa" a uniform and comprehensive directory of administrative services of the federal government, the states and the municipalities are being established in Germany for the first time. The aim is to provide a central information base for service management that is used by all administrative areas across applications and projects for all information and communication channels.[22]

XPlanung and XBau are standardized data formats for use in German municipal software solutions. XPlanung is the information model for all spatial planning, whereas XBau describes the content of messages in building supervisory procedures in a standardized structure. The application of these standards enables the simplification and faster handling of processes at approval and specialist authorities. The use of these standards is required by law for all IT processes that are newly implemented or substantially revised. Existing IT processes in the construction and planning administrations of local authorities must be upgraded to process XPlanung and XBau-based data

[19] Ruhr-Universität Bochum, Lehrstuhl Informatik im Bauwesen, 2023. "BIM-basierte Baugenehmigung in NRW", available https://www.inf.bi.ruhr-uni-bochum.de/iib/forschung/projekte/BIM_Baugenehmigung.html.de, accessed 30.4.2023.

[20] Bundesarchitektenkammer, 2023. "Digitaler Bauantrag", available https://bak.de/politik-und-praxis/digitalisierung/fuer-berufspolitisch-aktive-initiativen-zur-digitalisierung/digitale-planung-in-der-hochschulausbildung/, accessed 30.4.2023.

[21] brain-SCC GmbH, 2023. "OZG-Referenzimplementierung =Digitale Baugenehmigung", available https://www.digitale-baugenehmigung.de/de/rerefenzimplementierung.html, accessed 30.4.2023.

[22] The after-use will be implemented through the Fit Store, available https://www.fitko.de/fit-store, accessed 30.4.2023.

and message objects by the end of a five-year transition period (February 2023).[23]

Even today, BIM models in IFC format can be used as documents for XBau-compliant building documents. The research project “BIM-based building permit” (2017-2019), funded by the Future Construction research initiative of the Federal Institute for Research on Building, Urban Affairs and Spatial Development, developed an overall process of a BIM-based building application procedure based on a selection of use cases and implemented it as a prototype. As a result, a construction project in the city of Dortmund in 2021[24] received the first building permit based on BIM planning.

A follow up project aims to advance this further, creating a uniform basis for the automated checking of building code requirements with BIM-based testing tools. Furthermore, requirements for BIM models will also be developed to make the necessary information for the permitting process available digitally. Currently, pilot projects for the BIM-based building application are underway in several German states.

3.4.1 UK

Current adoption of digitised permitting processes and automated compliance checking in the UK is very limited. All bodies are still requiring the submitting of PDF based documentation (i.e., floor plans etc...), There is, as of current, no adoption of model-based submissions.

There is a variety of systems used to manage the submissions. Many local authorities use the Planning Portal to manage the submission or the "meta-data" (i.e., contact details, grid references etc.) that goes along with an application via a web-based interface. However, some local authorities still require the submission of this data on a PDF form. There is, however, no requirement to provide any hard copy submissions.

Local authorities may have various workflow management tools to help them manage and assign submissions to building control professionals once submitted, but these only manage data in PDF format and are often repurposed document management systems.

3.4.2 Spain

The electronic submission of building permits by means of digital certificates in Spain was implemented years ago in municipalities, local administrations, and professional associations, in compliance with Directive 2014/24/EU on Public Procurement[25] which was transposed into Spanish Law on 1st of October 2015 of the Common Administrative Procedure of Public Administrations (39/2015). Despite this legislation, even today many documents are submitted only in PDF or DWG format (plans, reports, budgets, and calculations) and there are not yet confirmed cases about digital BIM/GIS based permitting or compliance checking.

To date, there is no record of any city council processing permits automatically using BIM/GIS models. There is a pilot initiative of BIM and Blockchain based compliance checking leaded by the Professional Association of Building Engineers[26]. However, no results are published yet.

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[23] Dokumentation zu Conferring xPLanung, available https://mil.brandenburg.de/sixcms/media.php/9/191217_MIL_Konferenz_XPlanung_Dokumentation.pdf, accessed 30.4.2023.

[24] BIM-based planning (in Germany), available https://www.detail.de/de/de_de/bim-basierter-bauantrag-wie-funktioniert-das, accessed 30.4.2023.

[25] Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement and repealing, available https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0024&from=EN, accessed 15.03.2023.

[26] Signature with Blockchain Technology and Legal Backing, available https://www.aparejadoresmadrid.es/home/-/asset_publisher/MmTAO0541oFq/content/taller-firma-con-tecnolog%C3%ADa-blockchain-y-respaldo-legal/maximized, accessed 15.03.2023.

3.5 Conclusion

This section has outlined the results of the landscape review conducted as part of the ACCORD project. The purpose of this review has been to identify key existing examples of digital building permitting and automated compliance checking across the following fields: (a) academic projects, (b) commercial software products, (c) existing national/multinational projects, and d) existing efforts towards national adoption of digital building permit processes.

The understanding of the current work in the field will be invaluable to the ACCORD project in ensuring our work: (a) builds on the best practice in the field so far, (b) does not repeat the mistakes existing tools have made, and (c) is able to build on, and be compatible with, existing efforts towards adoption within the ACCORD demonstration countries.

4. State of the Industry Survey

This section will present the content and the results of the industry survey that was conducted. This survey was conducted with the following aims:

1. Gather and understand the attitudes of stakeholders to the prospects of the digitalisation of digital permitting and automated compliance checking.
2. Gather information on the software used and current national adoption to further inform the landscape review.
3. Gather a list of possible outcomes, obstacles, drawbacks, and requirements for the adoption of digital building permitting / automated compliance checking.
4. Gather contacts for future project dissemination activities.

The remainder of this section will firstly discuss the structure of the survey, its method of distribution and an analysis of the respondents. The results will then be presented and analysed followed by some conclusions.

4.1 Survey Structure

A survey of 25 questions was developed to answer the objectives, these were developed based on previous experience of the survey authors who have conducted similar surveys in the past. Table 3 shows the questions in the survey along with the objectives (from Section 4) to which they correspond. Out of these questions Q1, 5, 7, 8, 10, 12, 14, 16, 18, 19, 21, 23 and 24 were open questions, the remainder of the questions were closed.

Table 3. Survey Structure

No	Obj	Question
1	NA	What is your job title within your organisation?
2	NA	Please select all that apply to you: • I have experience of building permitting. • My role requires my involvement in building permitting processes. • I am experienced in using existing building permitting processes. • I am involved in influencing the implementation of building permitting processes. • I am involved in setting policy for building permitting
3	NA	Please select, from the following, the term that best describes your discipline within the industry: • Architect • Structural Engineer

		• Building Services Engineer • Construction Manager • Project Manager • Building Permitting/Control Professional • Surveyor • Urban Planner • Other (allows free text entry)
4	NA	Where would you say your primary experience lies: • Technical Aspects • Commercial Aspects • Political Aspects
5	NA	What existing software tools do you use (if any) as part of your work in building compliance processes
6	NA	Please select what country you work in
7	2	What efforts is your country currently making towards the digitisation of building permitting processes?
8	2	Are there any software tools commonly used in the building permitting area in your country or municipality?
9	4	Are you willing to take part in follow up activities organised by the ACCORD Project?
10	4	If you selected to participate in follow up activities, please provide your email address:
11	1	From a technology perspective, what do you think is possible in the next 10 years: • 0 - No Automation: The current manual processes are adequate • 1 - Automated Information Exchange: Automating submission of project information for building permitting using appropriate data models • 2 - Automated Validation: Automating the checking of information submitted for completeness • 3 - Partial Automation: Automatic assessment of some key aspects of the building permitting process • 4 – Automation: Fully Automated assessment of the entire building permitting process but requiring final human review and approval. • 5 - Full Automation: Fully automated building permitting • Not Sure
12	1,3	In your opinion, what are the technological limitations today? If there are limitations, what work is required to overcome these?
13	1	If applicable to your country, from a commercial perspective, what do you think is possible in the next 10 years: (Same options as Q11)
14	1,3	In your opinion, what are the commercial limitations today? If there are limitations, what work is required to overcome these?
15	1	From a political and policy making perspective, based on your knowledge, what is possible in the next 10 years: (Same options as Q11)

16	1,3	In your opinion, what are the political and policy making limitations today? If there are limitations, what change is required to overcome these?
17	3	As possible outcomes of adopting digitised building permitting processes, please assign importance to the following statements (Ranked Essential, Highly Desirable, Desirable or Not Required): A. A standardised data schema to formally document building permitting processes. B. A standardised data schema to represent applicable regulations/legislation/requirements. C. Standardised model formats to enable data-centric submission of information to build permitting processes. D. Artificial intelligence to interpret between regulations/requirements and proposals, such as natural language processing. E. Ability to link building permitting processes, applicable legislation and building data standards. F. Auditable rule processes to track decisions and uncertainty.
18	3	Please describe any other possible outcomes you feel are important
19	3	Please describe any drawbacks from the adoption of digitised building permitting you feel are important.
20	3	With reference to future requirements for the adoption of building permitting and automated compliance checking, please assign importance to the following technologies (Ranked Essential, Highly Desirable, Desirable or Not Required): A. A standardised data schema to formally document building permitting processes. B. A standardised data schema to represent applicable regulations/legislation/requirements Standardised model formats to enable data-centric submission of information to building permitting processes. C. Artificial intelligence to interpret between regulations/requirements and proposals, such as natural language processing. D. Ability to link building permitting processes, applicable legislation and building data standards. E. Auditable rule processes to track decisions and uncertainty.
21	3	Please describe any other technologies you feel are essential
22	3	With reference to future requirements for building permitting and automated compliance checking, please assign importance to the following additional commercial arrangements (Ranked Essential, Highly Desirable, Desirable or Not Required): A. Reduced costs for assessment B. Faster turnaround for assessment C. Ability to pre-check for compliance prior to formal submission. D. Use of digitised building permitting processes to be required for non-domestic projects. E. Use of digitised building permitting processes to be required for domestic projects.
23	3	Please describe any commercial benefits or cautions you feel are essential for automating regulatory compliance.
24	3	With reference to future requirements for building permitting and automated compliance checking, please assign importance to the following positions (Ranked Essential, Highly Desirable, Desirable or Not Required): A. Primacy of data models over documentation and drawings for the purposes of compliance submission B. Public right to see compliance assessments. C. Additional standard data and criteria for social, environment and economic impact assessments
25	3	Please describe any political or policy-making aspects you feel are essential

4.2 Survey Distribution & Analysis Methods

The survey was distributed through the ACCORD project partners. It was firstly translated into Catalan, Estonian, Finnish, French, German, Italian and Spanish (to match the languages of consortium partners). The survey was then made available in each of these language (along with English) via the ACCORD website. Links to the survey were then distributed via social media and direct dissemination by ACCORD partners.

Once the survey closed, the responses were integrated, and all free text responses translated back to English for analysis. Some free text responses were removed/moved based on these criteria:

- Remove all empty and no content responses (i.e., random characters etc..).
- Remove all responses that simply restate the question.
- Move responses to the correct question where respondents have answered a question in the wrong place.
- Remove out of scope answers (i.e., any answers not to do with the topic of the survey).

4.3 Survey Respondents

In total the survey had a total of 472 responses. This section will outline the breakdown of the respondents, drawing information from Questions 1-6.

The responses were divided between countries as shown in Table 4. This shows us that the survey was dominated by those working in Italy, but a good number of responses were also had from Spain, Finland, and Estonia.

Table 4. Distribution of Respondents per Country

Country	**Number of Respondents**
Italy	346
Spain	39
Finland	25
Estonia	12
Romania	8
Other (Outside of EU)	7
Germany	7
France	6
UK	5
Ireland	4
Netherlands	3
Poland	3
Portugal	2
Luxembourg	2
Austria	1
Greece	1
Belgium	1

How these respondents were divided across discipline boundaries is shown in Table 5. This showed that most respondents were architects, but, encouraging, we also had a good number from building permitting/control professions.

Table 5. Distribution of Respondents per Discipline

Discipline	**Number of Respondents**
Architect	391
Building Permitting/Control Professional	29
Other	29
Project Manager	9
Building Services Engineer	4
Construction Manager	3
Structural Engineer	3
Urban Planner	2
Surveyor	2

Experience shows how the respondents reported their primary competencies. This showed that, most respondents had a technical background. This is not surprising, as the project partners are primarily technical in nature and thus, it is to be expected that their reach is more with a technical audience.

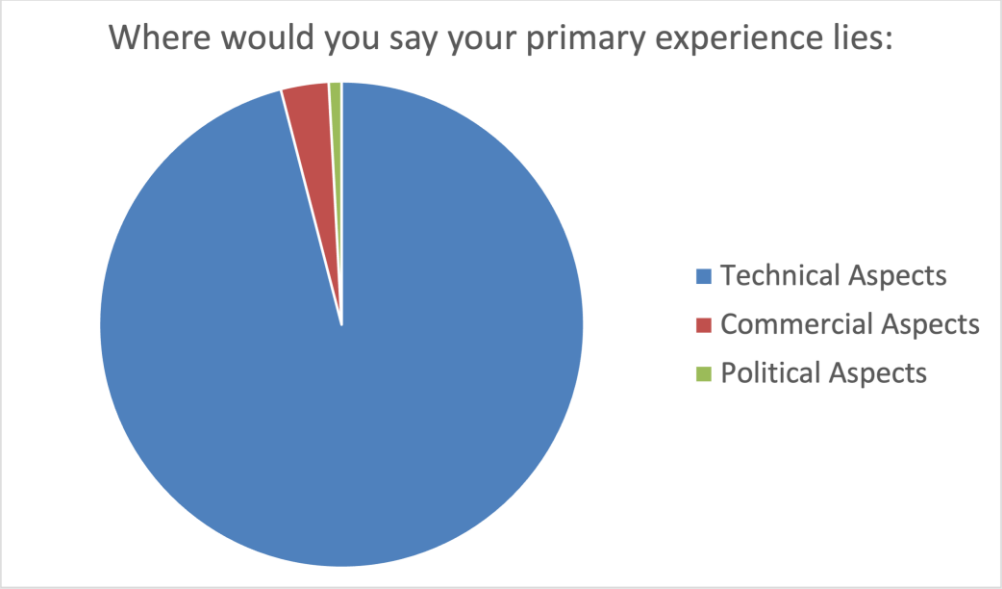

Figure 4. Primary Experience

Finally, Table 6 shows how respondents reported their experience in various aspects of digital building permitting or compliance checking. Virtually all (89%) respondents had some experience of building permitting, while 59% of respondents current role requires involvement in the building permitting process or were experienced in using existing building permitting processes (65%). Fewer, however, were in direct involvement in influencing the implementation of building permitting processes (25%) or setting policy for building permitting (14%).

Table 6. Experience Held

Experiences Held	Count
I have experience of building permitting.	419
My role requires my involvement in building permitting processes.	277
I am experienced in using existing building permitting processes.	308
I am involved in influencing the implementation of building permitting processes.	116
I am involved in setting policy for building permitting.	68

4.4 Views on Potential for Digital Building Permitting / Automated Compliance Checking

This section will examine respondents' views on the potential of digital building permitting / adopting automated compliance checking over the next 10 years. To achieve this, respondents were asked what level of automated they felt was possible from these options:

- 0 - No Automation: The current manual processes are adequate
- 1 - Automated Information Exchange: Automating submission of project information for building permitting using appropriate data models
- 2 - Automated Validation: Automating the checking of information submitted for completeness
- 3 - Partial Automation: Automatic assessment of some key aspects of the building permitting process
- 4 – Automation: Fully Automated assessment of the entire building permitting process but requiring final human review and approval.
- 5 - Full Automation: Fully automated building permitting
- Not Sure

They were asked to rate this focusing on three separate considerations: (a) technical, (b) commercial and (c) political.

Overall results are shown in Figure 5. Views on the Potential for Digital Building Permitting / Automatic Compliance Checking. This shows that the vast majority respondents believe that either partial or full automation (with final human approval) is the target that is possible. Even given this general trend, some differences between the categories are visible, with a visibly noticeable reduction in perceived potential from commercial and political viewpoints.

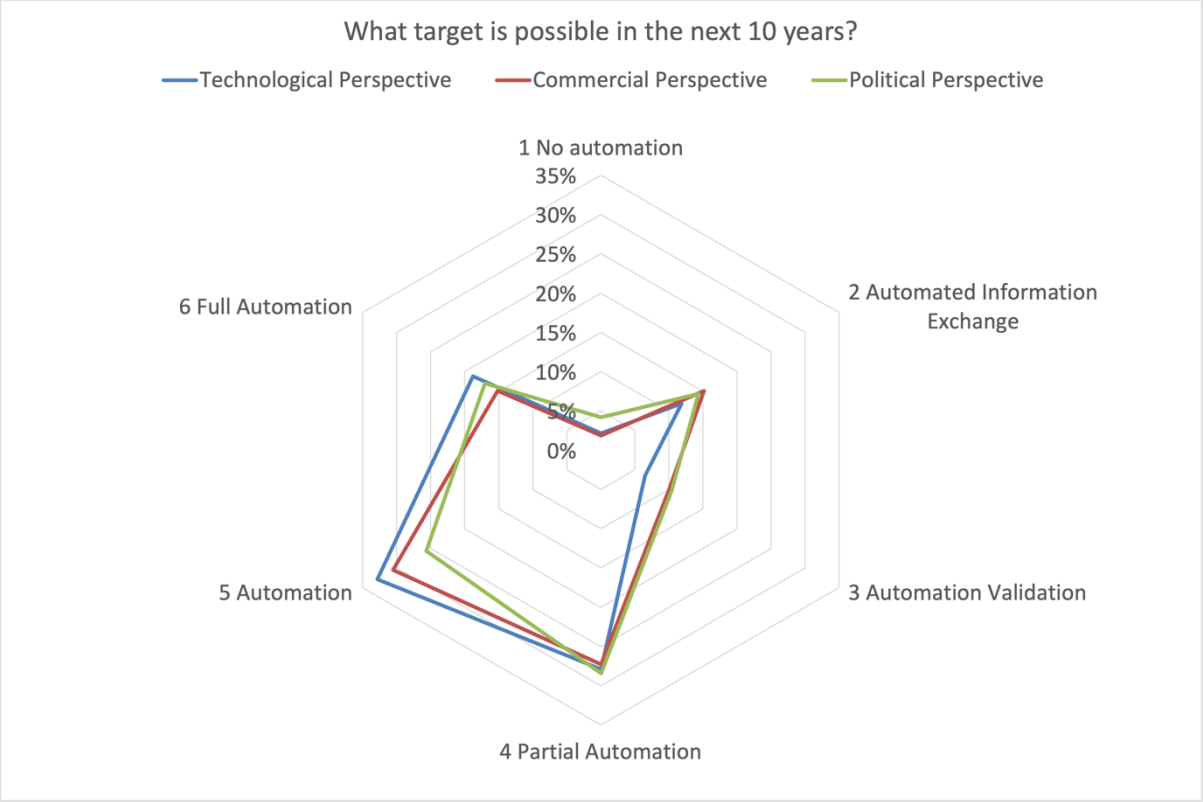

Figure 5. Views on the Potential for Digital Building Permitting / Automatic Compliance Checking.

Figure 6 illustrates this data broken down on a per country basis, when compared to all countries taken collectively (All). What this shows is that UK, Finland, France, and Romania exhibit rather different results to the other countries, which operate more in line with the average responses. These four countries show a much stronger trend towards partial automation, with less respondents voting for either of the full automation options.

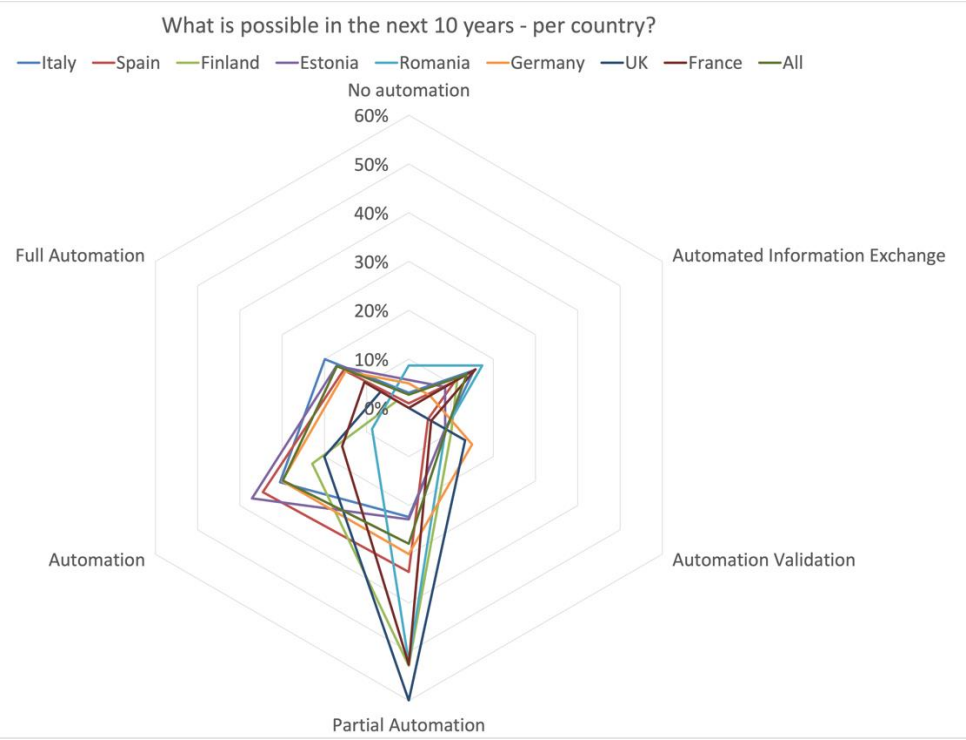

Figure 6. Country Specific Views

Figure 7 shows the breakdown of responses per discipline compared against all responses, unsurprisingly given the number of architect respondents, their views closely match the average response. However, when comparing between building permitting/control professional and project management a stark difference is visible. Project managers more strongly believe a higher level of automation is possible, whereas building permitting/control professionals view partial automation as being by far the most likely possibility.

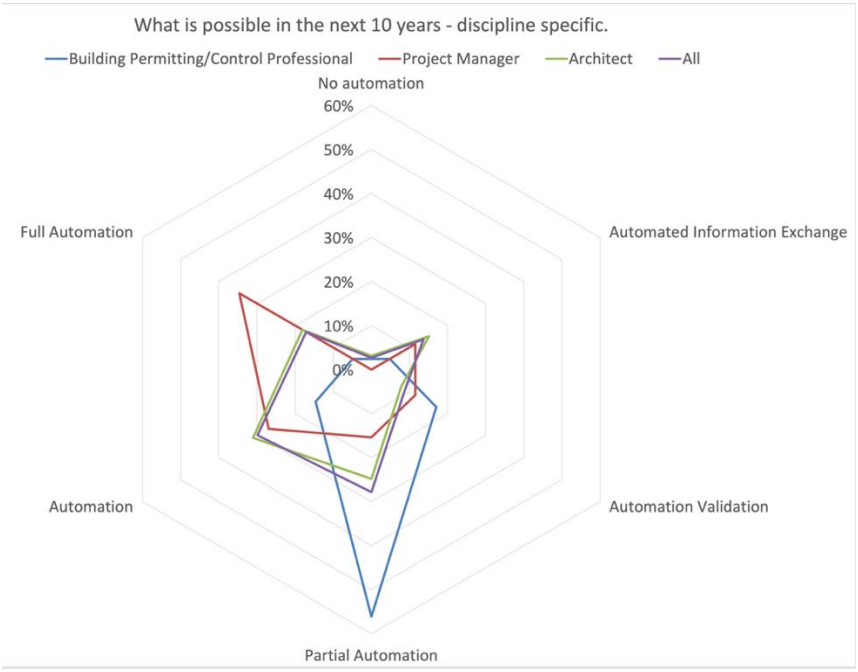

Figure 7. Discipline Specific Views

This section has provided some key intelligence on the attitudes of the industry to the feasibility and possibilities of digital building permitting / automated compliance checking. These can be summarised as:

- There is a clear view that either partial-automation or full automation are possible.
- The preference of the majority is clearly for maintaining a final human sign-off regardless of the level of automation achieved within the process.
- Several countries (UK, Finland, France, and Romania) are slightly more sceptical with most of their respondents choosing partial automation.
- Building control professionals also mirror this scepticism, with most of them only believing that partial automation is possible.

4.5 Desired Outcomes of Digital Building Permitting / Automated Compliance Checking

This section will describe the respondents view on the desired outcomes of digital building / permitting and automated compliance checking. This will be done by analysing the results of questions 17 and 18. Respondents were first asked to rank a set of desired outcomes, the results of this are shown in Table 7 in order of the priority expressed by the respondents (based on those selecting an outcome as essential).

Table 7. Outcomes of Digital Building Permitting / Automated Compliance Checking

Item	Essential	Highly Desirable	Desirable	Not Required
Time Saving	301	125	35	8
Increase in Certainty	224	155	77	13
Cost Saving	187	157	106	19
Encouraging awareness of compliance during the design process	176	188	84	21
Auditability	172	192	93	12
Better data/process flow between the design processes and permitting processes	172	185	92	20
Decrease in Subjectivity	169	151	107	42
More convenient access to machine readable regulations	155	168	116	30
Encouraging the creation of richer data models	113	141	146	69
Encouraging the better maintenance of accurate data models throughout the construction process	111	179	137	42

Furthermore, a total of 47 respondents left free text responses expressing other desired outcomes. These are shown in Table 8.

Table 8. Free Text Responses - Desired Outcomes

Desired Outcome	Count
Increase transparency	13
Wider access to digital information about buildings/structures	13
More uniform procedures	8
Improves information sharing i.e., to external parties	7

Better error detection	5
Better environmental modelling and decision making	2
Explicit connections between submitted data and regulations	2
Increase in creativity	2
Staff can spend more time on site	2
Clarification of Standards	1
Discourages unscrupulous practice	1
Increased uniformity of models	1

This has provided us with a wide set of desired outcomes for digital building permitting/automated compliance checking. Nearly all respondents agreed to all the outcomes provided in the survey and in addition several outcomes were suggested by multi respondents.

4.6 Possible Drawbacks/Obstacles for Adoptions of Digitised Building Permitting / Automated Compliance Checking

Respondents were also given the opportunity to identify and drawbacks/obstacles they see to the adoption of digital building permitting / automated compliance checking. In total 12 valid free text responses were received identifying drawbacks; these are shown in Table 9. A total of 247 free text responses were received identifying obstacles, these are shown in Table 10.

Table 9. Drawbacks to Digital Building Permitting / Automated Compliance Checking

Drawback	**Count**
Require higher digital skills to access	4
Reduction in design discussion between regulator and designer	3
Reduction in creativity	1
Cybersecurity	1
Reduction in skills to manually interpret regulations	1
Disconnection between modelling and reality	1
Increase in costs	1

Table 10. Obstacles to Digital Building Permitting / Automated Compliance Checking

Obstacle	**Count**
Differing processes between territories/ countries	86
Lack of relevant digital skills in regulators	59
Lack of appropriate software tools (in regulators)	36
No standard specification of design documentation/data	34
Resistance/Fear of change	27
Existing Platforms do not work well	25
Lack of Political will	25
Regulations are not suitable for automation (uncertainty/complexity)	25
Software Interoperability	22

Software Costs	14
Conflict Between local and national governments	3
Lack of communication between municipalities/departments	2
Adapting/creating standards to meet new requirements	2
Lack of BIM implementation	2
Information Security	2
Lack of definitions of competences	1
Cost of planning process	1
Lack of development of open software components	1

4.7 Requirements for Adopting Digitised Permitting / Automated Compliance Checking

The final aspect examined by the questionnaire is eliciting desired requirements for adopting digitised building permitting / automated compliance checking. A set of requirements were presented to the respondents for ranking in Questions 20, 22 and 24. Free text responses were sought in Questions 21, 23 and 25. Table 11 shows the rankings of the suggested requirements (based on those selecting a requirement as essential).

It can be seen from this table that nearly all respondents agree with requirements, except for "*Artificial intelligence to interpret between regulations/requirements and proposals, such as natural language processing"* which has a significant number of respondents voting not required.

Table 11. Ranking of Requirements for Digital Building Permitting / Automated Compliance Checking

Requirement	**Essential**	**Highly Desirable**	**Desirable**	**Not Required**
Faster turnaround for assessment	238	159	52	10
A standardised data schema to formally document building permitting processes.	220	169	64	10
Ability to pre-check for compliance prior to formal submission.	210	181	57	11
A standardised data schema to represent applicable regulations/legislation/requirements	208	174	66	14
Standardised model formats to enable data-centric submission of information to building permitting processes.	205	170	68	20
Auditable rule processes to track decisions and uncertainty.	183	179	85	13
Reduced costs for assessment	182	143	109	25
Ability to link building permitting processes, applicable legislation and building data standards	146	172	100	26
Public right to see compliance assessments.	123	143	108	71
Primacy of data models over documentation and drawings for the purposes of compliance submission	117	120	105	104

Additional standard data and criteria for social, environment and economic impact assessments	116	145	131	52
Use of digitised building permitting processes to be required for non-domestic projects.	114	180	130	35
Use of digitised building permitting processes to be required for domestic projects.	113	186	135	25
Artificial intelligence to interpret between regulations/requirements and proposals, such as natural language processing.	95	125	133	108

Table 12 shows the extracted requirements from the free text responses. Several requirements are elicited across several responses. The most frequently mention of which is a need for a standardised submission process.

Table 12. Free Text Requirements for Digital Building Permitting / Automated Compliance Checking

Requirement	**Count**
Standardised submission processes	11
Ability to link BIM to GIS	9
Intuitive user-friendly user interface	4
Extensive training and support	3
Open access to high level result data	3
Simple clear processes	3
Retain ability for human input	2
Robust and secure data infrastructure	1
Effective integration, open APIs	1
Transparency and Traceability of all results	1
Enable collection of suitable evidence	1
Generation of Reporting based on submissions (PDF + model)	1
Ensure correlation between passes/failures and regulations	1
Differentiate between competencies required to assess a given regulation	1
Enable visualisation of rules prior to checking	1
Direct communication between submitter and regulator	1

4.8 Conclusion

Overall, the analysis of this survey, completed by 472 respondents from the construction industry has given us several elements of important information for use in the later specification of the ACCORD project.

The key findings are:

- There is a clear view from respondents that either partial-automation or full automation are possible in the next 10 years.
- The preference of most respondents is for maintaining a final human sign-off regardless of the level of automation achieved within the process.

- The key desired outcomes as ranked by the respondents are (1) time saving, (2) increase in certainty, (3) cost savings, (4) increasing awareness of compliance during the design process and (5) auditability.
- The key obstacles that will need to be overcome in adopting digital building permitting / automated compliance checking were differing processes between territories/countries and lack of digital skills in regulators.
- A total of 16 key requirements were elicited and ranked as important by respondents.

5. Analysis of Relevant Standards

This section will describe the initial progress in identifying applicable standards for use in the ACCORD project. The scope of Task 1.1 in this area is to identify an initial set of standards that may be relevant, passing this list of standards to Task 2.1 where they can be analysed, and the list further refined.

To achieve this, a list of standards was elicited and categorised to gather as wide a list of possible resources for the project as possible. A loose definition of standard is applied, this means several items have been identified even though they are not yet formally approved as standards by a standardisation body.

The categories used to classify the findings are:

- **Semantic Interoperability:** Standards that enable interoperability related to file formats, i.e., data models, ontologies, schemas, and metadata. These are shown in Table 13.
- **Software Interoperability**: Standards that enable the interoperability between software applications i.e., APIs. These are shown in Table 14.
- **Managerial and Organisational:** Standards that provide managerial and organisation guidance. These are shown in Table 15.
- **Methodological Standards:** Standards that provide documentation on a specific methodology that should be followed to perform a given task. These are shown in Table 16.

The findings are shown in more detail in Table 13 to Table 16. These tables provide information on the standards name, a web link to the standard document, a general description and information on how it could be applicable to the ACCORD project. Furthermore, it should be noted that several standards could fit into multiple categories, in this case they will only be mentioned in one. Furthermore, commonly used industry standards such as JSON (JavaScript Object Notation), XML (eXtensible Markup Language), OWL (Ontology Web Language), XSD (XML Schema Definition) and RDF (Resource Definition Framework) due to their wide and common use across all fields of industry are excluded.

Table 13. Semantic Interoperability

Standard Name	Description	Applicability to ACCORD
CityGML	The CityGML standard defines a conceptual model and exchange format for the representation, storage, and exchange of virtual 3D city models.	ACCORD will integrate BIM and GIS data; thus, an understanding of common GIS data models/standards is required.
LADM	Defines a reference Land Administration Domain Model (LADM) covering basic information-related components of land administration (including those over water and land, and elements above and below the surface of the earth).	
LandInfra	Land and Infrastructure Conceptual Model is designed to model land and civil engineering infrastructure facilities.	
EXPRESS	The EXPRESS Definition Language for IFC Development is a conceptual schema language which provides for the	ACCORD will need to utilise the IFC format (and

	specification of classes belonging to a defined domain, the information or attributes pertaining to those classes (colour, size, shape etc.) and the constraints on those classes (unique, exclusive etc.)	understand the EXPRESS format in which the IFC's are defined). This may include its representation in ontological form as IfcOWL.
IFC	Industry Foundation Classes. Standardised Digital Description of the Built Environment	
IfcOWL	OWL representation of IFC	
OMNICLASS	Classification System commonly used in North America	ACCORD will require the utilisation of classification systems to identify building elements/products within building models.
UNICLASS	UNICLASS - UK Classification Schema for Built Environment Entities	
CCIC	A construction classification system.	
UNIFORMAT II	Standard Classification for Building Elements and Related Sitework	
eClass	eClass is the global reference data standard for the classification and unambiguous description of products and services.	
ETIM	ETIM is an open standard for the unambiguous grouping and specification of products in the technical sector through a uniform classification system.	
LBD ontologies	The Linked Building Data Community Group (LBD-CG) is a W3C Community Group that brings together experts in Building Information Modelling (BIM) and Web of Data technologies, who are working to address the challenge of managing the huge amount of data that is generated across the building life cycle. Among those ontologies: PRODUCT Ontology, PROJECT Management, Properties evaluation (PROPS), Ontology for Property Management (OPM), Building Topology Ontology (BOT), Ontology for Managing Geometry (OMG), Ontology for Geometry Formats (FOG), Geometry Metadata Ontology (GOM), RDF-based geometry (GEOM), Building Product Ontology for assembled products (BPO)	ACCORD will need to examine all available built environment semantic resources to ensure the building compliance ontology being developed aligns with current best practice.
SSN	The Semantic Sensor Network (SSN) ontology is an ontology for describing sensors and their observations, the involved procedures, the studied features of interest, the samples used to do so, and the observed properties, as well as actuators.	
SEAS	The SEAS knowledge model is a key enabler for the semantic interoperability for use cases and business models in energy efficiency.	
SAREF	The Smart Applications REFerence ontology (SAREF) is intended to enable interoperability between solutions from different providers and among various activity sectors in the Internet of Things (IoT) domain.	
RealEstateCore	RealEstateCore can describe the data within buildings for property owners	
ifcWOD	Formally extends the ifcOWL ontology to represent ifcOWL properties are standard ontology properties.	

COINS Building Information System	Defines a COINS compatible Building Information System.	
NTA 8035: Semantic modelling of information in the built environment.	Defines a method of data exchange based on a semantic description of data in the built environment.	
Brick	Brick is an open-source effort to standardize semantic descriptions of the physical, logical, and virtual assets in buildings and the relationships between them.	
digitalbuildings	The Digital Buildings project is an open-source, Apache-licensed effort to create a uniform schema and toolset for representing structured information about buildings and building-installed equipment.	
CB-NL	Provides semantic description of built environment concepts.	
CEN EN 17632: Building information modelling (BIM) - Semantic modelling and linking (SML)	This document addresses syntactic and semantic interoperability for information describing assets going through their life cycle in the built environment.	
IndoorGML	IndoorGML is an OGC standard for an open data model and XML schema for indoor spatial information. It aims to provide a common framework of representation and exchange of indoor spatial information.	ACCORD will integrate BIM and GIS data; thus, an understanding of common GIS standards/APIs is required.
Xplanung	Defines a single format and information model for all spatial planning.	ACCORD will need to examine all current efforts in terms of digitisation of planning to ensure our approach aligns with best practice.
BCF	BCF allows different BIM applications to communicate model-based issues with each other by leveraging IFC models that have been previously shared among project collaborators.	ACCORD will possibly require utilisation of BCF to communicate issues with models submitted for building permitting.
bcfOWL	Ontological representation of BCF	
IDS	A computer interpretable document that defines the Exchange Requirements of model-based exchange.	ACCORD will possibly use IDS to define the data requirements for regulatory compliance in a machine-readable way.
INSPIRE	The INSPIRE describes rules on interoperability of spatial data sets and services and technical guidelines (Data Specifications). It specifies common data models, code lists, map layers and additional metadata on the interoperability to be used when exchanging spatial datasets	ACCORD should consider all current efforts towards digitising planning processes to ensure our approach aligns with current research and best practice.

EPUB	Defines a distribution and interchange format for digital publications and documents. The EPUB format provides a means of representing, packaging, and encoding structured and semantically enhanced web content.	This format could possibly be relevant for the management of digitised regulatory compliance document.
eCOB	The eCOB® standard for the Creation of BIM Objects is an instrument for generating generic or industrial BIM objects with an information structure, facilitating interoperability between BIM programs throughout the entire life cycle of the construction. eCOB® is based on IFC, the European Harmonized regulatory context and the National regulations applicable to construction projects in a specific country. Currently, it is adapted to Spanish regulations (Technical Building Code, EHE, etc).	ACCORD may well need to utilise data from construction objects as part of the permitting process.
ISO/IEC 21838: Information technology — Top-level ontologies — Part 2: Basic Formal Ontology	Describes Basic Formal Ontology (BFO) requirements. Adopting these enables support the interchange of information among heterogeneous information systems.	ACCORD will need to ensure best practice ontology modelling standards are adopted when producing the ontology in T2.2.
ISO 16757: Data structures for electronic product catalogues for building services — Part 1: Concepts, architecture, and model	Defines data structures for electronic product catalogues for building services.	ACCORD will need to understand how properties are defined in a standardised way within projects and link these to the terminology used within the regulation documents.
CEN PREN 17549-1: Building information modelling - Information structure based on EN ISO 16739 1 to exchange data templates and data sheets for construction objects - Part 1: Data templates and configured construction objects	Information structure based on EN ISO 16739 1 to exchange data templates and data sheets for construction objects.	
COBie	The Construction-Operations Building information exchange (COBie) standard defines information for assets that are delivered as part of a facility construction project and is used to document the data for the BIM process.	ACCORD will need to consider existing data exchange mechanisms used in industry.

ELI	A framework to make legislation metadata available online in a standardised format, so that it can be accessed, exchanged, and reused across borders	ACCORD will need to represent the metadata of legislation and standards
PROV	The PROV Family defines a model, corresponding serializations, and other supporting definitions to enable the inter-operable interchange of provenance information in heterogeneous environments such as the Web	ACCORD will need to include the consideration of provenance of data as part of its approach.
DCAT	DCAT enables a publisher to describe datasets and data services in a catalogue using a standard model and vocabulary that facilitates the consumption and aggregation of metadata from multiple catalogues.	ACCORD may well require the cataloguing and exchange of datasets

Table 14. Software Interoperability Standards

Standard Name	Description	Applicability to ACCORD
3DTiles	3D Tiles is designed for streaming and rendering massive 3D geospatial content such as Photogrammetry, 3D Buildings, BIM/CAD, Instanced Features, and Point Clouds	ACCORD will integrate BIM and GIS data; thus, an understanding of common GIS standards/APIs is required.
OGC - FEATURES API	Features is a multi-part standard that offers the capability to create, modify, and query spatial data on the web.	
OGC 3D GEOVOLUMES API	For access and transfer of 3D geospatial content over the internet.	
OGC DISCRETE GLOBAL GRID SYSTEMS API	An API for accessing data organised according to a Discrete Global Grid System (DGGS).	
OGC MAPS API	Maps draft specification describes an API that can serve spatially referenced and dynamically rendered electronic maps.	
OGC TILES - API	The OGC API — Tiles standard defines building blocks for creating Web APIs that support the retrieval of geospatial information as tiles	
GML	Geography Markup Language	
InfraGML	Encoding of LandInfra information in GML	
Indexed 3D Scene Layers (I3S)	A container for arbitrarily large amounts of heterogeneously distributed 3D geographic data.	
GeoSPARQL	The OGC GeoSPARQL standard supports representing and querying geospatial data on the Semantic Web.	
CITY-JSON	CityJSON is a JSON-based encoding for storing 3D city models.	
OGC API - PROCESSING	Allows for processing tools to be called and combined from many sources and applied to data in other OGC APIs.	
OGC API - RECORDS	Offers the capability to create, modify, and query metadata on the web.	
BCF-API	BCF API Based Transmission	ACCORD may well need to utilise BCF to transmit
BCF-XML	BCF File Based Transmission	

		machine readable results of compliance checking.
LegalDocumentML	Use of XML in Legal Documents	Various existing methods of formalising rules within documents.
LegalRuleML	Enables legal arguments to be created, evaluated, and compared using rule representation tools	
W3C Rule Interchange Format	A family of rule interchange dialects that allows rules to be translated between rule languages and thus transferred between rule systems.	
RASE	RASE is a markup language for specifying construction rules.	
W3C SHACL	A language for validating RDF graphs against a set of conditions	Commonly used semantic rule/query specifications that will possibly be relevant to ACCORD.
W3C SPARQL	A query language for RDF.	
SWRL	SWRL includes a high-level abstract syntax for Horn-like rules in both the OWL DL and OWL Lite sublanguages of OWL.	
ISO 21597: Information container for linked document delivery — Exchange specification — Part 1: Container	Defines an open and stable container format to exchange files of a heterogeneous nature to deliver, store and archive documents that describe an asset throughout its entire lifecycle.	ACCORD may well need to facilitate transmission of BIM data from project teams to permitting processes.
DIN SPEC 91391: Common Data Environments (CDE) for BIM projects - Function sets and open data exchange between platforms of different vendors - Part 1: Components and function sets of a CDE; with digital attachment	Specification for communication with common data environments for BIM data.	ACCORD may well need to communicate/retrieve data from common data environments.
CAFM Connect	CAFM-Connect is an initiative of associations from the real estate industry that are committed to the digitization of real estate operations and have created a uniform and open data standard based on IFC to simplify cooperation in the industry.	ACCORD may well need to define data standards for IFC data; thus, this existing work will be importance reference.

Table 15. Managerial/Organisational Standards

Standard Name	Description	Applicability to ACCORD
FAIR PRINCIPLES	Provide principles intended to support the Findability, Accessibility, Interoperability, and Reuse of digital assets.	ACCORD will utilise FAIR to analyse and evaluate relevant digital assets.
ISO 19650: Building Information Modelling	Defines the management of information over the whole life cycle of a built asset using building information modelling (BIM).	ACCORD will need to consider the current standards that model authors will be complying with.
ISO 12911:2023: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) — Framework for specification of BIM implementation	Provides specifications for the commissioning of building information modelling (BIM).	
British Standard EN 17412-1: Building information modelling - level of information need. Concepts and principles	Establishes the concepts and principles for consistent detailing of the level of information need and information deliveries using building information modelling (BIM).	ACCORD may well need to define information requirements to ensure that BIM models submitted to the permitting process have all the required data items.
CEN/TR 17654:2021: Guideline for the implementation of Exchange Information Requirements (EIR) and BIM Execution Plans (BEP) on European level	Defines the processes involved in the procurement and delivery of information for planning construction projects. Specifically with reference exchange information requirement (EIR) and BIM execution plan (BEP), considering the administrative processes.	
CEN 17439: Guidance on how to implement EN ISO 19650-1 and -2 in Europe	Provide a guidance on how to implement ISO 19650-1 and -2 in Europe.	ACCORD will need to understand the requirements for BIM model authors to ensure its compatibility with them.
ISO 22263: Organization of information about	Specifies a framework for the organization of project information (process-related as well as product-related) in construction projects.	ACCORD will need to understand the frameworks in

construction works — Framework for management of project information		which BIM authors are preparing project information
CEN/TR 17741: Guidance, Framework, and Implementation of Common Data Environment (CDE) workflow and solution	Guidance for understanding and utilising EN/ISO 29481-1 Building information models - Information delivery manual (IDM)	ACCORD may well need to create IDM specification to specify the data required within BIM models.
ISO 16354: Guidelines for knowledge libraries and object libraries	Provides guidance as to distinguish categories of knowledge libraries and to lay the foundation for uniform structures and content of such knowledge libraries and for commonality in their usage	ACCORD may require the use of construction knowledge libraries.
ISO 23262: GIS (geospatial) / BIM interoperability	Proposes measures to improve interoperability between geospatial and BIM domains, namely, to align GIS standards developed by ISO/TC 211 and BIM standards developed by ISO/TC 59/SC 13.	ACCORD will need to integrate BIM and GIS datasets.
CEN WI 442023: Building information modelling - Exchange structure for product data templates and product data sheets	Guideline on how to understand and utilize EN/ISO 29481 Building information models - Information delivery manual	ACCORD will need to understand the requirements for BIM model authors to ensure its compatibility with them.
ISO 23387: Data Templates for Construction Objects Used in The Life Cycle of Built Assets - Concepts and Principles	Sets out the principles and structure for data templates for construction objects.	ACCORD may well need to utilise data from construction objects as part of the permitting process.
NEN 2660: Rules for information modelling of the built environment - Part 1: Conceptual models	Sets out rules for information modelling in the built environment.	ACCORD will need to understand the requirements for BIM model authors to ensure its compatibility with them.
ISO 50008: Energy management and energy savings —	Gives guidelines for how the energy management team (EnMT) in an organization can define, request, and regularly access the data and information needed to implement an energy management system	Existing guidelines on how data is exchanged in the built environment may well provide

Building energy data management for energy performance — Guidance for a systemic data exchange approach		inspiration for ACCORD developments.
XP P07-150: Properties of products and systems used in construction - Definition of properties, method of creation and managing properties in a harmonized system of reference	Describes how properties of products and systems used in construction should be defined. Includes definition of properties, method of creation and managing properties in a harmonized system of reference	ACCORD will need to understand the requirements for BIM model authors to ensure its compatibility with them
ISO 22057: Sustainability in buildings and civil engineering works — Data templates for the use of environmental product declarations (EPDs) for construction products in building information modelling (BIM)	Provides the principles and requirements to enable environmental and technical data provided in EPDs for construction products and services, construction elements and integrated technical systems to be used in BIM to assist in the assessment of the environmental performance of a construction works over its life cycle.	ACCORD will need to understand how properties are defined in a standardised way within projects and link these to the terminology used within the regulation documents.

Table 16. Methodological Standards

Standard Name	Description	Applicability to ACCORD
ISO 29481-1: Building information models — Information delivery manual — Part 1: Methodology and format.	Defines a methodology that links the business processes undertaken during the construction of built facilities with the specification of information that is required by these processes, and a way to map and describe the information processes across the life cycle of construction works.	ACCORD will need to link information specifications to the business processes that are executed during the permitting process.

ISO 23386: Building information modelling and other digital processes used in construction — Methodology to describe, author and maintain properties in interconnected data dictionaries.	Establishes the rules for defining properties used in construction and a methodology for authoring and maintaining them.	ACCORD will need to understand how properties are defined in a standardised way within projects and link these to the terminology used within the regulation documents.
ISO 12006: Building construction — Organization of information about construction works.	Defines a framework for the development of built environment classification systems.	ACCORD will need to utilise built environment classification systems to identify objects within the building.
CEN TC442: Building information modelling - Exchange structure for product data templates and product data sheets based on ISO 16739-1 - Part 2: Requirements and configurable products	Framework for implementation of Common Data Environment Solutions, in accordance with EN ISO 19650	Use of common data environments may well be required within the ACCORD project.
LEXiCON	Best practice for specification and management of construction project data.	Use of construction project data may well be required for compliance checking in ACCORD.
CEN PREN 17473: Building information modelling (BIM) - Data templates for construction objects used in the life cycle of any built asset - Data templates based on harmonised	Provides a methodology and process to create data templates for construction products that are covered by harmonized technical specifications	ACCORD will need to understand how properties are defined in a standardised way within projects and link these to the terminology used within the regulation documents.

technical specifications under the Construction Products Regulation (CPR)		

This section has presented a list of standards (or standard like items) that could well be candidates for use in the ACCORD project. This initial set of standards, as well as their possible use cases will be further analysed in Task 2.1, ready for possible selection for use in the project.

6. Current Building Permitting Processes in ACCORD's Demo Countries

This section will outline a high-level description of the general building permit process in each demonstration country, with more detailed process models and descriptions provided as annexes. Also, the building permit related laws and regulations are shortly mentioned.

6.1 Finland

6.1.1 Introduction to Building Permitting in Finland

In Finland, the Land use and building act is central legislation for construction, regulating requirements for buildings and construction and building permitting and land use planning. According to the law, a municipality is responsible for building and planning, although, for planning, there is also province-level planning. More detailed regulations are defined in Land use and building decree and Building Codes. A municipality shall also have a building ordinance to define local regulations. Current regulations with references are presented in Annex A. It shall be noted that this legislation is under comprehensive renewal, and changes will affect permitting procedures, starting in 2025.

Building permitting is a one-phase procedure, and the permit is applied with the architectural design and brief descriptions of technical systems. Typically, a consultative phase precedes the application submission. In this phase, the authorities give feedback for concept design. The issued permit includes requirements from the authorities to provide detailed structural and HVAC design for municipal approval, but those are not checked comprehensively as the responsibility of the design and engineering always lies with the approved designer. The permit also sets other requirements for inspection and documentation, which are checked during the commissioning phase.

Finland has 309 municipalities (in 2022) which have issued between 29 000 to nearly 40 000 building permits in recent years (Figure 8). In Figure 8 the left-hand axis represents permit numbers, and the right-hand axis represents approved area (in m^2). Small building types, like single-family houses and smaller ones, represent about 80% of the total issued building permits and cover 25-30% of the total approved building area (m^2).

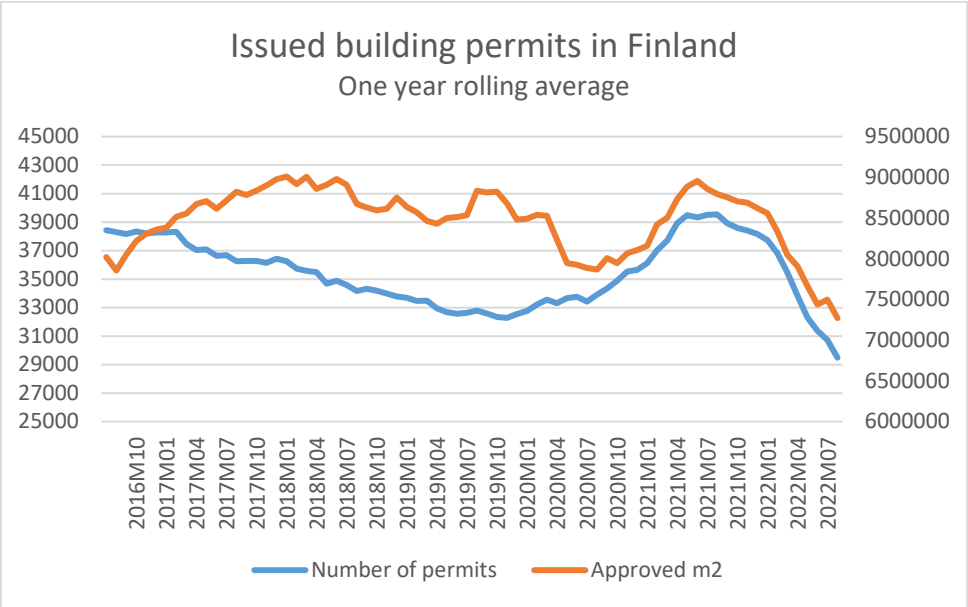

Figure 8. Granted building permits in Finland, source: Statistics Finland

According to a survey conducted by the Association of Finnish municipalities[27], over 90 % of municipalities have organised the building permitting in their own organisation, and only a few makes cooperation or have common authorities for the permitting. It is estimated that about 1070 person-years are needed in the municipal building authority organisations, and about 70% of that is professional work and the rest consists of administrative activities. The permitting and control activities represent about 75% of the work in building authority organisations. The survey compared the number of needed building permitting/control professionals to inhabitants. The numbers varied from 0.45 professionals / 1000 inhabitants (municipalities below 5000 inhabitants) to 0.12 professionals / 1000 inhabitants (municipalities over 100 000 inhabitants).

Different types of permits are handled by municipal building authorities (Table 17). Nearly 70% of permit decisions are related to building permits and 25% to action permits, which are needed for minor work or building changes. A building authority's average working hours for processing a building permit varied by the population of a municipality, indicating the average size of the projects in the municipalities. In small and mid-sized municipalities with below 50 000 inhabitants, around 7-8 working hours/building permit was used. In bigger municipalities, 22 h (50 000- 100 000) and 34 h in municipalities with over 100 000 inhabitants were needed. However, the survey only had five responses from these municipalities.

Table 17. Permit types in Finland

Permit type	**Permit description**
Building permit (rakennuslupa in Finnish)	The permit needed for new construction.
Action permit (toimenpidelupa in Finnish)	Instead of a building permit, an action permit may be applied for in the case of structures and installations such as masts, containers, and smokestacks, when deciding the permit issue does not in every respect require the steering otherwise necessary in building

[27] Lindqvist, H. (2021), Kuntien rakennusvalvonnan hallintokysely 2021 - Raportti kyselytutkimuksen tuloksista, Association of Finnish Municipalities (Kuntaliitto).

Permit to demolish a building (rakennuksen purkamislupa in Finnish)	The permit needed to demolish a building.
Permit for landscape work (maisematyölupa in Finnish)	Earth works, tree-felling or corresponding action altering the landscape may not be carried out without a permit (restriction on action) in areas.

Each municipality has a fee for building permitting and other authority activities. The building permit fee is around 300-900 € + 4-8 €/m2 depending on the municipality and type of building. There are also some higher fee categories for specific projects.

The authority sets in the building permit the requirements for control and documentation activities during construction. Those include different types of responsibilities to applicants, designers, and contractors, for example:

- Provision of detailed technical designs for authorities' inspection before construction
- Required meetings and inspections at the site during construction.
- Documentation requirements, e.g., for quality control, moisture management and preparation of the building logbook
- Collection of the CE-marking documents of used products

There are also qualification requirements for construction and HVAC contractors' responsible site managers who must get approval for the position in the project.

6.1.2 Finnish Building Permit Process

The current Finnish building permit process is divided into phases, which are described in detail in Annex B. The process described contains the most extensive type of permitting excluding a committee process which in principle is much the same with an extra phase where the permit is issued by the committee. However, the process is generic in the sense that the process differs somewhat depending on the building type and its size. Also, permit practices vary between municipalities, but the legislation provides a solid framework. Already 35 Finnish municipalities have started to collaborate to align permit practices[28].

Before a building permit can be issued, the building project must meet the requirements set by the authorities, and it must comply with regulations and good construction practices. Neighbours must be informed before the application can be processed. During the processing of the permit application, the building permit application is checked, and, if necessary, addition (missing attachments or form data) requests are made, and statements from other building authorities are required.

A building permit can be issued when all the information regarding the construction project is registered, eligible designers and overseeing foremen have been approved, and the required attachments and drawings have been submitted. In the decision-making phase, the building control authority decides, stamps the approved and checked documents and records the information in the building permit service. The approved building permit decision is recorded in the publication list, and after the appeal period, the decision is legally binding.

Currently, the building permit services use mostly pdf documents, but also IFC files can be uploaded in those municipalities that use Cloudpermit's service. In the Cloudpermit building permitting service, six municipalities have the functionality to locate an IFC model in a city model to implement the cityscape assessment. This is done in an external service provided by Sova3D Ltd. Figure 9 shows an indicative representation of the IFC model located in the city model in the City of Järvenpää. The

[28] Common building control practices (Rakentamisen Topten-käytännöt, in Finnish), available https://www.toptenrava.fi/asp2/default.aspx, accessed 21.11.2022.

other building permitting service in Finland, Trimble Locus, also has the same kind of cityscape assessment function.

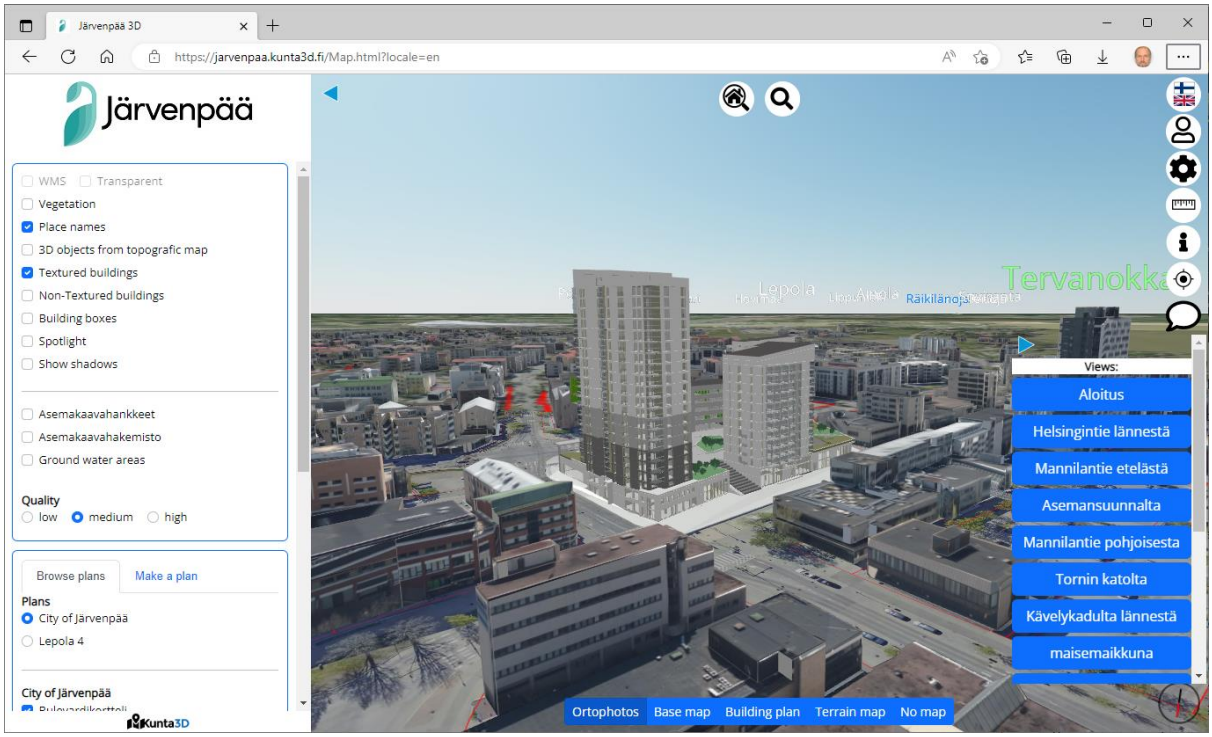

Figure 9. An IFC model located in the city model for assessing the city scene. (Source: jarvenpaa.kunta3d.fi)

The Finnish municipalities are now preparing for the renewal of the land use and building act since the new law will require builders to deliver BIM models to a national archive or registry, which will eventually lead to a BIM-based building permit process.

Although municipalities would use the same web-based building permit service, they may have organised data management differently. For example, the cloud-based service may transfer the data to the municipality's other data registry and a national registry maintained by the Digital and Population Data Services Agency. The Finnish Ministry of Built Environment has financially supported the building permit officers' BIM expertise education.

The length of the building permit process varies between municipalities. For example, in the city of Järvenpää, the time goal for issuing a permit is two months. This kind of goal steers the authorities toward consulting applicants so that they submit applications with the required documents.

The main stakeholders in the Finnish building permit process are.

- The building permit applicant (usually the owner of the land plot)
- Main architect (and other designers)
- Local building control authority
- Other authorities, such as the rescue department
- Neighbour(s)

In addition to the mentioned authorities, there are other authorities which are related to the building permit process, such as

- The competent ministry
- The regional environment centres.
- The regional council
- The local authority

6.2 Estonia

6.2.1 Introduction to Building Permitting in Estonia

In Estonia, the Building Code[29] is central legislation for construction, regulating requirements for buildings, construction and building permitting. However, there are also other important laws, that need to be followed, depending on the usage type of the building. Land use planning is regulated by Planning Act[30]. According to the law, a municipality is responsible for building and planning, although, for planning, there are also regional (county) level and state level planning. A municipality shall also have a building ordinance to define local regulations. Current regulations with references are presented in Annex C.

Building permit is applied with the preliminary stage construction designs, which consists of graphical representation of architectural design (floor plan and facade drawings), site plan and fire safety and brief textual descriptions of technical systems and load bearing structures. A consultative phase can precede the application submission, but it is not typical for this process and is mostly sought after by private owners who want building permit for a single house. Real estate developers are already acquainted with the process and do not need consultation. In consultative phase, the authorities can give feedback for concept design, but mostly provide information which regulations and guidelines should be followed. Building permit also sets requirements for construction design audit before beginning of construction works if it is needed by regulation. After receiving building permit, construction design should be taken to technical stage before starting construction. After construction detailed technical stage construction design which consists of architectural, structural and HVAC design and as built documents must be submitted for municipal approval before building can be taken to use. This process is issuing certificate of occupancy aka usage permit. All requirements that fall under responsibility of local government must be checked comprehensively because of the Supreme Court's ruling, which states that the interpretation of any regulations in the permit procedure is the responsibility of the local government and cannot be put by the local government on the designer, because otherwise the permit procedure would be an unnecessary bureaucratic process.

Estonia has the population of 1.331 mil people (2021) and 79 municipalities (2023) which have issued between 4 500 to 11 000 building permits in recent years (Figure 10). Small building types, like single-family houses and smaller ones, represent about 31% of the total issued building permits.

[29] Building Code - https://www.riigiteataja.ee/akt/105032015001?leiaKehtiv , accessed 11.03.2023
[30] Planning Act - https://www.riigiteataja.ee/akt/126022015003?leiaKehtiv , accessed 11.03.2023

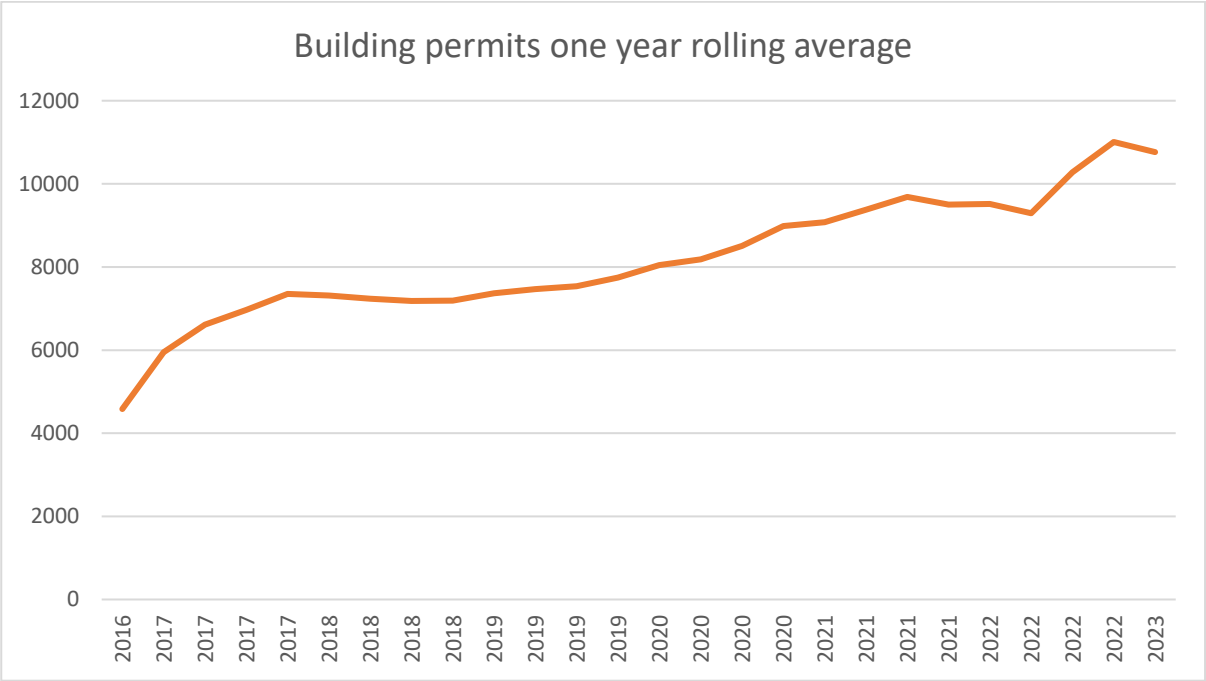

Figure 10. Granted building permits in Estonia per quarter, source: EHR information portal.

Different types of permits are handled by municipal building authorities (Table 18). Nearly 80% of permit decisions are related to building permits and 20% to construction notices, which are needed for minor work or building changes.

Table 18. Permit types in Estonia

Permit type	**Permit description**
Building permit (*ehitusluba* in Estonian)	The permit needed for new construction and for expanding existing construction over 33%. In case of non-residential buildings for any expanding and reconstruction the permit is needed.
Construction notice (*ehitusteatis* in Estonian)	Instead of a building permit, a construction notice may be forwarded to local municipalities for smaller construction works like buildings with constructional area up to 60m2 and height up to 5m. Also, for some masts and other facilities. If municipality is not reacting within 10 days, construction works can be started, otherwise there will a simpler procedure than with building permit.
Permit to demolish a building (*ehitusluba ehitise lammutamiseks* in Estonian)	The permit needed to demolish a building.

Each municipality has a fee for building permitting and other authority activities. The fee is same for all the municipalities as it is set in Building Code. The building permit fee is around 150-250 € depending on the type of building.

Data about time consumption for permit processing regarding working hours of processers is not widely surveyed. The data from Tallinn Urban Planning department from 2019 states that for smaller buildings, building permit assessment takes 7.3 hours for simple building and 17.3 hours for complex

building[31]. These times don´t take into consideration work done by utility network owners and all state departments that are involved in permit processing.

6.2.2 Estonian Building Permit Process

The current Estonian building permit process is divided into phases, which are shortly described in the following and then in more detail in Annex D. The process is generic in the sense that the process differs somewhat depending on the building type and its size. Also, permit practices vary between municipalities, but due to central permitting system of National Building Registry, these variations are minimal and don't affect the overall process.

Before a building permit can be issued, the building project must meet the requirements set by the authorities, and it must comply with regulations and good construction practices. Neighbours and other interested parties (set by detail zoning plan, design conditions and Administrative Procedure Act) are involved in the permitting process by local government. During the processing of the permit application, the building permit application is checked, and, if necessary, statements from other building authorities are required by the permitting authority, who is responsible for involving all necessary parties to the permitting process.

A building permit can be issued when all the information regarding the construction project is registered, and the required textual and graphical materials about construction design have been submitted. In the decision-making phase, the building control authority decides and signs the building permit or the refusal of giving building permit as an administrative act in the Building Registry. The approved building permit decision is recorded in the Building Registry, and after the appeal period, the decision is legally binding.

Although, the maximum length of the building permit process is set 30 calendar days in the Building Code, the actual length of the building permit process varies between municipalities. In the city of Tallinn, the mean time for issuing a permit is ca 100 days (2017-2020), in the city of Tartu 40-50 days (2017-2020) and in Estonia overall 30-35 days (2017-2020). The time that application is in the hands of applicant for corrections, is considered into previously mentioned times.

The main stakeholders in the Estonian building permit process are:

- The building permit applicant (can be the owner or any other person/company, that the owner has delegated the task by contract. Usually applicant is not the owner)
- Local building control authority
- State authorities, such as the Rescue Board, Health Board, Environmental Board and Transport Administration, Consumer Protection and Technical Regulatory Authority
- Neighbour(s) of the building, other interested parties (set by detail zoning plan, design conditions and Administrative Procedure Act) and the owner of the building if the owner is not the applicant.
- Utility network owners

6.3 Germany

In Germany, for erecting, altering, and changing the use of physical structures a building permission is required. Building permission is granted by the lower building authorities in the relevant Federal state. Public building regulations in Germany are distinguished between "building regulation law" on national level and "planning law" on state level (Described in more detail in Appendix E).

[31] Introducing a Building Information Model (BIM)-based process for building permits in Estonia, Final Report, https://eehitus.ee/wp-content/uploads/2019/12/Final-report.pdf , accessed 12.03.2023.

6.3.1 Introduction to Building Permitting in Germany

The Federal Republic of Germany is characterized by its federal structure according to Article 20 (1) of the Basic Law (“Grundgesetz”). Federal states are composed of a central government (“Bund”) and constitutive states (“Länder” or “Bundesländer”). Each federal state has its own constitution, territories as well as independent legislative, executive and judiciary state power.

The 16 states differ widely in population and size of territory. The three most populous states have a population of over 10 million, others have fewer than two million. Governmental functions are assigned to the states by the Basic Law and the state constitution. The activities of the states focus on administrative tasks and contributions to federal legislation. From the constitutional point of view, local authorities form part of the states which makes the function of local governments extremely important.[1]

States and local authorities are responsible for administration**.** The Basic Law states that the states exercise governmental powers and discharge governmental functions except as otherwise provided or permitted (Article 30).

At the local government level, territorial authorities (“Gebietskörperschaften”) have jurisdiction over their territory. Territorial authorities include municipalities (“Gemeinden”, “Kommunen”) forming part of a county (“kreisangehörige Gemeinden”) and county-free cities (“kreisfreie Städte”). Counties are territorial authorities with the right of self-government given that they have been provided with autonomous functions transferred to them by law or byelaw. Municipalities are local self-governing bodies with the right assigned to manage all affairs of the local community on their own responsibility within the limits set by law (“self-government tasks”). In the county-free cities, the municipality and county coincide.

The local council and local administration are the institutions providing the citizens with solutions and the most necessary services. Germany contains over 13.000 local authorities with a considerably varying size. Figure 11. provides an overview of the individual areas of responsibility in German public administration.

Figure 11. Administrative Map of Germany: States, Administrative districts, Counties (source: Federal Agency for Cartography and Geodesy).

According to the German Federal Statistical Office, the number of issued building permits for building construction in Germany[32] dropped significantly from 248.688 permissions in the year 2020 to 217.617 permissions in 2021 (Figure 12). The number of building permits for the construction of new buildings declined accordingly from 158.227 to 136.647 during the same year. In January 2023, the German Federal Statistical Office stated that the decreased number of building permits issued for new constructions over a period of one year was -25,5% for one-family dwellings, -48,4 % for two-family dwellings and -28,6 % for multi-family houses[33].

[32] German Federal Statistical Office, 2023. "Building permits for building construction in Germany". Online, available https://www.destatis.de/EN/Themes/Economic-Sectors-Enterprises/Construction/Tables/permits.html, accessed 29.4.2023

[33] Federal Agency for Cartography and Geodesy, 2023. Press release no. 108 as of 17 of März 2023". Online, available https://www.destatis.de/DE/Presse/Pressemitteilungen/2023/03/PD23_108_3111.html, accessed 30.4.2023.

Specification	Unit	2017	2018	2019	2020	2021
Total						
Buildings / construction work	Number	219,494	222,678	232,208	248,688	217,617
Dwellings, total	Number	346,810	360,493	368,589	380,736	354,403
Living floor space	1,000 m²	35,056	35,900	37,058	38,780	35,645
Estimated building costs	Euro million	106,142	115,024	120,597	130,338	134,963
Construction of new buildings						
Buildings	Number	145,016	146,493	151,657	158,227	136,647
Dwellings	Number	308,162	317,823	327,263	336,432	311,019
Living floor space	1,000 m²	30,589	31,547	32,393	33,630	30,500
Estimated building costs	Euro million	89,070	95,953	101,440	109,428	112,244

Figure 12. Building permits for building construction in Germany (2017-2021) (source: German Federal Statistical Office).

For building construction works in Germany, the following building permit types are granted by local authorities according to planning and building law (see Table 19):

Table 19. Main building permit types in Germany

Permit type	**Permit description**
Outline-/ Preliminary building permission (“Bauvorbescheid”)	Binding decision by a lower building authority on individual aspects to be decided upon during the building permitting procedure (and before submitting the proper building permit application).
Building permission (“Baugenehmigung”)	Erecting, altering, and changing the use of physical structures requires a building permit unless otherwise provided by Sections 60 to 62, 76, and 77 of the Standard Building Regulations (Section 59).
Simple building permit (“Vereinfachte Baugenehmigung”)	Administrative simplification for building projects given that preconditions apply as outlined in the Standard Building Regulations.
Type approval (“Typengenehmigung”)	Administrative simplification for structural installations that are to be erected in the same design at several locations (“moveable structures”) given that preconditions apply as outlined in the state building regulations.
Deviation or Exempt (“Abweichung” or “Befreiung”)	The Federal Building Code permits exemptions from determinations in zoning plans being explicitly planned according to type and scope of the zoning plan.
Exemption from permission (“Genehmigungsfreistellung”, “Kenntnisgabeverfahren”)	Procedure specified by state building regulations permitting exemptions from building approval for the construction of assets or buildings under fulfilment of determined conditions.

Building permission costs in Germany vary between 0.5 and 1% of the total construction budget. Costs may differ from state to state, as do the “building documents” for building permit applications.

The preparation costs of “building documents” for architects or engineers consists of around 10% of the construction costs. The responsible authority charges an additional fee calculated according to the following equation - based on the example of a one-family dwelling:

- Building value = Building value € / m³ *x* enclosed space (in m³)
- Costs = Building value *x* 0.5%

Given a building value of 200 Euro per m³ and an enclosed space of 800m³, the calculation is as follows:

- Building value = 200 € / m³ *x* 800m³ = 160.000 €
- Costs = 160.000 € *x* 0.5% = 800 €

6.3.2 German Building Permit Process

This section will provide a high-level description of building permitting processes in Germany, more detail on these processes is given in Annex F.

The State building regulations (“Landesbauordnungen”) regulate at the state level what must be observed technically in building projects and when a building permit is required. State building regulations are similar in content and structure from state to state with some differing arrangements. The Standard Building Regulations 2022 (“Musterbauordnung - MBO”) provide an overview of existing rules.

Erecting, altering, and changing the use of physical structures require a permit unless otherwise provided for in the Standard Building Regulations (Section 59). Normally, a building permit is required, unless one of the following applies:

- priority of other permit proceedings (Section 60),
- building projects not subject to permit procedures, demolition of physical structures (Section 61),
- exemption from permission (Section 62),
- authorisation of moveable structures (Section 76),
- building authority authorisation (Section 77).

Depending on preconditions, the Standard Building Regulations differentiate between a simple building permission procedure and a proper building permission procedure. It must be ascertained for every project whether and what procedures must be followed according to the relevant state building regulations.

Building permission is granted by the lower building authorities in the given state. Lower building authorities (of counties, country-free cities or municipalities forming part of a county) are provided with administrative powers in the case this competence has been assigned to them. The building documents (“Bauvorlage”) and the building permit application - if required for the specific project according to the state building regulation, are submitted to the appropriate authority. The building documents are to be prepared and signed by authorised parties.

It depends on the relevant state ordinance pertaining to building documents (“Bauvorlagenverordnung - BauVorlV”) what documents and drawings (site plan, ground plan, elevations, sections) with what scale are to be submitted. Structural inspections are regulated by the Construction Inspection Ordinance (“Bauprüfverordnung - BauPrüfVO”). The building authority obtains the consent of the municipality and consults all the bodies and agencies required to decide whether approval can be granted.

Building permission is to be granted if the building project does not conflict with any provisions of public law which are to be considered in the authorisation procedure. Building permission is a so-

called “tied decision”, that means the authority has no margin of discretion which safeguards the constitutional right to build under Article 14 of the Basic Law.

Building permission expires if the building project is not started within three years (sometimes four or six years) after permission has been granted, or if execution of the works is interrupted for longer than one year. On application, it can be extended for one year.

The architect or engineer authorized to submit building documents can submit an outline planning application (“Bauvoranfrage”) before the application for building permission proper to clarify individual aspects relating to the project, for instance whether land is suitable for building and type and degree of building and land use. The lower building authority then issues an outline or preliminary building permission (“Bauvorbescheid”) based on a binding decision, and by which it is bound in the subsequent building permission procedure Preliminary building permit is valid for the same period as building permission proper[34].

In the simplified building permit procedure, the building authority only checks a section of particularly important requirements, such as permissibility under building planning law or compliance with a local design statute. The simplified procedure is generally carried out for all projects requiring approval that are not special construction projects, for example high-rise buildings, hospitals, sports facilities.

Type approvals (“Typengenehmigungen”) are intended as an administrative simplification for structural installations that are to be erected in the same design at several locations. On 22 February 2019, the German Conference of Construction Ministers (“Bauministerkonferenz”) decided to include type approval for building structures in the Standard Building Regulations (“MBO”).

6.4 United Kingdom

6.4.1 Introduction to Building Permitting

This chapter primarily concentrates on England, which, by a significant margin, constitutes the largest portion of the United Kingdom (UK), accounting for approximately 84% of the population. The UK is made up of four distinct countries: England, Wales, Scotland, and Northern Ireland. It is essential to note that there are variations in building and planning regulations among these individual countries within the UK, reflecting their unique historical, cultural, and geographical contexts. For instance, while England has adopted the National Planning Policy Framework, Scotland follows its own distinct planning framework, known as the Scottish Planning Policy. However, despite these differences in building and planning regulations, the application, review, and approval procedures in each country share notable similarities, ensuring a consistent approach to development and growth across the United Kingdom. Current regulations are shortly presented in Annex G.

There is a relatively low level of digitisation in the UK permitting and compliance processes. Most Local Authorities operate, and strongly prefer, submission via online portals, but paper-based applications are still allowed. The submission material is expected to be in PDF form, though some flexibility may be allowed for some aspects of the Building Control process, as will be discussed in the respective sub-chapter. There is no other data collected at the time of submission and each building control authority is responsible for archiving their submissions. While most Local Authority archiving for new planning applications is now in digital (PDF) form, older archives are in hard copy.

6.4.2 UK Building Permit Process

The UK Building Permitting and Compliance process operates on two levels: receiving Planning Permission (PP) and passing Building Control (BC). The processes are controlled under 2 separate

[34] Pahl-Weber, E. and Henckel, D. (eds.) “The Planning System and Planning Terms in Germany. A Glossary.” Studies in spatial development. Online, available https://www.arl-net.de/system/files/media-shop/pdf/ssd/ssd_7.pdf, accessed 30.4.2023.

entities and are governed by different laws. Some particularities are introduced because the four countries are operated under different legal frameworks. Nevertheless, the processes including the challenges for automating compliances are similar disregarding some distinctive differences due to the use of different regulations. More detail on the UK processes is given in Annex H.

UK Planning Process

Planning in England is governed by the *Town and Country Planning Act 1990*. This separate planning into two aspects: forward planning (i.e., future strategy), and development control (i.e., managing current development). The Planning application procedure is set out in the *Town and Country Planning (Development Management Procedure) (England) Order 2015, SI 2015/595*.

A particular feature of the English planning system is that the overall Planning of an area falls under the Local Planning Authority (LPA), which sets out the required parameters, manages the Planning Application process, and monitors compliance. Planning applications are decided based on their individual merits and their accordance with the local development plan. As a rule, the government does not set specific provisions at a national level (some exceptions are described in Section 38(6) of the Planning and Compulsory Purchase Act 2004 and section 70(2) of the Town and Country Planning Act 1990). Instead, the government sets out the National Planning Policy Framework, which Local Authorities must consider when preparing the local development plan. Local Authority planning policies and decisions must also reflect relevant international obligations and statutory requirements.

The National Planning Policy Framework was last revised on 20 July 2021. This sets broad targets for the local development plans, identifying 16 strategic aims, such as “Building a strong, competitive economy”, “Making effective use of land”, “Achieving well-designed places”, and “Conserving and enhancing the historic environment”.

Planning Permission is usually needed if a new building is constructed, major changes are to be made to an existing building (e.g., an extension to a house), or the use of a building changes (e.g., switch from commercial to residential). A series of exceptions, under the heading Permitted Development, do not require planning permission, as this is taken to be granted automatically by order of central government. These typically include minor changes to existing properties, such as certain types of enclosures and sheds, installation of certain chimneys, internal alterations, etc.

The main types of Planning Application are:

- outline application, for undertaking a development “in principle”, without providing a detailed design.
- full application, for developments that include building, engineering, or other works.
- householder application, for alterations or extensions to a single residential dwelling, within the plan boundary.

These can be followed by two other types of application:

- reserved matters application, providing details of the building design. This follows approval of an outline application and should typically be submitted within three years.
- prior approval application. This is typically for specialised matters relating to works that would otherwise fall under Permitted Development.

It should be noted that it is not uncommon in England to seek planning permission without intending to pursue the work immediately (or, in some cases, at all), but as a way of influencing the potential sale price of a property. Once Planning Permission is granted, the applicant typically has three years to commence the works. If work does not start during this period, a new application needs to be made.

The required documents are set out by each LPA, however, as a rule for a new building they include:

- a location plan, that shows the application site in relation to the surrounding area (typically in 1:1250 or 1:2500 scale),
- a site plan,

- adequate plans and drawings to describe the works for the level of detail required,
- supporting documents
- the relevant fee

Fees vary widely, depending on the type of application and LPA. Sample costs start from £96 for a simple Prior Approval application, continue to £462 for a development with a gross floor space between 40 and 75 m^2, and can run to many thousands for major developments (capped at £300k)[35].

In the year ending September 2022, authorities undertaking district level planning in England received 422,300 planning applications, down 12% on the year ending September 2021[36]. The number of planning applications received, decided, and granted annually, has remained roughly similar over the past decade (Figure 13). There is, however, a general upwards trend in the number of housing units granted planning permission (Figure 14).

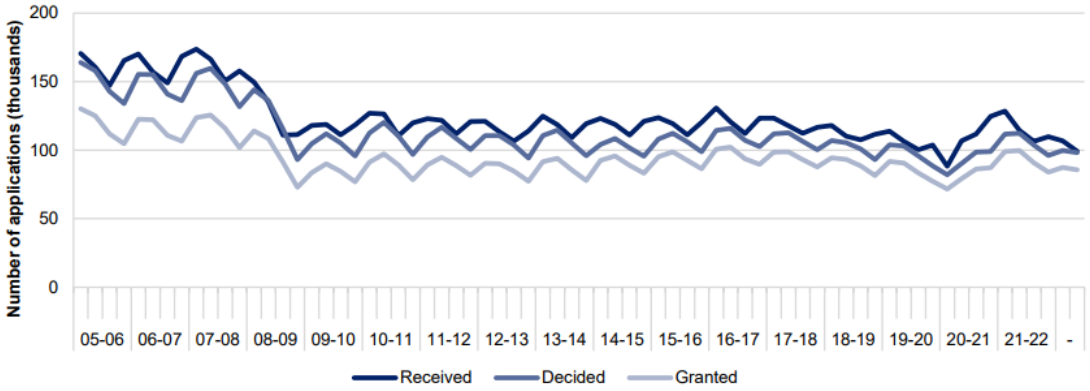

Figure 13. Number of planning applications received, decided, and granted in England, quarter ending June 2005 to quarter ending September 2022. (Source: Department for Levelling Up, Housing and Communities)

[35] Source: Planning Portal
https://ecab.planningportal.co.uk/uploads/english_application_fees.pdf
[36] Source Department for Levelling Up, Housing and Communities
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1124519/Planning_Application_Statistics_July_to_September_2022_Statistical_Release.pdf

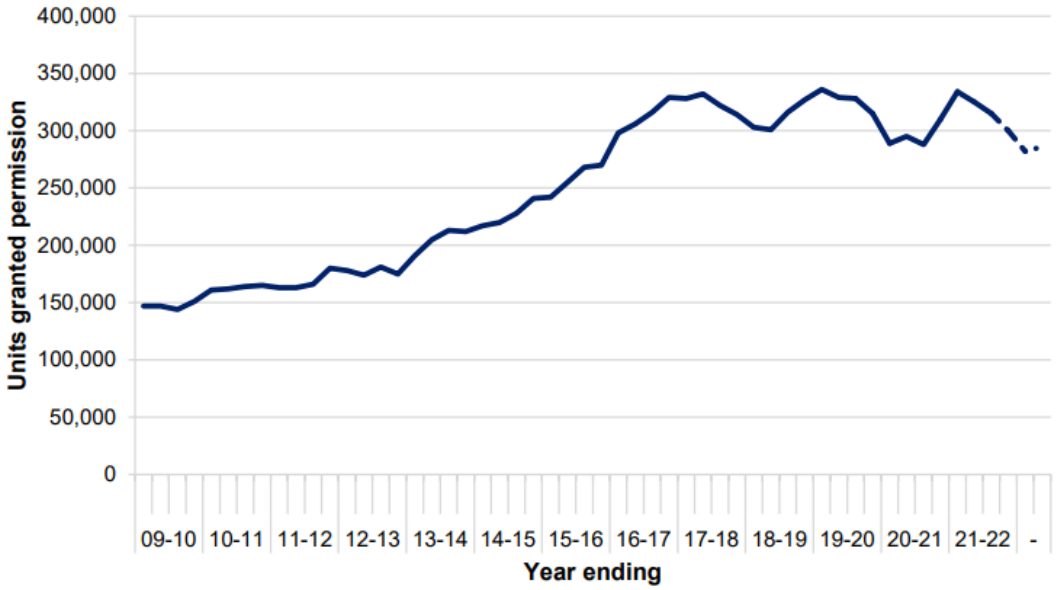

Figure 14. Number of housing units granted planning permission in England, year ending June 2009 to year ending September 2022 (Source: Department for Levelling Up, Housing and Communities)

The UK planning application process is described in more detail in Annex H.

The main actors in the Planning Application process are:

- the Applicant
- the Local Planning Authority

Supporting actors are:

- the designers (if appointed)
- other authorities (if required)
- neighbours (if required)

The Building Control Process

Building Regulations 2010 set out the required standards for work involving buildings in England. Enforcement of the Building Regulations is based on the Building Act 1984. Typically, Building Regulations apply when constructing a new building; making changes to an existing building; changing the use of an existing building; changing building services that fall under the category of "controlled service" (e.g., a boiler) or "controlled fitting" (e.g., a window). The Building Regulations are applicable to all stakeholders of the building process, including owners, agents, designers, builders, and installers. The verification mechanism is typically based on inspection.

Building Regulations cover a wide range of areas from structure, material, and workmanship to energy and water efficiency, fire safety, and building services issues.

While the main areas the Building Regulations cover are like those in other European countries, the Building Control process in England has some differences to other models. The most important differences are:

- The inspection and certification of Building Control issues can be undertaken by private providers.
- In some cases, third-party certification can remove the need for Building Control (i.e., the work can be inspected and certified by a third party, or in-house).
- Owners can choose if they wish to inform the Local Authority prior to starting the work. Even though it is advisable they do, this is not a strict requirement.

- While there are preferred design codes, Building Regulations allow for various ways to demonstrate that an adequate standard has been met, including past versions of design standards, or guidance set out in Approved Documents. In some cases, the deciding factor for the design code to use might be insurance or warranty aspects. In others, the entity that undertakes Building Control might set out its expectations.

Approved Documents are published by the government and provide advice on how to meet the requirements of the Building Regulations for common situations, with a particular focus on residential construction. The current Approved Documents are:

A: Structure

B: Fire safety

C: Site preparation and resistance to contaminants and moisture

D: Toxic substances

E: Resistance to the passage of sound

F: Ventilation

G: Sanitation, hot water safety and water efficiency

H: Drainage and waste disposal

J: Combustion appliances and fuel storage systems

K: Protection from falling, collision and impact

L: Conservation of fuel and power

M: Access to and use of buildings

P: Electrical safety – dwellings

Q: Security – dwellings

R: Physical infrastructure for high-speed electronic communications networks

The digitisation process is at a similar level to that of the Planning Process. Local Authorities would typically have a Building Control portal, where information would be expected to be uploaded in PDF. However, the use of private Building Inspectors allows the option for some flexibility.

The building control process is described in more detail in Annex H.

The actors of the Building Control process are:

- the owner (or agents acting on their behalf)
- the designers and builders
- the Building Control body, which can be either:
  - the Building Control body of a Local Authority, or
  - a licenced private Building Inspector, or
  - a third-party certification body (e.g., a manufacturer)
- other authorities (e.g., the Fire Authority, or the Sewage Undertaker), if needed.

6.5 Spain

6.5.1 Introduction to Building Permitting

In Spain, the territorial legislative system is organised into three different levels of government: (1) National, (2) Regional, and (3) Municipal. The Spanish Constitution gives autonomy to municipalities to intervene in all matters affecting their interests. Building permissions are some of the main activities carried out by municipalities. More detail of the Spanish Regulations is given in Annex I.

Spain consists of 17 regions, also called autonomous communities, including the archipelago of the Canary Islands in the Atlantic Ocean and the archipelago of the Balearic Islands in the Mediterranean Sea, and two autonomous cities in northern Africa: Ceuta and Melilla (Figure 15).

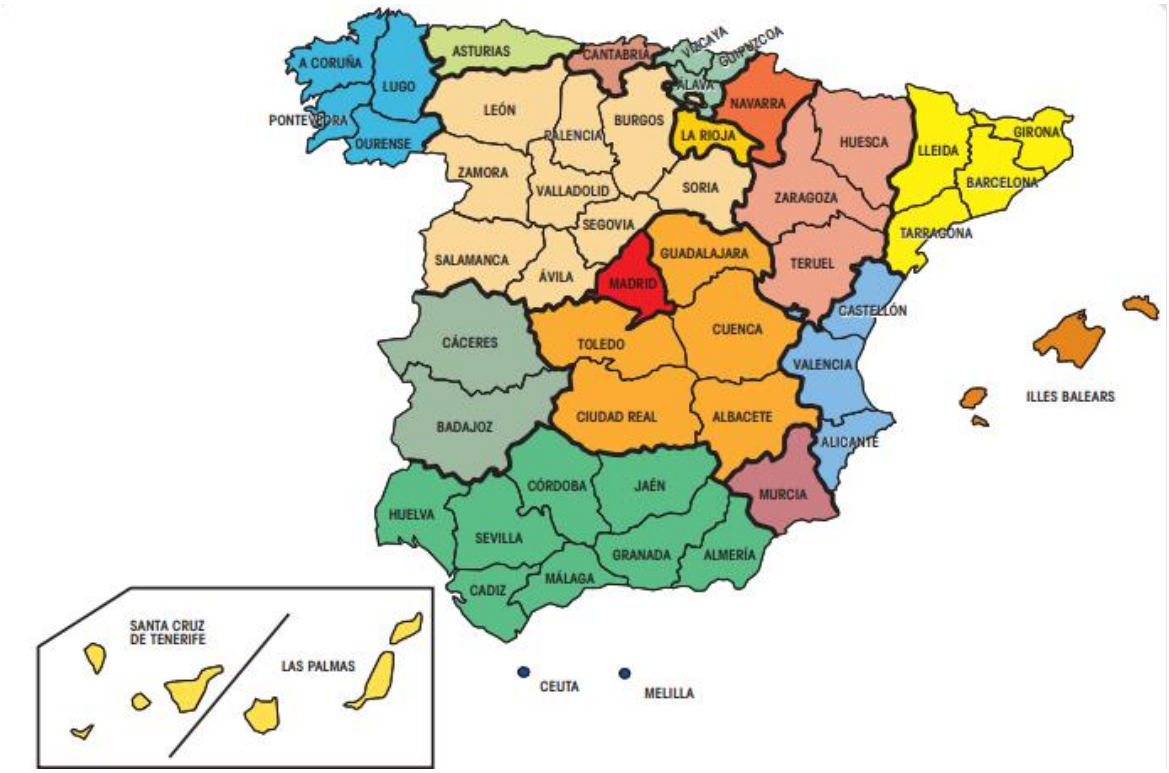

Figure 15. Spain regions map (indicated by colours) and provinces (indicated by thick lines) (Source: Spanish Ministry of Public Administrations[37]).

Each region is itself divided into provinces, making a total of 52 provinces and 8,112 municipalities. The region with the largest number of municipalities is Castilla y León and the lesser is Ceuta y Melilla with two municipalities (Figure 16).

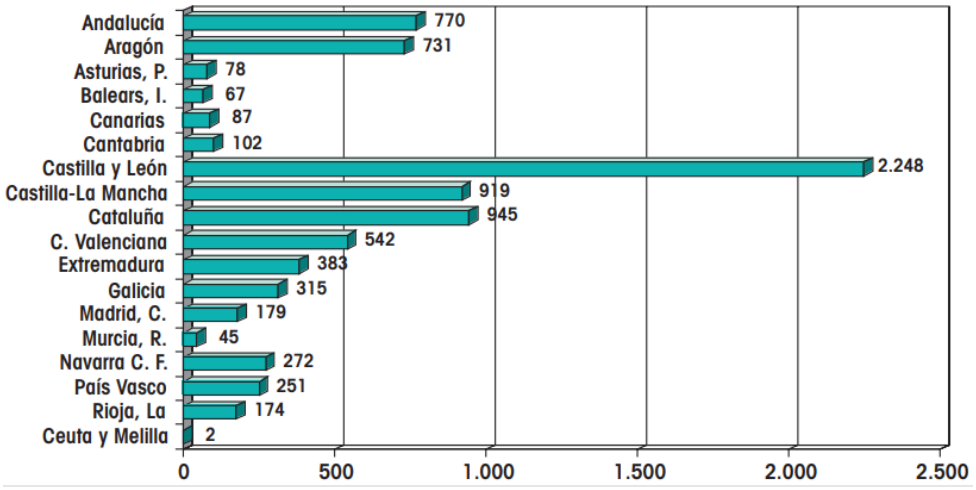

Figure 16. Number of municipalities per region (Source: Spanish Ministry of Public Administrations[37]).

The municipality and the province are the basic forms of local organisation in Spain. However, there are others that are more specific:

- Islands.
- Entities smaller than municipalities (entidades de ámbito territorial inferior al municipio, EATIM, in Spanish) such as villages, neighbourhoods, parishes, councils, etc.
- Commonwealths (mancomunidades in Spanish).
- Counties (comarcas in Spanish).
- Metropolitan areas.
- Port authorities.
- Other grouping of municipalities.

In general, the municipality is the local authority that has the competence to grant building permits in its territory. However, in some cases, the above-described local bodies may have a role in the building permit process, especially for specific projects that fall within their competence. It is important to consult case-by-case which local authority should grant the relevant building permit for a specific urban site or given building.

According to Spanish regulations, a planning or building permit is an act for controlling a project prior to using the urban rights for building and filling the land with a particular purpose under given conditions.

The process for obtaining a building permit in Spain typically involves applying to the local planning authority, which will review the plans and ensure that they comply with local regulations, such as those related to safety, health, environmental impact, and urban planning. The application may also require a report from a qualified architect or engineer and may involve public consultation. Once the permit is granted, construction can begin but it will be subject to periodic inspections by the local authorities to ensure compliance with the approved plans. Violations of urban regulations related to building permits may result in fines or other penalties, as well as the requirement to halt construction or demolish illegal structures.

[37] The local regime in Spain, available: https://www.hacienda.gob.es/Documentacion/Publico/SGT/CATALOGO_SEFP/232_Regimen-Local-ESP-INTERNET.pdf, accessed 15.03.2023.

The available data in the Spanish National Institute of Statistics (INE) show that in year 2011 there was a decrease in the amount of building permits as a delayed response from the financial crisis in 2009. Since then, the total number of building permits remained stable between 51,000 and 60,000 all along the decade until 2019 (Figure 17).

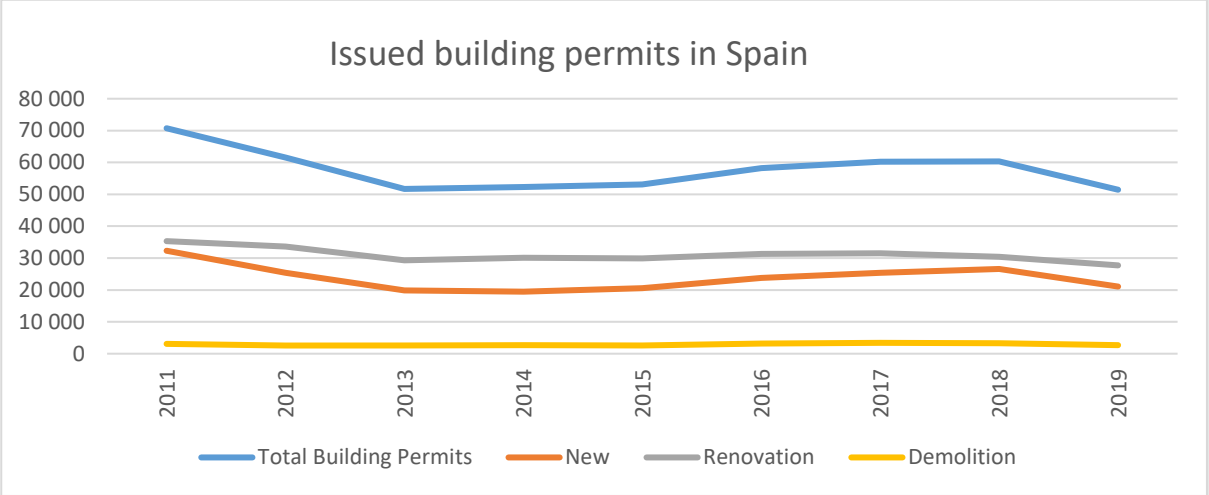

Figure 17. Issued building permits in Spain (Source: Spanish Statistical Office[38]).

Furthermore, from these figures it can also be observed that there was an average of 57,735 building permits between 2011 and 2019, of which: 54% were building permits for renovation works, 41% were permits for new construction works, and only 5% were for demolition works (Figure 18).

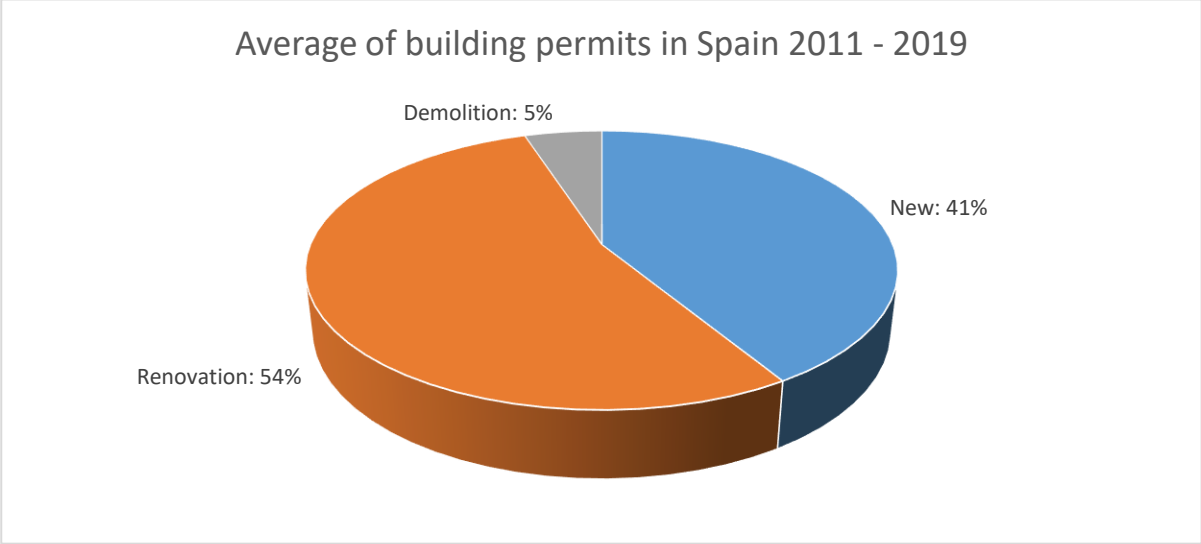

Figure 18. Issued building permits in Spain between 2011 and 2019

[38] Building construction publications (municipal building licenses), available: https://www.mitma.gob.es/informacion-para-el-ciudadano/informacion-estadistica/construccion/construccion-de-edificios/publicaciones-de-construccion-de-edificios-licencias-municipales-de-obra, accessed 15.03.2023.

There are several types of administrative authorizations to be granted by authorities that can enable the execution of building works. These are described in Table 20.

Table 20. Types of administrative permits in Spain

Permit type	**Permit description**
Planning or building permits	Grant new construction, renovation or demolition works.
Declaration of absence of the need to permit	Grant division or segregation of land if there is not urban parcellation.
Urban development projects	Grant projects that carry out planning and construction of the urban environment.
Local ordinary works	Grant a provisional use of the land of 7 years as a maximum, prior to re-parcellation and without preventing the execution of the envisaged urban planning.
Enforcement or restoration orders	Grant the execution or restoration of buildings with safety or health problems, or when the restoration is required due to external factors such as natural disasters.

The cost of a building permit in Spain can vary depending on diverse factors, such as the location of the property, the type of construction, the size of the project, and the fees charged by the local government or municipality.

Building permit fees in Spain can range from a few hundred euros to several thousand euros. For example, a small renovation or construction project may cost a few hundred euros for a building permit, while a larger commercial or residential construction project could cost several thousand euros.

In addition to the building permit fee, there may be other costs associated with obtaining the necessary permits and approvals for a construction project in Spain, such as fees for technical reports, environmental impact assessments, heritage reports and other related documentation.

6.5.2 Spanish Building Permit Process

The current building permit process in Spain is divided into different phases, which are described in more detail in Annex J. The general flow of the process is for the most part generic, in which some parts only change the responsible for carrying out some of the actions: (1) promoters for private works, or (2) the municipalities when it comes to public works.

The building permit is divided into the following four sequential grants, some of which only apply in certain cases:

- For private projects, the granting of the administrative license to request financing for the construction works. For public projects, the final approval of the local works project.
- The granting of the certificate of effectiveness, for both public and private projects.
- Start of work act, for both public and private projects.
- The granting of the Safety and Health Plan, for both public and private projects.

The main stakeholders in the Spanish building permit process are:

- The building permit applicant (usually the owner of the land plot or the promoter).
- Main architect (or a representative of the bureau in charge of carrying out the design).
- Local building control authority (municipal authority).
- Other authorities, such as associations of architects and the regional government land department.

Applications for building permits in Spain are processed in accordance with local legislation, in addition to the legislation on common administrative procedure of the country's public administrations, and the procedural aspects of urban planning legislation.

Building permits that require other administrative authorizations in addition to the urban planning permission (e.g., environmental license, activity license, heritage report, roads, railway, water, fire safety, etc.), cannot be granted until the other authorizations have been granted.

Applications for building permits are subject to a technical project in the case of a new construction or extension, restoration, refurbishment, or total or partial demolition of existing buildings if they affect:

- Foundations or structural elements.
- Volumes or built-up areas.
- The urban use.
- The number of dwellings, premises, or other elements of private uses.

The technical project must identify the affected property and contain at least the necessary written and graphic documentation with the technical characteristics of the works in sufficient detail to make it possible to verify their compliance with the urban planning legal system and the applicable legislation.

For new construction and extension projects, the authorized project may be a basic project with the minimum content required by law. Prior to the start of the works, an execution project, and a report from the project management on the compliance with the authorized project must be provided.

In restoration, refurbishment or demolition projects, the authorized project must define the works and justify their compliance in accordance with the applicable legislation and what is required by municipal ordinances.

The record for granting the building permits issued by an authority must incorporate technical and legal aspects. The permit is granted in accordance with the provisions of the applicable legislation, urban planning and municipal by-laws on land use and building in force at the time of the resolution of the application.

The building permits for the execution of the works must set maximum periods for starting and finishing them in proportion to their size. If not indicated, the deadlines are one year to start and three years to finish. Both deadlines are calculated from the day after the notification of the granted license and are automatically extended for half of the deadlines if the person entitled to start the works asks for it before the given deadline.

The building permits expire if the deadline to start the works or the deadline to finish them elapses, including the respective extensions without having been initiated or finalized. For these purposes, the issued licenses must contain the corresponding expiration notice.

The holder of a building permit must provide the granting administration with a copy of the work commencement report attested by the project manager of the works, subsequently, a copy of the final certificate of works also expedited by the project manager. If the authorized works do not require project management to execute them, these documents must be replaced by the corresponding responsible declaration of the person holding the planning license.

When the deadline to start the works or the deadline to finish them has expired, including their respective extensions, without them having been started or finished, the granting administration must declare the expiration of the urban planning license granted, with a prior audience to the person holding the license.

The failure to declare the expiration of the planning license does not authorize the persons involved in the execution process of the works to start or continue them beyond the terms allowed by the license nor, consequently, exempt them from the administrative responsibilities that may arise from the execution of works carried out outside the mentioned deadlines.

Following the conclusion of the construction all works are subject to a final physical on-site inspection that, if not completed satisfactorily, could lead to the need for physical changes to the building.

6.6 Regulations aimed for digitalisation

This section presents the preliminary laws/regulations/guidance that will be targeted for digitalisation within each country demonstration.

Finland will focus on four types of regulations:

1) Real estate building and spatial information, which is regulated by the national requirements in Government Decree on the Population Information System, in Finnish: Valtioneuvoston asetus väestötietojärjestelmästä 2010/128[39], a summary in English[40]
2) Accessibility, which is regulated by Government Decree on Accessibility of building, in Finnish: Valtioneuvoston asetus rakennuksen esteettömyydestä 241/2017[41], in English Government Decree on Accessibility of Buildings[42]
3) Operational safety, which is regulated by Government Decree on operational safety in building, in Finnish Valtioneuvoston asetus rakennuksen käyttöturvallisuudesta 1007/2017[43], in English Government Decree on operational safety of buildings[44]
4) Carbon dioxide equivalent calculation which will be governed by national decree that is under development but will be in effect starting 1st of January 2025. A draft version is available in Finnish[45].

Estonia will focus on four types of regulations:

1) Fire safety requirements for the building[46]
2) Accessibility, building requirements arise from the special needs of disabled people[47]
3) CO2 calculation, no regulation yet. Purpose is to work out usable methodology for building permit checking, in collaboration with the Finnish demonstration.
4) Schools and kindergartens requirements, Health protection requirements for the land area, buildings, premises, furnishings, indoor climate, and maintenance of preschool institutions[48] Health protection regulation for schools[49]

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[39] https://www.finlex.fi/fi/laki/ajantasa/2010/20100128#L2P23 (in 24 § Rakennustiedot, 25 § Rakennushanketta kuvaavat tiedot, 27 § Huoneistoa koskevat tiedot, updated: 30.10.2014/852)
[40] https://dvv.fi/en/real-estate-building-and-spatial-information
[41] https://www.finlex.fi/fi/laki/ajantasa/2017/20170241
[42] https://ym.fi/documents/1410903/35099218/Accessibility+of+Buildings.pdf/56f06cd3-4a27-6ee3-e553-e35731ffa70b/Accessibility+of+Buildings.pdf?t=1680607572789
[43] https://www.finlex.fi/fi/laki/alkup/2017/20171007
[44] https://ym.fi/documents/1410903/0/YMa+k%C3%A4ytt%C3%B6turvallisuus+1007_2017+EN.pdf/ee85f7a4-0ef7-d489-a450-70a2469a2361/YMa+k%C3%A4ytt%C3%B6turvallisuus+1007_2017+EN.pdf?t=1668155648754
[45] Shared for opinions, under further development: https://www.lausuntopalvelu.fi/FI/Proposal/DownloadProposalAttachment?proposalId=70fe9e3d-e065-4143-ba6e-4e1f63299842&attachmentId=19499
[46] https://www.riigiteataja.ee/akt/123022021013
[47] https://www.riigiteataja.ee/akt/131052018055
[48] https://www.riigiteataja.ee/akt/111102011003
[49] https://www.riigiteataja.ee/akt/128082013010?leiaKehtiv

Germany will focus on three types of regulations:

1) Land use permitting machine readable regulation in land use plans (development plans): floor space index, ground space index, floor area, buildable area, building height, conservation area, zoning[50]
2) Environmental Compliance: Lifecycle Assessment and Green Building Certification. German Sustainable Building Council (DGNB e.V.) Certification scheme
3) Building permit for industrialized timber housing

The UK will focus on Automatic Checking of Structural Integrity of Steel Modular House Components, specifically:

1) EN 1990. Eurocode 0: Basis of Design[51]
2) EN 1991. Eurocode 1 : Actions on Structures[52]
3) EN 1993-1-1. Eurocode 3: Design of Steel Structures[53]

Relevant Eurocode National Annexes (NAs) associated European Norms (ENs) and European Technical Assessments (ETAs) of specific products will be added as applicable for each design case.

Spain will focus on urban regulations, such as the minimum plot, Buildability, Maximum occupancy, Minimum facade, Regulatory height, Minimum separations, Occupancy of auxiliary buildings from National level (CTE, Spanish Technical building code); Regional level (Catalan regulation code); Municipal level (City parameters harmonization across Europe cities); EU Directive 2014/24/UE.

6.7 Conclusion

This section has analysed and described the existing construction permitting and compliance processes in the demonstration countries. The processes start with the applicant needing a building permit and end with the applicant receiving the building permit that allows the applicant to start the construction phase. The following information has been identified in each demonstration country through process modelling: (a) the actors/stakeholders involved, (b) the activities and (c) the regulations involved.

Over 80% of Finnish municipalities use an online building permitting system for submitting data needed for receiving the building permit. There are two online building permitting systems in use. Building drawings can be submitted as pdfs, but also as an IFC file in some municipalities, and IFC -based submission will be the new normal in Finland in less than two years, when the new Building Act will be in effect. Some municipalities' use software (Solibri Model Checker) to support the accessibility compliance checking.

Estonia also has an online building permitting system for pdf or IFC based submission, which all municipalities use. The building permit process includes 47 automatic checks against the Building Code. In the future, in addition to automated rule checking, technical data about the building will be extracted from the IFC model and sent to building permit application automatically.

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[50] https://xleitstelle.de/xplanung/releases-xplanung (relevant in accord project: XPlanGML 5.4 Version (https://xleitstelle.de/xplanung/releases-xplanung?fid=1164#block-bootstrap-xleitstelle-page-title) and XPlanGML 6.0.2 Version (https://xleitstelle.de/xplanung/releases-xplanung?fid=1402#block-bootstrap-xleitstelle-page-title)

[51] https://eurocodes.jrc.ec.europa.eu/EN-Eurocodes/eurocode-basis-structural-design

[52] https://eurocodes.jrc.ec.europa.eu/EN-Eurocodes/eurocode-1-actions-structures

[53] https://eurocodes.jrc.ec.europa.eu/EN-Eurocodes/eurocode-3-design-steel-structures

Germany has developed an overall process of a BIM-based building application procedure based on a selection of use cases and implemented it as a prototype of an R&D project, where one construction project in the city of Dortmund in 2021, received a building permit based on BIM planning.

UK has conducted research on developing building permitting, but currently the process has a low level of digitalisation. Most local authorities operate and prefer submission via online portals, but paper-based applications are allowed.

In Spain, documents are submitted only in PDF or DWG format and no cases on digital BIM/GIS based permitting or compliance checking exist.

7. Conclusions

This deliverable has documented the results of Task 1.1 (*Landscape Review of Built Environment Compliance and Permitting)* and Task 1.2 (*Identification of Building Permitting Processes and Regulations*) of the ACCORD Project.

In doing so it has analysed the complex landscape of built environment compliance checking and permitting across Europe to ascertain the requirements for the future digitalisation of this complex interdisciplinary field. The project partners have conducted a landscape review and analysis of the current adoption of the concept of digitalisation of building permitting and compliance checking. A survey has also been conducted into the attitudes of stakeholders to the prospective digitalisation of this domain in a range of European countries.

This deliverable has met the first five objectives of WP1.

Conduct a landscape review and analysis of current adoption of the concept of digitalisation of building permitting and compliance checking across: Has been met through the conduct of the landscape review (Section 3).

Conduct an EU wide survey into the attitudes of stakeholders to the prospective digitalisation of this domain: Has been met through the conduct and analysis of the EU wide survey (Section 4).

Ascertain the current laws, regulations and guidance that currently drive building permitting across EU consortium member states: Has been met through the identification and analysis of regulations within each of the accord demo countries (Section 0).

Investigate and formally model the existing building permitting and compliance checking processes in the demonstration countries: Has been met through the conduct of process modelling of building permitting processes in ACCORD demo countries (Section 0).

Perform a preselection of regulations/requirements to focus the future development of prototype implementation within the demonstration projects: Has been met through the pre-selection of regulation based on analysis and consultation within each demo country (Section 0).

Meeting these objectives has provided the following key outputs that will benefit the remainder of the project:

- A solid understanding of the state of the art in the field in the areas of academic and EU projects and commercial software.
- Data and understanding on the views of members of the industry, specifically their attitudes to digital building permitting and compliance checking along with their views on the obstacles, benefits, and requirements for achieving this ambitious goal.
- A knowledge of standards that may be applicable for the ACCORD project to feed into later developments.

- Detailed understanding of the level of adoption along with pre-selection of the regulations that the project will consider in each of our demo countries.
- Process mapping of building permitting processes in ACCORD demo countries.

This solid basis will pave the way for the development of the ACCORD semantic framework. This framework will have the potential to achieve real change and drive forward the digitisation of this area.

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Annex A: Finnish Building Permit Related Laws and Regulations

Land Use and Building Act (5.2.1999/132)

The current state-level Land Use and Building Act (132/1999)[54] aims to "create a healthy, safe and comfortable living environment that is socially functional and where the needs of various demographic groups are taken into account."[55] It specifies buildings' general conditions, technical requirements, building permit process and authorities' building supervision.[56]

The technical requirements are related to the strength and stability of structures, fire safety, health, user safety, accessibility, noise abatement and noise conditions, and energy efficiency.

The Land Use and Building Act is currently being reformed. The new law will probably be in effect starting the 1st of January 2024 and will probably be called "Building Act".

Land Use and Building Decree

The Land Use and Building Decree[57] was issued in 1999. It includes provisions for the following:

- Town planning
- Municipal building ordinances
- Planning and building about shore areas.
- Plot division
- Expropriation of land in relation to community structure
- General requirements for building
- Building permits and other supervision by authorities

The National Building Code of Finland

Other guidelines and provisions related to buildings are issued in the National Building Code of Finland. Usually, Building Code regulations apply to new buildings only, but in renovations or alterations, the regulations may be required due to the type and extent of the measure or use of the building or part of it that may be changed[58].

Building codes

- Planning and supervision
- Strength and stability of structures
- Fire safety
- Health
- Safety of use
- Accessibility (Decree 241/2017 Government Decree on Accessibility of building)[59]

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[54] 5.2.1999/132 Maankäyttö- ja rakennuslaki, available https://www.finlex.fi/fi/laki/ajantasa/1999/19990132, accessed 2.1.2023.

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[57] Land Use and Building Decree (in English), available https://www.finlex.fi/en/laki/kaannokset/1999/en19990895.pdf, accessed 2.1.2023.

[58] The National Building Code of Finland, available https://ym.fi/en/the-national-building-code-of-finland, accessed 2.1.2023.

[59] 241/2017 Government Decree on Accessibility of building (pdf), available https://www.ym.fi/download/noname/%7B0227BAF6-C406-4BF8-9177-837E6B7CF29D%7D/140057, accessed 2.1.2023.

- Noise abatement and noise conditions
- Energy efficiency of buildings
- Use and maintenance manual.
- Housing design

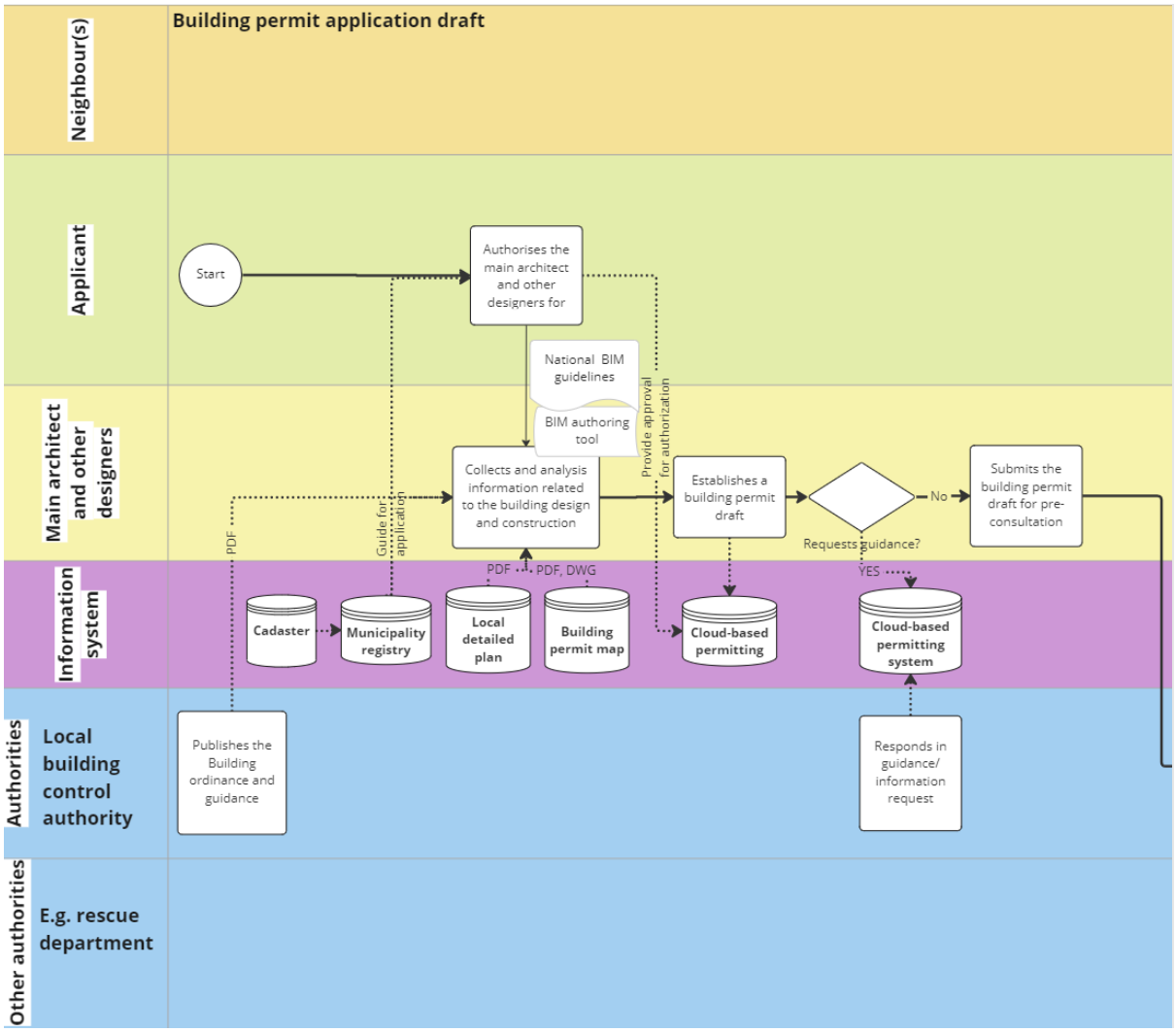
Building ordinance

Each local authority has a building ordinance which includes regulations based on local conditions. These regulations are necessary for organised and appropriate building, taking cultural, ecological, and scenic values into account, and for creating and maintaining a good living environment.

The building ordinance regulations may concern construction sites, the size and location of buildings, a building's suitability for its surroundings, the method of construction, planting, fences and other constructions, management of the built environment, organisation of water supply and drainage, definition of areas requiring planning, and other corresponding matters of local importance on building.

Annex B: Finnish Detailed Process Descriptions

Building permit application draft



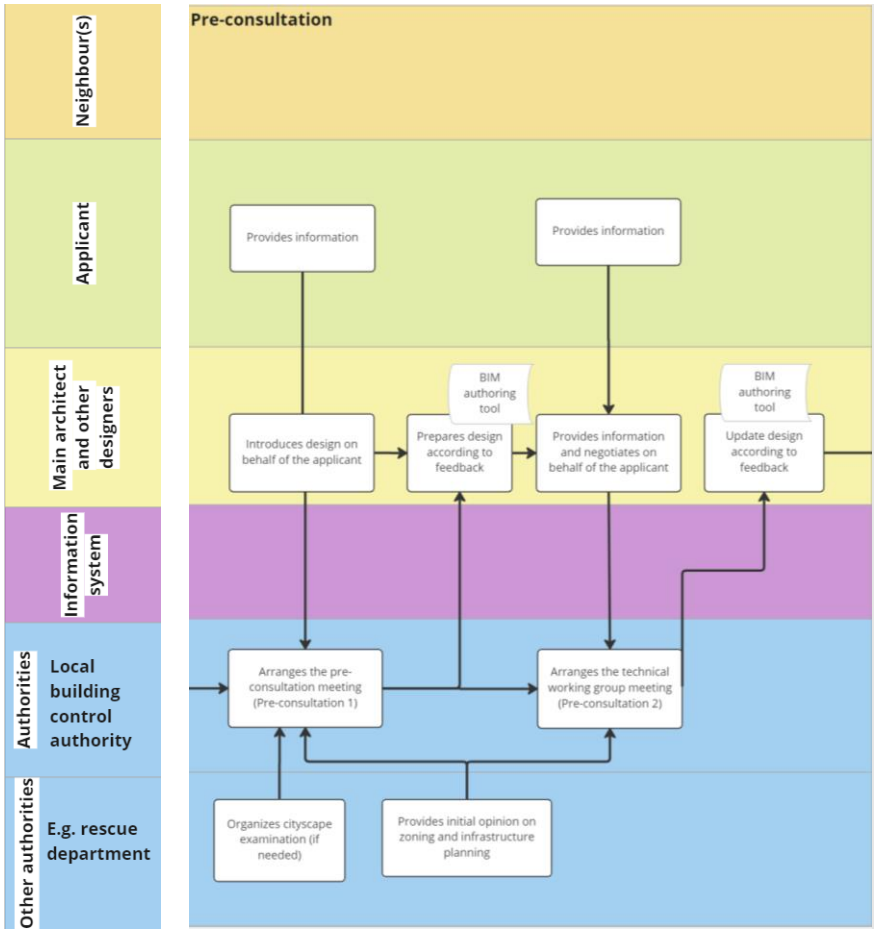
The building permit process starts when an applicant needs a new building permit. The applicant, either the owner of the land plot or the architect authorised by the owner, can apply for the building permit. According to the law, the permit application can be submitted as incomplete, and it can be updated after it has been submitted. However, the local authorities guide the applicants to submit as complete an application as possible. Usually, the applicant seeks personal pre-consultation with the building control authority to clarify the permit procedure. The pre-consultation is not mandatory and cannot be legally required. It is common practise for anything larger than a single dwelling and very useful in densely built areas. However, in the countryside and less crowded areas it is very possible to have applications be processed without any pre-consultation.

In the early phase, the authorised main designer (architect) gathers needed initial information from the municipal registries and local detailed plan[60] as well as orders the plot map from municipal survey services. The national-level cadastre information is needed to indicate land plot ownership.

[60] The government sets the national land use goals. Then, there is the regional plan, under which resides the local master plan, which provides general guidance on the land use of the municipality. The local detailed plan details the organisation of land use, building and development.

In larger projects, the building design is usually done using a BIM authoring tool (ArchiCAD or Revit). BuildingSMART Finland has prepared national Common BIM requirements (COBIM[61]) since 2012, and these guidelines are planned to be renewed. Also, the ongoing municipalities' RAVA3Pro project is renewing the BIM guidelines to apply for a BIM-based building permit.

Pre-consultation



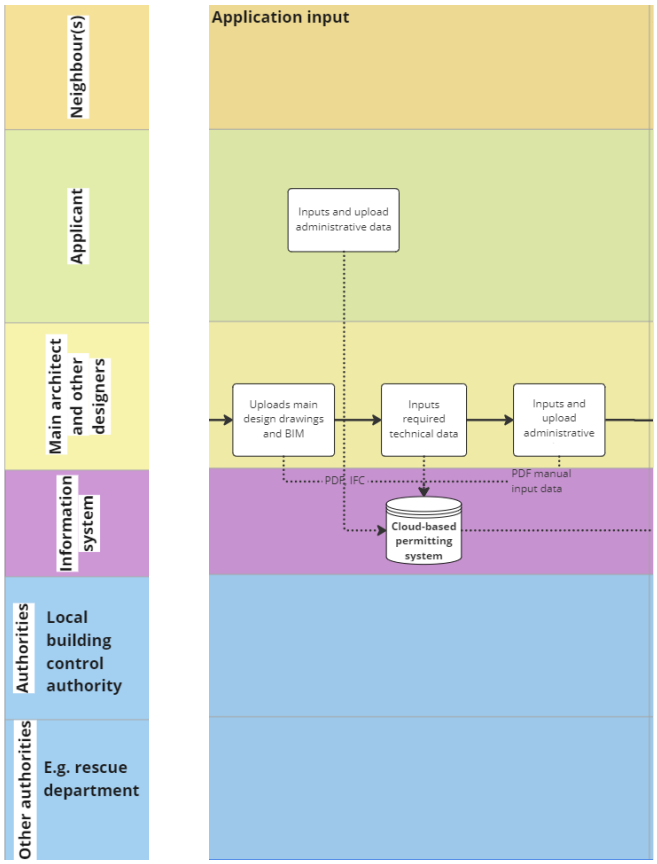
During the pre-consultation phase, the local building control authority can organise two meetings to guide the applicant and evaluate urban scene effects. The first meeting is for a general consultation regarding the initial design proposal and specific needs of the permitting process. The local building control authority initially checks that the chosen designers have the needed qualifications for the project. An important part is an evaluation of how the proposed building fits in the location and the surrounding urban scene. This cityscape examination is usually done in bigger projects.[62] The cities may have organized a city scene board for this kind of evaluation.

The second meeting is more technical in nature. Usually, technical details are discussed, and e.g., the rescue department may provide its initial guidance and requirements. Also, other authorities may provide initial statements on zoning and infrastructure planning.

[61] https://wiki.buildingsmart.fi/en/04_Guidelines_and_Standards/COBIM_Requirements

[62] Cityscape and Technical Working Group in city of Helsinki, available https://www.hel.fi/en/urban-environment-and-traffic/plots-and-building-permits/building-permits/building-permit-or-statement#cityscape-and-technical-working-group, accessed 5.1.2023.

Application input



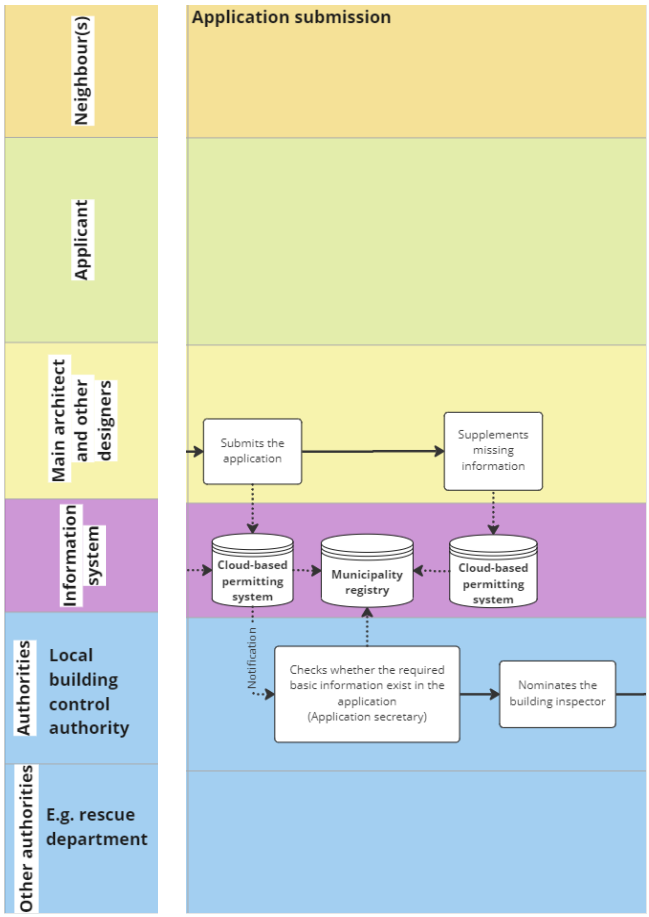
The applicant establishes the permit application in the municipality's cloud-based permitting service and inputs and uploads information when available. Some formal data sheets of the building and project are to be filled. The main architect or the applicant uploads the main design drawings (pdf). In Finnish practice, only the main architectural drawings are provided for permitting, and structural topics and HVAC systems are described generally. The detailed designs for these are required for inspection in building permit terms that the building inspector defines in the permit decision.

Sometimes the architectural BIM as an IFC file may also be provided with an application. For example, in the city of Järvenpää, all big building's permit applications are accompanied by BIM for mostly visual checking.

At this phase, some technical descriptions and documents need to be uploaded to the building permit service, depending on the building type and size. Finally, also the needed administrative data, such as the notice of property conveyance or documents of designers' qualifications, are uploaded to the service. Municipalities usually have guidance to provide the needed documentation, and in most cases, this guidance is built into the cloud-based permitting system[63].

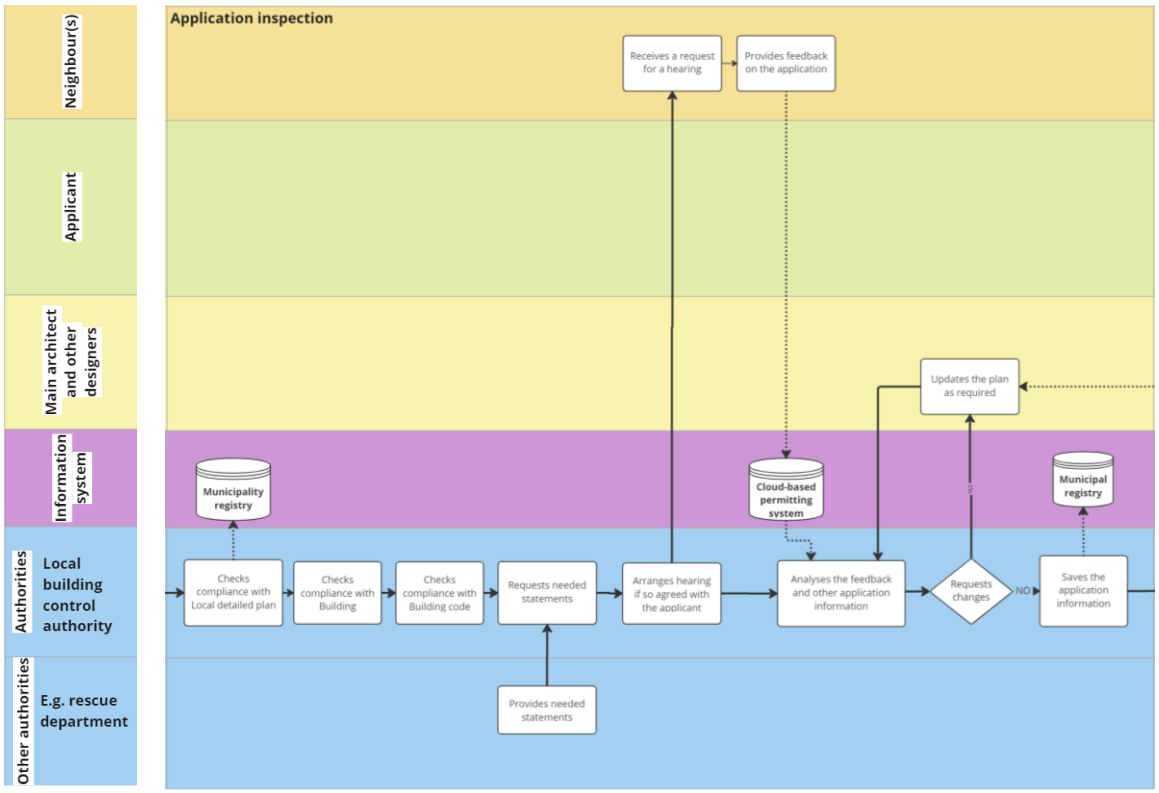
[63] A compressive list of the City of Helsinki (in Finnish), available https://www.hel.fi/static/rakvv/lomakkeet/Lupa-asiakirjat.pdf, accessed 5.1.2023.

Application submission



During the application submission phase, the applicant or the main architect submits the application to the building permit service. Once the application is submitted, the local building control authority's secretary checks whether the required basic information exists in the application and requests the supplement information if missing. After pre-check, the secretary nominates a building inspector for the project according to the municipality's practice.

Application inspection



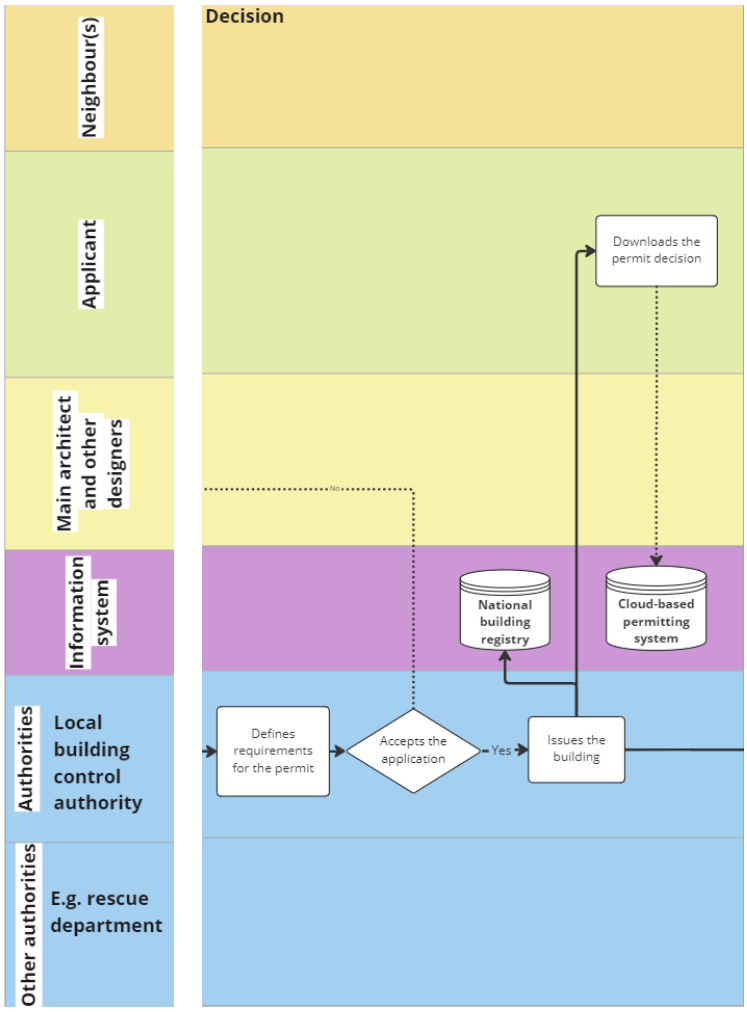
During the application inspection phase, the local building control authority will check the application's compliance with the local detailed plan. Also, compliance with building ordinance and compliance with building codes are checked. Currently, the manual compliance checking does not cover all details, and it is based on sampling in line with the municipality's practise.

The building inspector requests the needed statements from other authorities, and they have fourteen days to provide their statements.

After the checks, the neighbours are sent a request for a hearing, and the neighbour can provide his/her opinion within two weeks. The hearing of the neighbour can be done in the building permit service if the email address of the neighbour is known. If not, then the request is made by traditional mail. The home address of the neighbour can be received from the national building registry.

The applicant may be requested to update the plan. The authority sends the application information to the municipal registry.

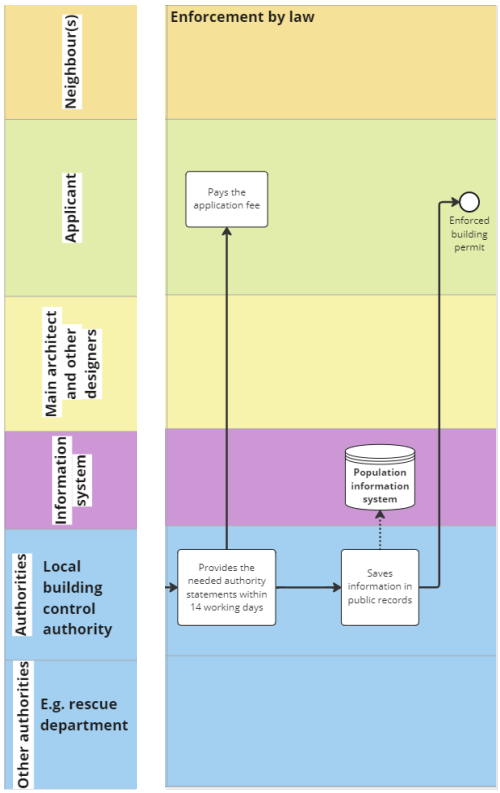
Decision



During the decision phase, the local building control authority defines the requirements for the permit. After that, if the application is accepted, the authority issues the building permit. The permit applicant may download the application (pdf) from the building permit service.

The decision maker varies in different municipalities. In some municipalities, the decision maker is the person handling the building permit application, whereas in some municipalities, the decision maker can be the leading building inspector. Decisions can also be made by a committee in larger projects. Usually, the building control inspector has been delegated power up to a certain building volume and when the project scope is large enough a committee must be involved.

Enforcement by law



During the enforcement by law phase, a fourteen days' period, complaints against the project can be raised. If the decision is made by a committee the period is 30 days. If no complaints are made, the authority provides the needed authority statements within fourteen working days and saves permit information in the public records, like the Municipal registry and States Population Information System, which includes the building registry. The applicant is charged for the municipally set fee of the permit.

Annex C: Estonian Building Permit Related Laws and Regulations

Planning Act

Planning Act was majorly renewed in 2015. The purpose of this Act is to create, through spatial planning, the prerequisites for a democratic, long-term, balanced spatial development, land use, high-quality living and built environment that considers the needs and interests of society members, promoting environmentally friendly and economically, culturally, and socially sustainable development.

The Act stipulates conditions for different level of planning, from which master plans and detail zoning plans are important for building permit process. In the permitting process one of main responsibilities of local government is to assess construction design documents against conditions set in the planning phase. There can be mostly 4 different use cases:

- There is existing detail zoning plan without additional design conditions (design conditions are regulated in the Building Code)
- There is existing detail zoning plan with additional design conditions (can be set after 5 years of establishment of detail plan)
- There is master plan and design conditions without detail zoning plan requirement.
- There is master plan and design conditions in an area with detail zoning plan requirement, but falls under exception set in the Planning Act

Building Code

The Building Code was majorly renewed in 2015. The purpose of this code is to promote sustainable development and ensure safety, purposeful performance, and usability of the built environment. It includes provisions for the following:

- mechanical durability and stability.
- fire safety.
- hygiene, health, and environment.
- the safety of use and access, including the evacuation and rescue needs of people from the building and the operational map.
- protection against noise.
- energy efficiency and efficiency.
- sustainable use of natural resources.
- special needs of disabled people.
- performance and interoperability and compatibility of the building.
- requirements arising from purpose and use, i.e., condition requirements, including maintenance requirements.
- marking of the building and its location.

In addition, there are 20 more detailed Ministry level regulations referred to from Building Code. Most of them are relevant for building permit process.

Other state level laws

For some type of buildings, there are additional laws with their more specific regulations, that are not covered with Building Code, but are relevant for building permit process. These are following:

- Public Health Act[64] - valid for schools, kindergartens and water facilities like pools and spas.

[64] Public Health Act, https://www.riigiteataja.ee/akt/113032019131?leiaKehtiv, accessed 13.03.2023.

- Occupational Health and Safety Act[65] - valid for office buildings.
- Fire Safety Act[66] - in addition to fire safety requirements set in the Building Code.
- Tourism Act[67] - valid for accommodation buildings like hotels and hostels.
- Heritage Protection Act[68] - requirements for buildings under heritage protection.
- Product Conformity Act[69] - requirements for building products.

Together with the Building Act and its regulations, there are ca 50 national level regulations, that must be followed for the building permit process.

Building ordinance

Each local authority has a building ordinance which includes regulations based on local conditions. These regulations are necessary for organised and appropriate building, taking cultural, ecological, and scenic values into account, and for creating and maintaining a good living environment.

The building ordinance regulations may concern construction sites, the size and location of buildings, a building's suitability for its surroundings, the method of construction, planting, fences and other constructions, management of the built environment, organisation of water supply and drainage, definition of areas requiring planning, waste managements, parking, and other corresponding matters of local importance on building.

[65] Occupational Health and Safety Act, https://www.riigiteataja.ee/akt/109072020007?leiaKehtiv , accessed 13.03.2023.
[66] Fire Safety Act, https://www.riigiteataja.ee/akt/112122018071?leiaKehtiv , accessed 13.03.2023.
[67] Tourism Act, https://www.riigiteataja.ee/akt/131012020018?leiaKehtiv , accessed 13.03.2023.
[68] Heritage Protection Act, https://www.riigiteataja.ee/akt/119032019013?leiaKehtiv , accessed 13.03.2023.
[69] Product Conformity Act, https://www.riigiteataja.ee/akt/130062020023?leiaKehtiv , accessed 13.03.2023.

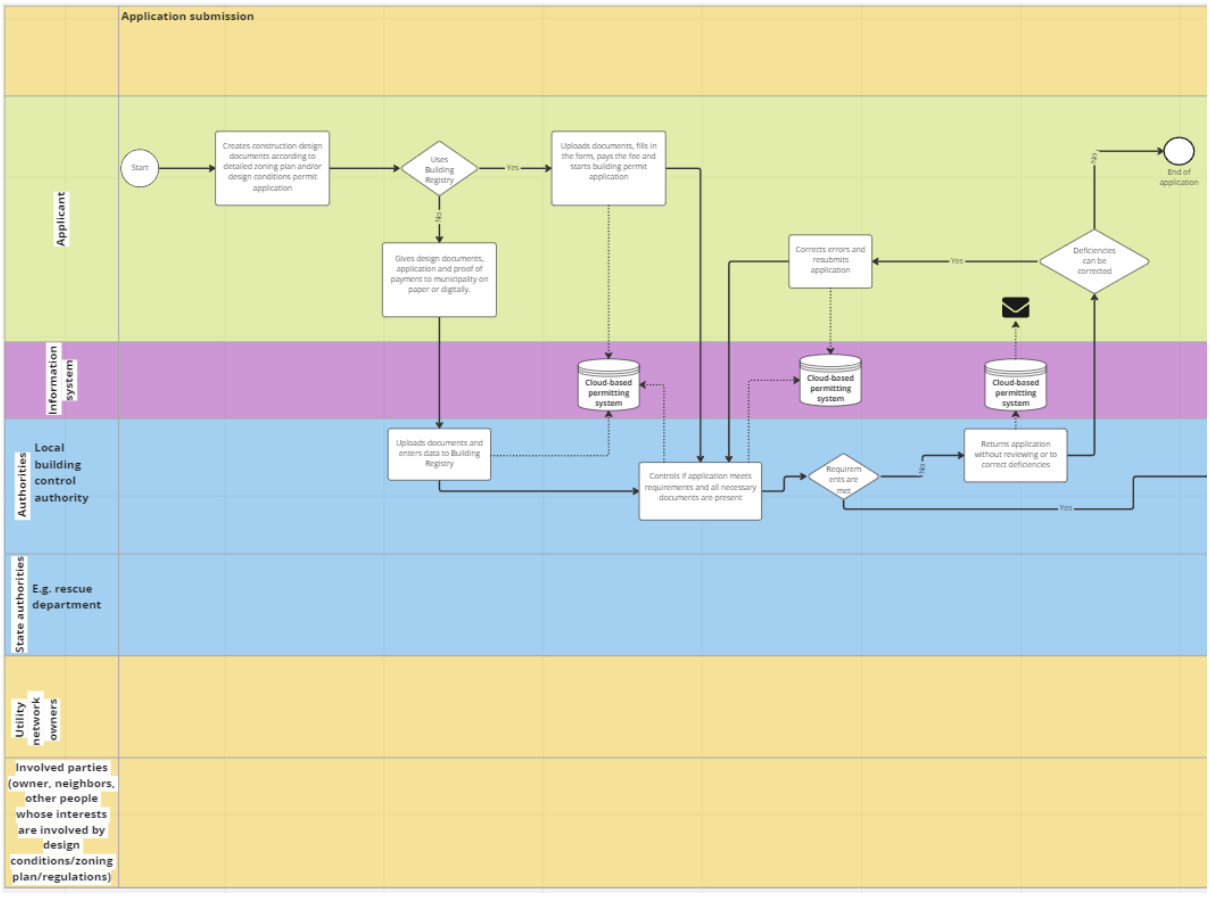
Annex D: Estonian Detailed Process Descriptions

Pre-consultation and application draft

In Estonia pre-consultation is possible by contacting local municipality, but it is not obligatory process in the building permitting and therefore, not described further in the process. In addition, local governments have guidelines on their website to make building permit application easier for the applicant. If applicants have a sketch, they can get feedback to it from local municipality.

Technically it is possible to load not complete construction design documents (draft) to the Building Registry during the submission phase, but it is strongly not recommended by the local authority, because it prolongs permitting process. Construction design must be thought through and completed at least to preliminary design level before starting application. Requirements for preliminary design level are set by construction design standard EVS 932:2017 and regulation Requirements for the construction project[70].

Building permit application submission



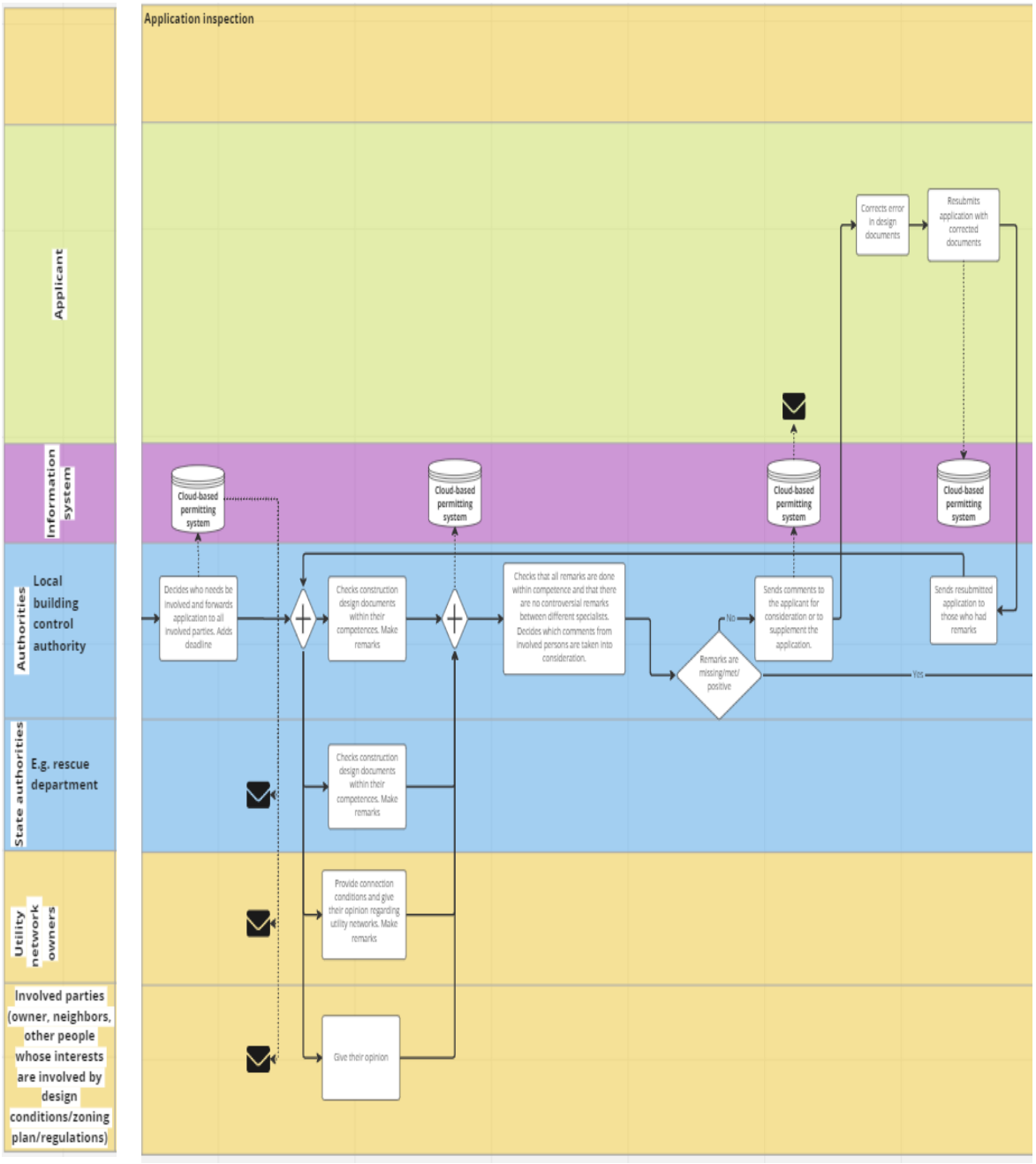
In submission phase applicant (owner or some other person delegated by owner) have a decision either to do the submission fully digital in the Building Registry or to take construction design and all other necessary documents to local authority on paper (exception in the law). In any case permit process will be carried through in Building Registry procedural environment IT solution. If documents are on paper, then it is the task of the local authority to scan them in, upload to the Building Registry and insert data about the building(s) in the registry. Fee must be paid before submission.

[70] Requirements for the construction project https://www.riigiteataja.ee/akt/118072015007?leiaKehtiv, accessed 14.03.2023.

When the application has been submitted, it reaches local authority. It varies by the municipality how application is directed further, but overall process is quite similar. In some municipalities there is a secretary that picks up the applications and directs them to permit processers, in other processers pick it up from their desktop according to their working procedure. In some municipalities the division of tasks is territorial, in others by the type of buildings on application.

Processer controls if application meets all requirements for example, if the fee is paid, correct permit type is selected, all the documents that are needed are presented, all technical data about the building is added to the Building Registry. If requirements are not met, processer can decide either to return document without reviewing (ends the permit process for this application) or to correct deficiencies. If deficiencies cannot be corrected, it ends the permit process for this application. Otherwise, applicant must correct deficiencies and resubmit the application. If all requirements are met, inspection phase begins.

Application inspection



If all requirements from last phase are met, inspection phase begins. Processer decides by the application which specialists within the municipality, which state authorities, which utility networks owners and who else to involve in the process. Invitations to join the process are sent through Building Registry cloud based permitting system.

Number of involved people and other authorities is largely depending on the size of municipality and type of the building. For example, in Tallinn 9 different specialists can be added only from Urban Planning Department, additionally 6 other local departments with their specialists can be involved. In smaller municipalities there can be only 3-5 specialists.

State authorities are not involved in all cases (except Fire Board), but regarding type of the building. Up to 7 state authorities can be included in the permitting process: Rescue Board, Health Board, Environmental Board and Transport Administration, Consumer Protection and Technical Regulatory Authority, Ministry of Defence and Agriculture and Food Board. State authorities are coordinating

authorities and their remarks must be considered by the processing authority and applicant. All other involved parties in the permit process make their remarks as opinion and it is the task of local processing authority to decide which of these must be followed by applicant.

Utility network owners are added if their networks are in contact area of buildings on permit application. Their task is to provide technical conditions for connecting building to network and give their opinion about provided solution.

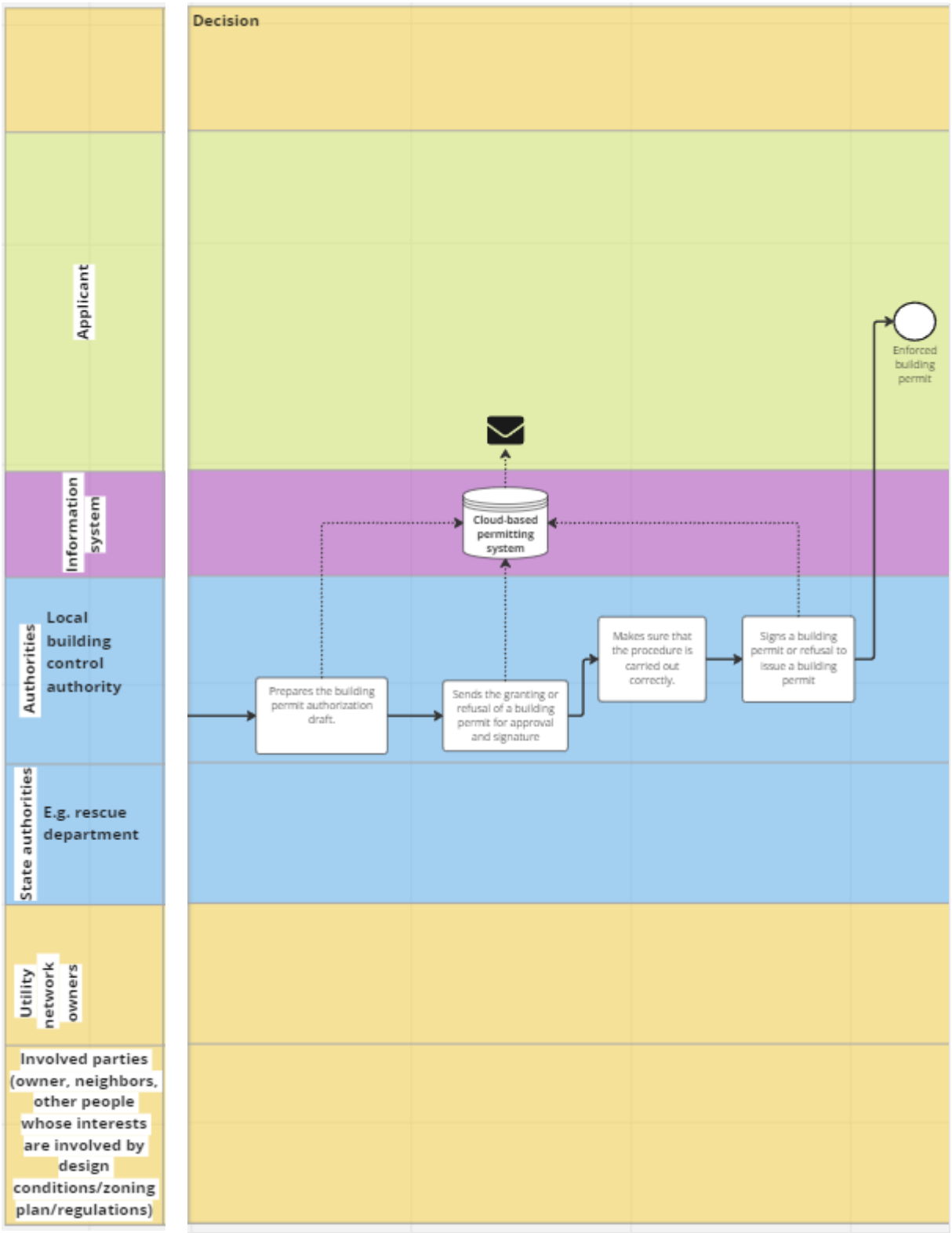
Neighbour(s) of the building, other interested parties (set by detail zoning plan, design conditions and Administrative Procedure Act) and the owner of the building if the owner is not the applicant are also involved in the process. Processer of local authority decides who must be involved.

All who are added get a notification to their email address and a deadline of 10 calendar days to do their tasks. Everyone added review the application by their competence and make remarks in the Building Registry permit system, if there are any.

After remarks are made, processer looks them through and forwards all obligatory remarks (state authorities) and compiles other remarks (makes changes if there are controversies in the remarks or they are not made by the competence of the remark maker) and forwards them to applicant for correction. Applicant must correct the documents and send the application back to processer. This circle will continue until there are no remarks, all remarks are positive, or all remarks are met by the applicant. On average there are 3-4 rounds before all remarks have been corrected. In very rare cases for smaller building permits, there have been 2 rounds. Some applications last more than 10 rounds before everything are completely corrected.

If there are no remarks, all remarks are positive or all remarks are met by the applicant, the process will go to the decision phase.

Decision



During the decision phase, the processer of local building control authority prepares the building permit authorisation draft (administrative act draft) and sends it for signing. The signer of building permit varies in different municipalities. In some municipalities, it is the head of the department

responsible for building permitting, whereas in some municipalities, it can be the City Council or Parish Council. The permit applicant may download the final permit (pdf) from the Building Registry.

Annex E: German Building Permit Related Laws and Regulations

Public building regulations in Germany are distinguished between “building regulation law” (“Bauordnungsrecht”) on national level and “planning law” (“Bauplanungsrecht”) on state level.

Laws are accomplished by protection and maintenance acts on national, state, and municipal level, for instance the Monument Protection Act (“Denkmalschutzgesetz”) as well as statutes on municipal level.

Relevant Building regulation law on a national level:

- Standard Building Regulation 2022 (“Musterbauordnung - MBO”)
- Federal Building Code (“Baugesetzbuch - BauGB”)
- Zoning plan / Binding land use plan (“Bebauungsplan / verbindlicher Bauleitplan”)
- Federal Land Utilisation Ordinance (“Baunutzungsverordnung - BauNVO”)
- Plan sign ordinance (“Planzeichenverordnung - PlanZV”)
- Building Documents Ordinance (“Bauvorlagenverordnung - BauvorlV”)
- Valuation Ordinance “Wertermittlungsverordnung -WertV”

Relevant Planning laws on a state level:

- State Building Code (“Baugesetzbuch - BauGB”)
- Special Construction Ordinance (“Sonderbauverordnung - SBauVO”)
- Construction Inspection Ordinance (“Bauprüfverordnung - BauPrüfVO”)

Annex F: German Detailed Process Descriptions

This appendix describes the German as-is building permit process at macro level including the outline or preliminary building permission (“Bauvorbescheid”) and the building permission proper (“Baugenehmigung”).

The starting point of the German as-is building permit process is the “digital building permit” (implementation required until the end of 2022) using XPlanung and XBau data formats and standards (required until the end of February 2023).

The overall process structure is based on the German Service Phases (“Leistungsphasen - LPH”) in accordance with the German Fee Structure for Architects and Engineers 2021 (“Honorarordnung für Architekten und Ingenieure - HOAI 2021”)1. The following phases are considered relevant for the building permit procedure:

1. **Basic evaluation** - Basic investigations of the building project.
2. **Preliminary planning**
    a. Registration and first request to the construction portal
    b. Compilation of (application) documents
    c. Application for preliminary building permit
    d. Inspection of preliminary building application
    e. Decision and granting of preliminary building permission
    f. Entry into force.
3. **Design planning**
    a. Coordination with the specialist planners
    b. Negotiations with the authorities about the approvability.
4. **Approval planning**
    a. Preparation of the building (application) documents
    b. Application for building permit
    c. Inspection of building application according to planning law
    d. Inspection of building application according to German State Building Codes
    e. Consultation of specialised authorities
    f. Decision and granting of building permission
    g. Entry into force.

No further distinctions are made of inspections according to planning law and the German State Building Codes.

The generic as-is process takes into consideration differences or different options concerning roles and responsibilities of the so called “building permit applicant” as indicated in the German State Building Codes (“Landesbauordnungen - LBO”). The following roles apply for the German building permitting process:

- Building permit applicant
- Building owner
- Architect or engineer authorized to submit building permits (“Bauvorlagenberechtige/r”);

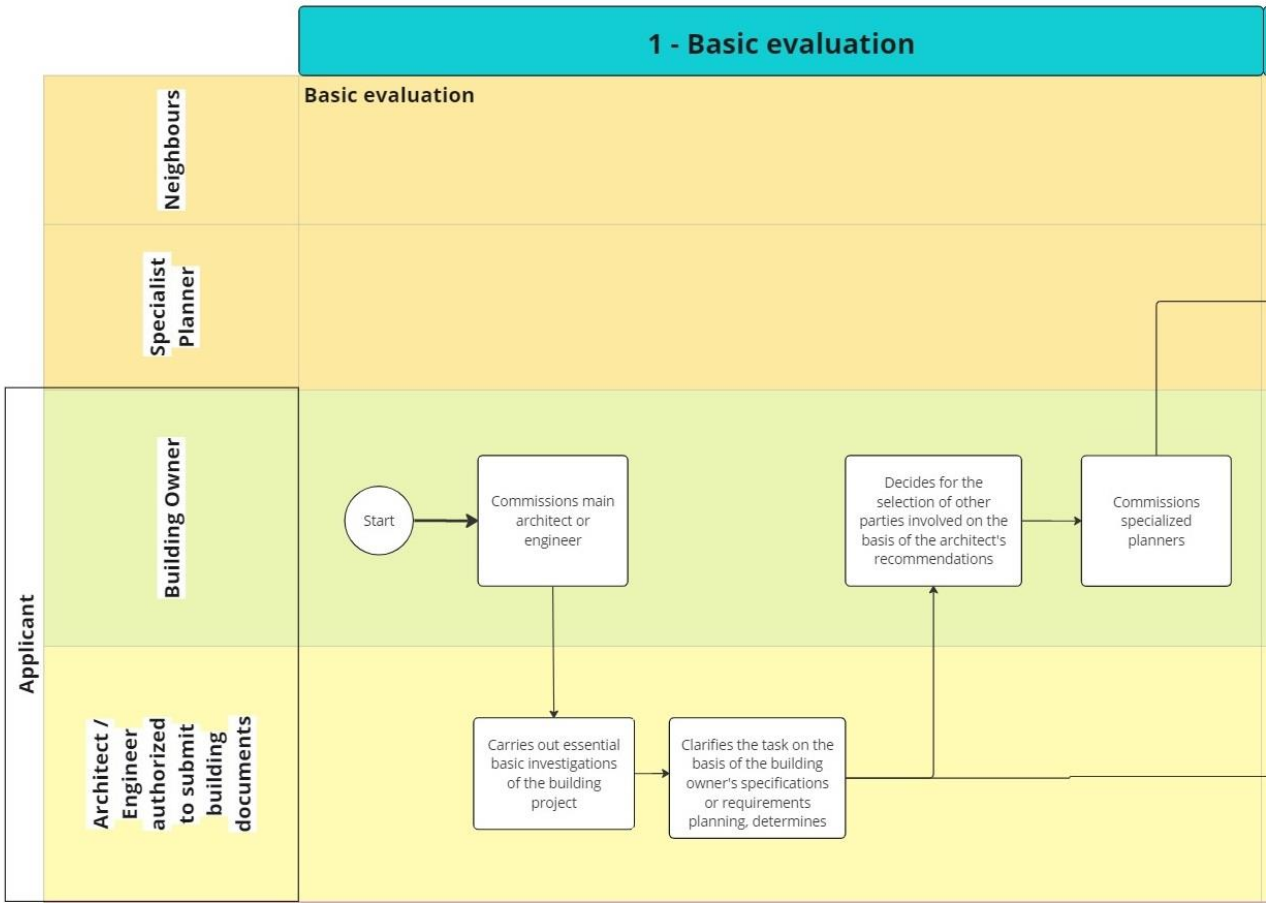
- Specialist planners (from various disciplines: structural engineering, HVAC planning, electrical planning, planning of conveying technology, and others);
- Authorities:
    - Construction supervision (“Bauaufsichtsbehörde”) or lower building authority (“Untere Bauaufsichtsbehörde”),
    - Internal and external inspection units,
    - Construction chamber (“Baukammer”);
- Neighbours.

Additional roles and responsibilities are distinguished for describing the German building permit process at use case level or to-be processes, if applicable.

The following paragraphs will describe each phase mentioned previously.

Basic evaluation

The diagram below provides an illustration of the basic evaluation phase:



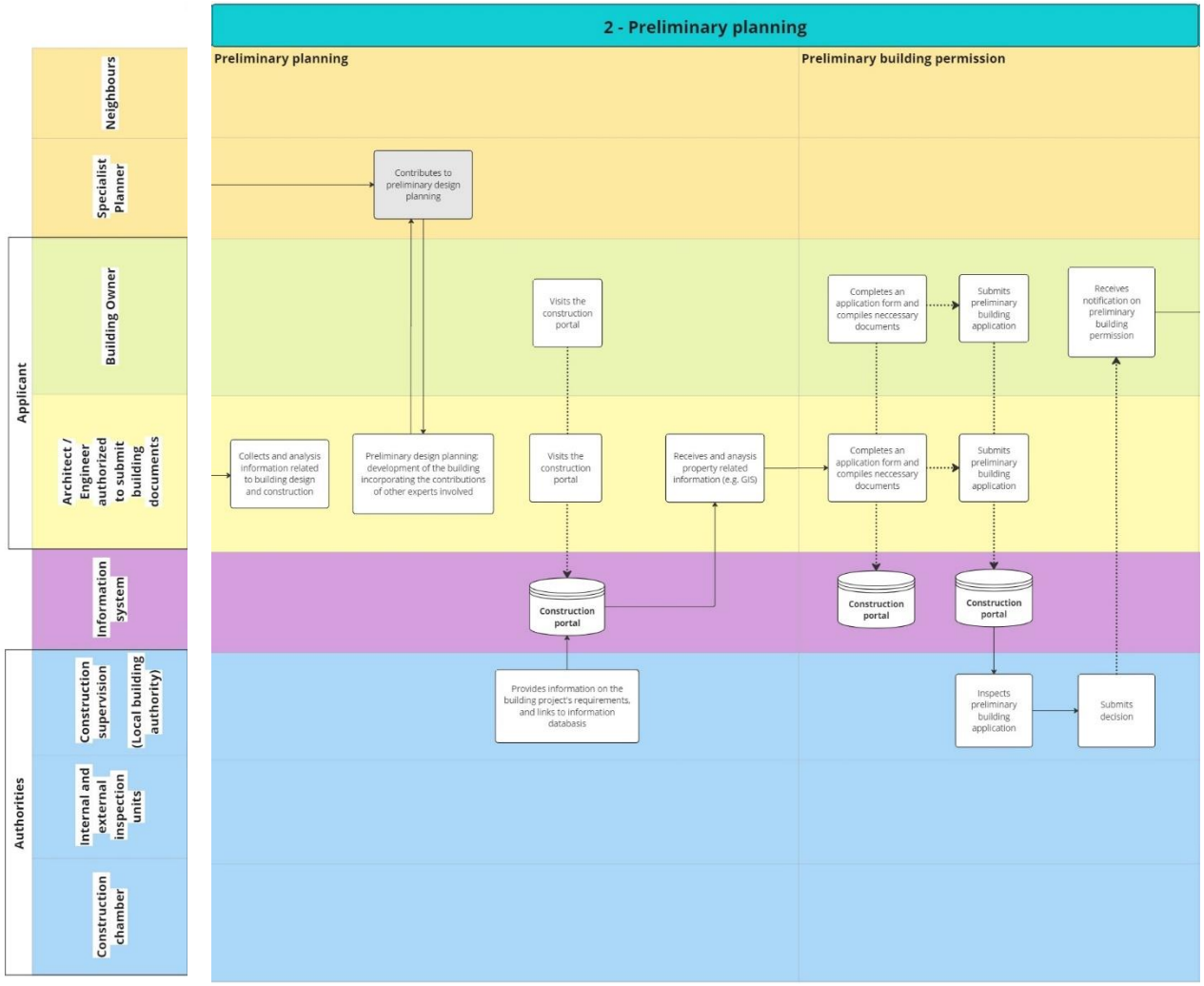
After commissioning, the main architect by the building owner, the basic evaluation phase (according to Service Phase 1 “HOAI 2021“) of the project starts. During this phase, essential points are set for the later building permit approval of the structure: The architect carries out essential basic investigations of the building project, which serve as a basis for the following planning phases and the evidence to be provided to apply for a preliminary building permission.

During basic evaluation phase, the architect clarifies the task based on the building owner's specifications or requirements planning, determines the planning boundary conditions and advises the client on the overall performance requirements. The architect formulates decision-making aids for the selection of other parties involved in the planning process, undertakes an on-site visit, and finally summarizes, explains, and documents the results.

The building owner is free to decide whether the compilation of relevant documents and/or the determination of the building project's auditability by submitting the preliminary building application are already commissioned as a special service during this service phase or in the following preliminary planning phase. In the first case, services, and activities for obtaining the preliminary building permission, which are presented in the following phase, are already conducted during basic evaluation phase.

Preliminary planning

The figure below illustrates the preliminary planning phase.



Based on previous basic investigations, the architect prepares the preliminary design planning in accordance with the building requirements and general conditions while coordinating the client's objectives with the public-legal boundary conditions as well as third-party planning.

The preliminary planning phase (according to Service Phase 2 "HOAI 2021") includes the examination of concept variants, their influences on structure, design, expediency, economic efficiency, and environmental compatibility, and which brought to a decision with the client. Planning

tasks involve the detailing of functional areas and space program, definitions of the building structures, the development of the building incorporating the contributions of other experts involved in the planning process, including considerations of the supply and disposal and examining constraints on the site and those resulting from production and assembly processes on the site.

In the preliminary planning phase, the architect obtains official maps and evaluates them. Preliminary consultations are held with the authorities and other parties involved in the planning process to determine whether the project can be approved.

In addition, a cost estimate must be prepared. For this purpose, properties such as the equipment standard or the gross floor area must already be known in the preliminary planning phase. The architect finally summarizes, explains, and documents the results.

The “building permit applicant”, that is the building owner and/or the main architect authorized to submit building documents, register, and send a first request to the construction portal. After naming the building project (ideally) an indication is received of whether building documents are required or not. In addition, general property-related information, e.g., GIS, via links to corresponding offers can be obtained.

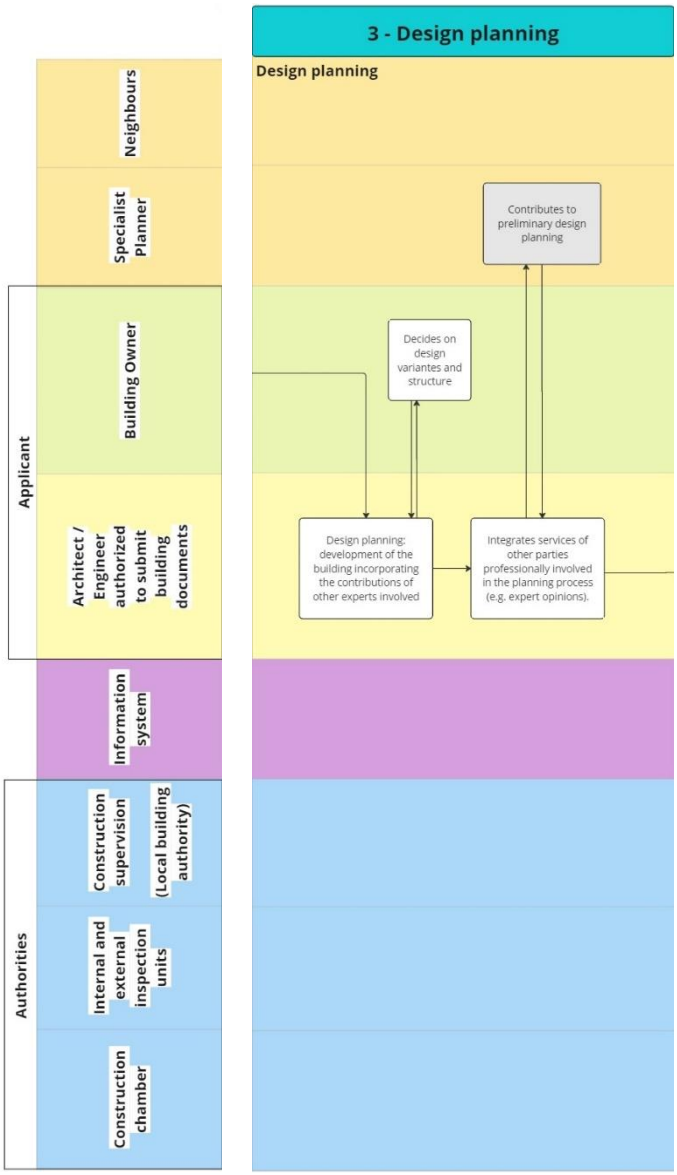
The compilation of relevant documents and/or the submission of the outline planning application (“Bauvoranfrage”) are commissioned as a “special service” during this service phase. For this purpose, the building owner assigns access rights for users of the construction portal (and grants or withdraws general power of attorney, if applicable). The “building permit applicant” completes an application form and compiles the necessary documents in accordance with the Model Building Code and the respective State Building Code.

An application for a preliminary building permit can be made formally or informally. In the case of an informal application, it is usually sufficient to submit a site plan and sketches of the building project. For a formal application, information about the property, documents about the planned building project with dimensions and building class, a site plan, an excerpt from the cadastral map and information about drainage and water supply must usually be submitted.

The construction supervision inspects the application in accordance with the respective State Building Code and checks the basic buildability of the site. After positive evaluation, the local building authority makes the binding decision of the outline- or preliminary building permission (“Bauvorbescheid”) to be granted.

Design planning

The figure below illustrates the design planning phase.

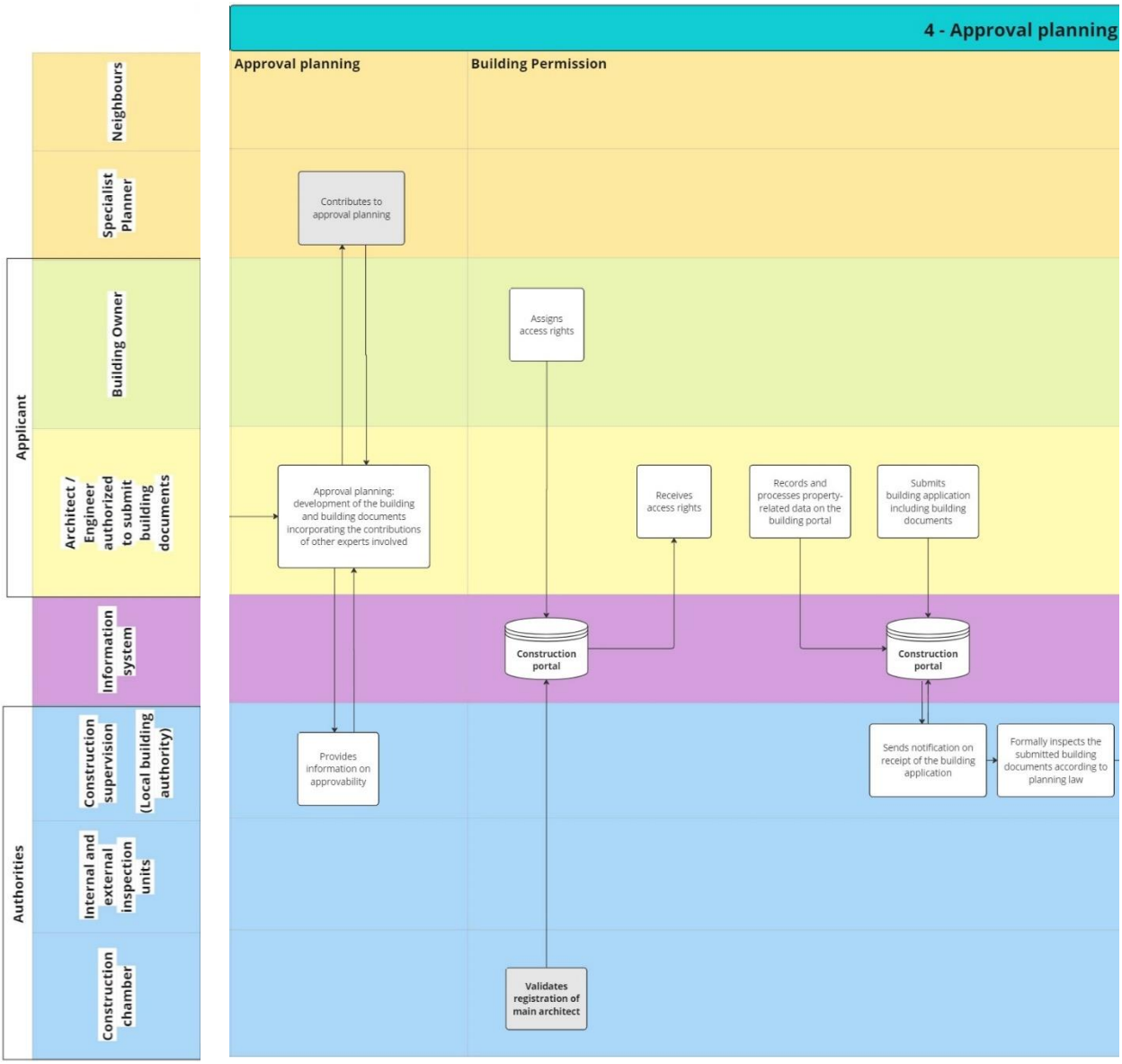


During the design planning phase (according to Service Phase 3 “HOAI 2021“), the architect elaborates the preliminary design concept to such an extent that it can form the basis for local approval and detailed preparation for execution. The service is developed in accordance with the building owner and includes the technical coordination and integration of contributions of specialist planners.

The design considers essential interrelationships and requirements (e.g. concerning urban planning, design, functional, technical, economic, ecological, social, public-legal and legal aspects) as a basis for the further service phases and the necessary public-law approvals, and integrates services of other parties professionally involved in the planning process (e.g. expert opinions). The architect’s service also includes object descriptions, cost estimation, drawing of the overall design, with design drawings of all involved specialist areas (scale according to type and size of construction project) and negotiations with the authorities about the approvability.

Approval planning

The figure below illustrates the approval planning phase.



The approval planning (according to Service Phase 4 “HOAI 2021”), also called input planning or submission planning, includes all services for the compilation of a building application based on the existing design with the aim of obtaining a building permit. The approved design is considered as the basis for the implementation planning (Service Phase 5 “HOAI 2021”).

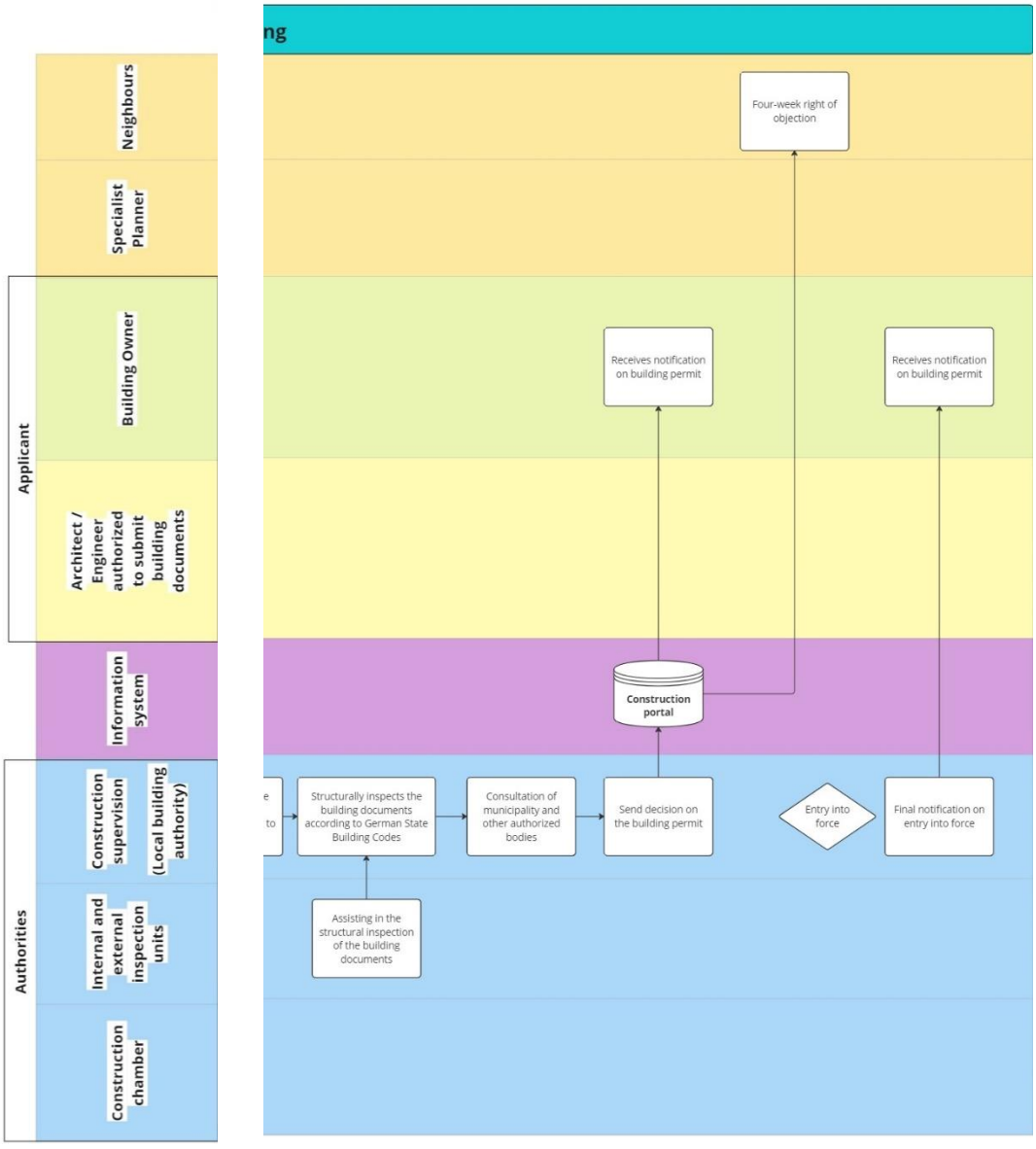
Services developed by the architect involve the preparation and compilation of documents and evidence for public-law approvals or consents, including applications for exceptions and exemptions, as well as necessary negotiations with authorities, using the contributions of other parties professionally involved in planning.

For all building projects with authorization to submit building documents (“Bauvorlagenberechtigung”), the building application is to be submitted digitally to the authorities making use of the local construction portal according to the procedure required by the Model Building Code and the respective State Building Code as well as the specifications defined by the building owner (competence coordination).

The following steps apply for using the construction portal:

1. Unique registration by the architect or engineer authorized to submit building documents,
2. Registration by the building owner as a natural/legal person,
3. The building owner assigns access rights, creates project folder and, if necessary, forms a team (with the building owner or authorized representative to be documented by general power of attorney),
4. The architect or engineer authorized to submit building documents records and processes property-related data on the building portal (e.g. excerpts from the real estate cadastre, parcel map).

The figure below illustrates the second part of the approval planning phase.



The building documents are to be prepared and signed by authorised parties. It depends on the relevant state ordinance pertaining to building documents (“Bauvorlagenverordnung - BauVorlV”) what documents and drawings (site plan, ground plan, elevations, sections) with what scale are to be submitted. In Germany, a building application usually consists of the following parts:

- Input plan with floor plans, views, and sections on a scale of 1:100
- Building application form
- Building description
- Statistical survey sheet
- Thermal insulation certificate
- Proof of stability (static calculation, statics)
- Official site plan for the building application, usually on a scale of 1:200 (smaller scales only for large plots)

If necessary, further necessary proofs and information, which are required by the construction supervision for the issuance of the permit.

The construction supervision formally inspects the submitted building application according to planning law and structurally inspects it according to German State Building Codes. The structural inspection can also be conducted by an inspection office or an inspecting body. In the following, the lower building authority obtains the consent of the municipality and consultation of required bodies and agencies.

Corrections or modifications to the application can be necessary resulting in the submission of modified building documents. The construction authority transmits the results of the formal and structural inspection and sends messages concerning the decision and regarding the fee notice to the applicant.

The building owner must prove the consent of neighbours to the building project. The architect can be assigned with this task as a special service. In case the consent was not obtained before the application inspection, neighbours have the right to challenge the building permit within 4 weeks before it enters into force.

Other special services of the architect in this approval planning phase include the provision of evidence, of technical, constructional, and building physics nature, obtaining official approval in individual cases, or technical and organizational support of the building owner in opposition proceedings and legal action.

Annex G: UK Building Permit Related Laws and Regulations

Planning and building regulations in the UK encompass a diverse range of policies and standards to guide the development and construction of buildings, ensuring sustainable growth, public safety, and environmental protection. The UK consists of four countries: England, Scotland, Wales, and Northern Ireland, each with its own distinct planning and building regulatory framework. While England follows the National Planning Policy Framework (NPPF)[71], Scotland, Wales, and Northern Ireland have their own planning policy guidance, namely Scottish Planning Policy (SPP), Planning Policy Wales (PPW), and the Strategic Planning Policy Statement for Northern Ireland (SPPS). Despite differences in policy and regulatory details, all four countries share the common goal of promoting sustainable development and preserving the built and natural environment.

Building and planning laws in the UK are complex, involving multiple levels of government and various regulations. This outline provides a general overview of some key aspects but is not exhaustive:

Planning System

National Policy Statements (NPSs) are a set of documents that outline the UK Government's strategic approach to planning and development for nationally significant infrastructure projects (NSIPs). NPSs cover various sectors, such as energy, transport, water, and waste management. They provide a framework for decision-making, setting out the government's objectives, policies, and assessment criteria for each sector. By offering clear guidance, NPSs help streamline the planning process and facilitate informed decisions by the Planning Inspectorate and the relevant Secretary of State. Additionally, NPSs ensure that infrastructure projects align with national priorities while considering environmental, social, and economic factors. The Planning Inspectorate oversees appeals against planning decisions.

NPPF sets out the government's planning policies and principles for England. It aims to streamline and simplify the planning process, focusing on sustainable development, housing, economic growth, and environmental protection. The implementation of NPPF is supported by Planning Practice Guidance (PPG)[72], which is a comprehensive online resource that provides detailed guidance, explanations, and advice to assist local planning authorities, developers, and other stakeholders in interpreting and applying the policies outlined in the NPPF. PPG covers a wide range of topics, including housing, economic development, design, environmental protection, and heritage assets, among others. Similarly, SPP, PPW and SPPS sets out the relevant planning policies for the other three countries.

Local planning authorities (LPAs) are the primary bodies responsible for overseeing the planning system within their respective jurisdictions in the UK. Typically, they are part of local government organizations, such as district councils, borough councils, or unitary authorities. LPAs play a crucial role in shaping the built environment by preparing local development plans, setting out policies and guidelines for land use and development in their areas. They also assess and determine planning applications, ensuring that proposed projects align with local and national policies. Additionally, LPAs enforce planning rules, address violations, and handle appeals, promoting orderly development and safeguarding community interests.

Land Use

[71] NPPF: https://www.gov.uk/government/publications/national-planning-policy-framework--2

[72] Planning practice guidance, https://www.gov.uk/government/collections/planning-practice-guidance

The Town and Country Planning Act 1990[73] is a key piece of legislation governing land use and development in England and Wales. The Act provides the legal framework for the planning system, establishing the need for planning permission for most development projects and setting out the process for submitting and determining applications. It also grants local planning authorities the power to create local development plans, which guide land use decisions in their respective areas. The Act emphasizes the importance of sustainable development, balancing economic, social, and environmental considerations. It also covers enforcement and appeals mechanisms, ensuring proper adherence to planning policies and decisions. There are a few key aspects of the Act relating to land use highlighted below:

- Zoning: Under the Town and Country Planning Act 1990, local development plans are required to allocate land for specific uses, ensuring orderly growth and efficient use of resources.
- Green Belt: The Act supports the designation of Green Belt areas surrounding urban centers to restrict urban sprawl, protect the countryside, and maintain the distinct character of rural communities.
- Brownfield land: The Town and Country Planning Act 1990 emphasizes the importance of reusing previously developed land, known as brownfield sites, for redevelopment where possible, promoting regeneration and reducing pressure on undeveloped land.

Planning Permission

Planning permission is a crucial aspect of the UK's planning system, primarily governed by the Town and Country Planning Act 1990. It is required for most development projects, including the construction of new buildings, significant alterations to existing structures, and changes in the use of land or buildings. Obtaining planning permission ensures that proposed developments comply with local and national planning policies, and it helps to balance the need for growth with the protection of the environment and local community interests.

There are different types of planning permission, such as full planning permission, which grants approval for a complete development proposal, and outline planning permission, which focuses on the general principles of a development, leaving details to be agreed upon later. Prior approval is another type of planning consent, applicable in cases where permitted development rights (PDRs) allow for certain changes, but specific aspects still require local authority approval.

Permitted development rights (PDRs) are exemptions from the planning permission requirement. PDRs enable specific types of minor works, such as extensions or alterations to residential properties, to be carried out without obtaining planning permission. However, certain conditions and limitations apply to these rights to ensure that developments do not adversely impact the environment or neighboring properties.

Other planning related regulations

Listed building and conservation areas: The Planning (Listed Buildings and Conservation Areas) Act 1990[74] plays a vital role in preserving the UK's architectural heritage and historic environment. It establishes two primary categories of protected assets: listed buildings and conservation areas. Listed buildings are structures identified as having special architectural or historic interest, warranting extra protection to ensure their long-term preservation. This designation includes a wide range of buildings, from ancient monuments to more recent structures of notable architectural merit. In

[73] Town and Country Planning Act 1990, https://www.legislation.gov.uk/ukpga/1990/8/contents

[74] The Planning (Listed Buildings and Conservation Areas) Regulations 1990, https://www.legislation.gov.uk/uksi/1990/1519/contents/made

addition to individual buildings, the Act also provides for the designation of conservation areas. These are defined as areas with special character or appearance, which should be preserved or enhanced due to their historic or architectural significance. Conservation areas can include historic city centres, villages, or other groups of buildings that collectively contribute to the area's distinct character. When it comes to development or alterations within listed buildings or conservation areas, additional consent is often required. This means that any proposed changes to a listed building or new developments within a conservation area must receive approval from the local planning authority. This extra layer of scrutiny ensures that the special character of these assets is maintained, preserving the UK's rich architectural and historic legacy for future generations.

Environmental Impact Assessment (EIA): The Town and Country Planning (Environmental Impact Assessment) Regulations 2017[75] make it mandatory for certain types of development projects to undergo an EIA in the UK. This requirement applies to developments with the potential for significant environmental effects, ensuring that the project's consequences on the environment are thoroughly evaluated and considered during the planning process. The EIA process promotes informed decision-making and helps to minimize negative environmental impacts, supporting sustainable development in line with the regulations' objectives.

Appropriate Assessment (AA)[76]: Habitat Regulations Assessment (HRA) is a process mandated by the Conservation of Habitats and Species Regulations 2017, which evaluates the potential impact of a plan or project on protected sites and species. It ensures that developments do not adversely affect the integrity of designated habitats, such as Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). By conducting an HRA, decision-makers can identify necessary mitigation measures, safeguarding biodiversity and conserving valuable ecosystems in accordance with the obligations set out in the regulations.

Tree protection orders (TPOs): TPOs are usually made by a local authority to protect an individual or groups of trees or woodland from damage and destruction. Also, trees in a conservation area that are not covered by a TPO are protected in law under section 211 of the Town and Country Planning Act 1990.

New Environment Act: The Environment Act 2021[77] sets out long term targets in each of the four key priority areas: air quality; biodiversity; water; and waste. It establishes a new environmental governance framework post-Brexit, setting ambitious targets and legally binding commitments. It created the Office for Environmental Protection (OEP), an independent watchdog responsible for ensuring compliance with environmental law and monitoring progress toward environmental objectives. The targets are expected to be achieved through a set of measures focusing on UK businesses and supply chains.

Building Control in the UK

Building control in the UK is a regulatory system designed to ensure that buildings and structures meet appropriate health, safety, accessibility, and energy efficiency standards. Each of the four countries in the UK has its own set of regulations, with the Building Regulations 2010[78] applying to England and Wales, while Scotland and Northern Ireland have separate building standards and regulations with some differences in technical requirements and procedures.

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[75] The Town and Country Planning (Environmental Impact Assessment) Regulations 2017, https://www.legislation.gov.uk/uksi/2017/571/contents/made

[76] Appropriate Assessment (AA), https://www.gov.uk/guidance/appropriate-assessment

[77] Environment Act 2021, https://www.legislation.gov.uk/ukpga/2021/30/contents/enacted

[78] The Building Regulations 2010 (England and Wales), https://www.legislation.gov.uk/uksi/2010/2214/contents/made

In Scotland, the Building (Scotland) Regulations 2004[79] and the associated Scottish Building Standards[80] set the technical requirements for building design and construction. They cover aspects such as structural integrity, fire safety, sound insulation, and thermal performance. The Scottish Building Standards Agency, operating as Building Standards Scotland, oversees the building control system in Scotland and provides guidance through Technical Handbooks.

Northern Ireland follows the Building Regulations (Northern Ireland) 2012[81] and subsequent amendments, which specify the technical requirements for buildings in the region. The Department of Finance's Building Standards Branch administers the building control system in Northern Ireland and offers guidance through Technical Booklets[82].

Developers and homeowners across all four countries must obtain building control approval for most new constructions, extensions, or significant alterations. Local authorities or approved private inspectors carry out the building control process, which involves plan checks and site inspections.

Building Regulations 2010

The Building Regulations 2010 are a set of statutory instruments that apply to England and Wales, governing the design and construction of buildings to ensure the safety, health, welfare, and convenience of occupants, as well as promoting energy efficiency and accessibility. These regulations set minimum standards for various aspects of building work, including structural integrity, fire safety, ventilation, sound insulation, and thermal performance.

The Building Regulations are performance-based, meaning they outline the objectives to be achieved without prescribing specific methods or materials. To help professionals and homeowners comply with the regulations, a series of Approved Documents has been developed. These Approved Documents provide practical guidance on how to meet the requirements of the Building Regulations, offering recommended solutions and best practices. While following the guidance in Approved Documents is not the only way to achieve compliance, doing so offers a degree of assurance that the relevant requirements have been met. the Approved Documents for the Building Regulations 2010 in England and Wales are as follows:

- Approved Document A: Structure
- Approved Document B (Volume 1): Fire safety (Dwellings)
- Approved Document B (Volume 2): Fire safety (Buildings other than dwellings)
- Approved Document C: Site preparation and resistance to contaminants and moisture
- Approved Document D: Toxic substances
- Approved Document E: Resistance to the passage of sound
- Approved Document F: Ventilation
- Approved Document G: Sanitation, hot water safety, and water efficiency
- Approved Document H: Drainage and waste disposal

[79] Building (Scotland) Regulations 2004, https://www.legislation.gov.uk/ssi/2004/406/contents/made

[80] Scottish Building Standards: https://www.gov.scot/policies/building-standards/

[81] Building Regulations (Northern Ireland) 2012, https://www.legislation.gov.uk/nisr/2012/192/contents/made

[82] Northern Ireland Technical Booklets, https://www.finance-ni.gov.uk/articles/building-regulations-technical-booklets

- Approved Document J: Combustion appliances and fuel storage systems
- Approved Document K: Protection from falling, collision, and impact.
- Approved Document L1A: Conservation of fuel and power in new dwellings
- Approved Document L1B: Conservation of fuel and power in existing dwellings
- Approved Document L2A: Conservation of fuel and power in new buildings other than dwellings
- Approved Document L2B: Conservation of fuel and power in existing buildings other than dwellings
- Approved Document M (Volume 1): Access to and use of buildings (Dwellings)
- Approved Document M (Volume 2): Access to and use of buildings (Buildings other than dwellings)
- Approved Document N: Glazing - safety in relation to impact, opening, and cleaning (Wales only)
- Approved Document P: Electrical safety - Dwellings
- Approved Document Q: Security - Dwellings
- Approved Document R: Physical infrastructure for high-speed electronic communications networks
- Approved Document 7: Materials and workmanship

It is important to note that obtaining building control approval is necessary for most new constructions, extensions, and significant alterations. This process typically involves submitting plans and specifications to a local authority or an approved private inspector, who will check the proposals for compliance with the Building Regulations. Upon completion of the project, inspections are carried out to ensure that the building work has been executed according to the approved plans and complies with the regulations.

Other building related regulations

Health and safety: The Construction (Design and Management) Regulations (CDM)[83] are a set of UK health and safety regulations that apply to construction projects. Their primary aim is to improve safety and reduce risks associated with construction work. CDM regulations cover the entire project lifecycle, from design and planning to construction and post-completion maintenance. They outline the roles and responsibilities of key stakeholders, such as clients, designers, contractors, and workers, ensuring effective communication, coordination, and risk management throughout the project.

Asbestos control: The Control of Asbestos Regulations 2012[84] is a set of UK health and safety regulations designed to manage and mitigate the risks associated with asbestos exposure. Asbestos, a hazardous material once widely used in construction, poses significant health risks when inhaled. The regulations require employers and building owners to identify, assess, and manage the presence of asbestos-containing materials. This includes carrying out asbestos surveys, maintaining an asbestos register, implementing an asbestos management plan, and ensuring proper training for employees working with asbestos-containing materials.

Access services and facilities: The Equality Act 2010[85] is a UK law that prohibits discrimination in the provision of goods, facilities, or services. This includes access to buildings and spaces. It ensures that everyone is treated equally, regardless of their age, disability, gender reassignment, race,

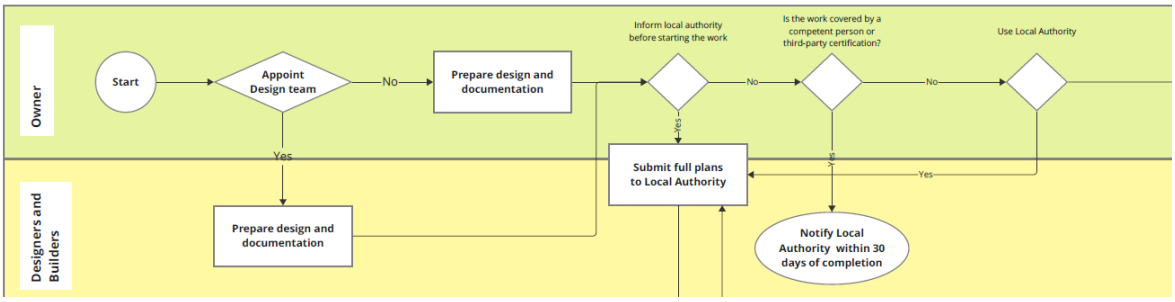
[83] The Construction (Design and Management) Regulations 2015, https://www.legislation.gov.uk/uksi/2015/51/contents/made
[84] The Control of Asbestos Regulations 2012, https://www.legislation.gov.uk/uksi/2012/632/contents/made
[85] Equality Act 2010, https://www.legislation.gov.uk/ukpga/2010/15/contents

religion or belief, sex, or sexual orientation. Service providers must make reasonable adjustments to accommodate the needs of disabled people, such as providing accessible ramps or hearing loops. This law promotes inclusion and diversity, making sure that everyone has the same opportunities to access services and facilities.

Annex H: UK Detailed Process Descriptions

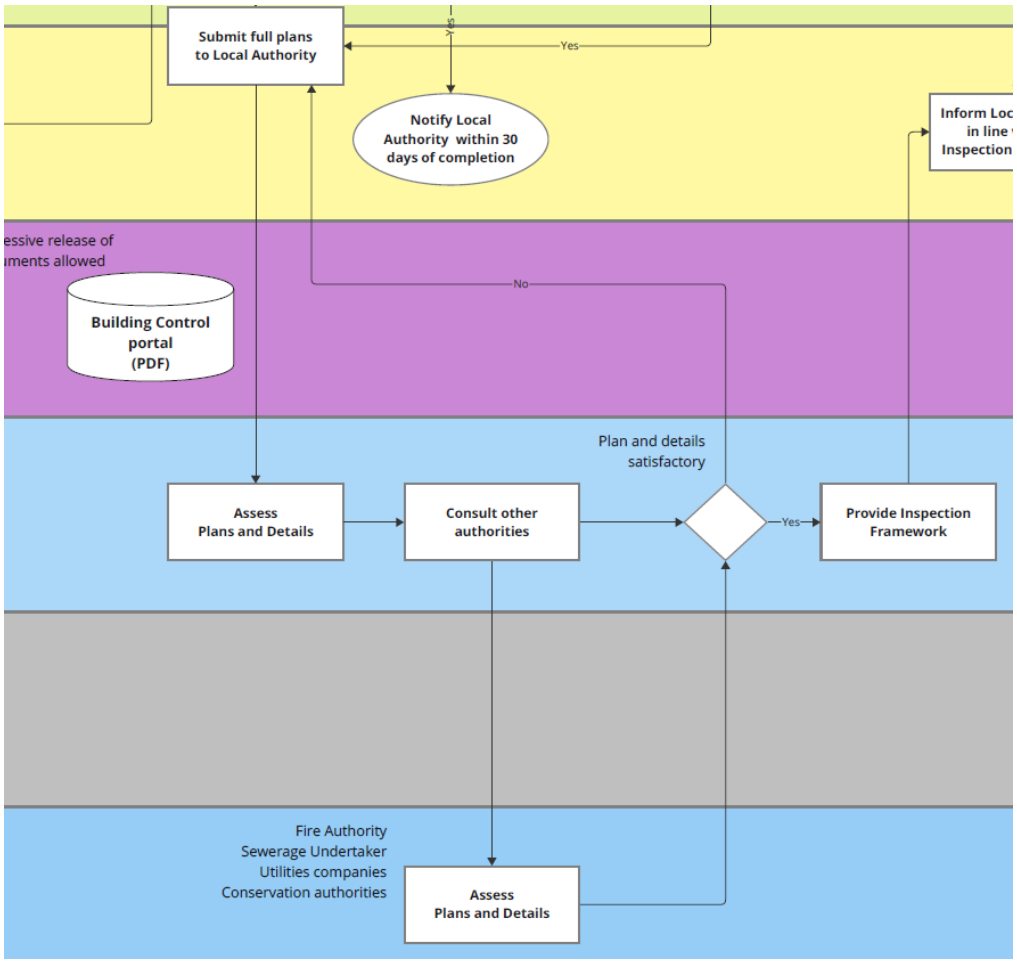
The process starts with the preparation of the design and the documentation. As with Planning Permission, this will usually, but not necessarily, involve an external team of designers and builders.

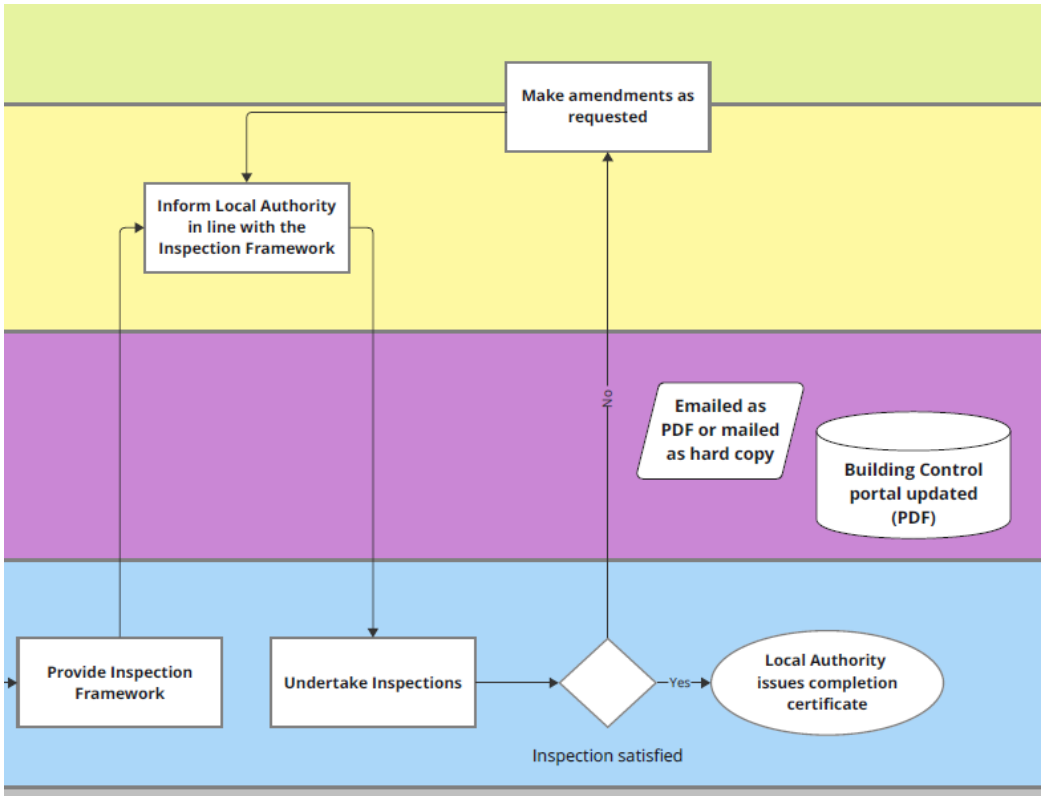
For simple works such as house renovation, the owner may choose to notify the local authority to start work instead of submitting full plans. Likewise, for specialist works such as window installation, the owner may choose to notify relevant Local Authority within 30 days of completion (Figure below).



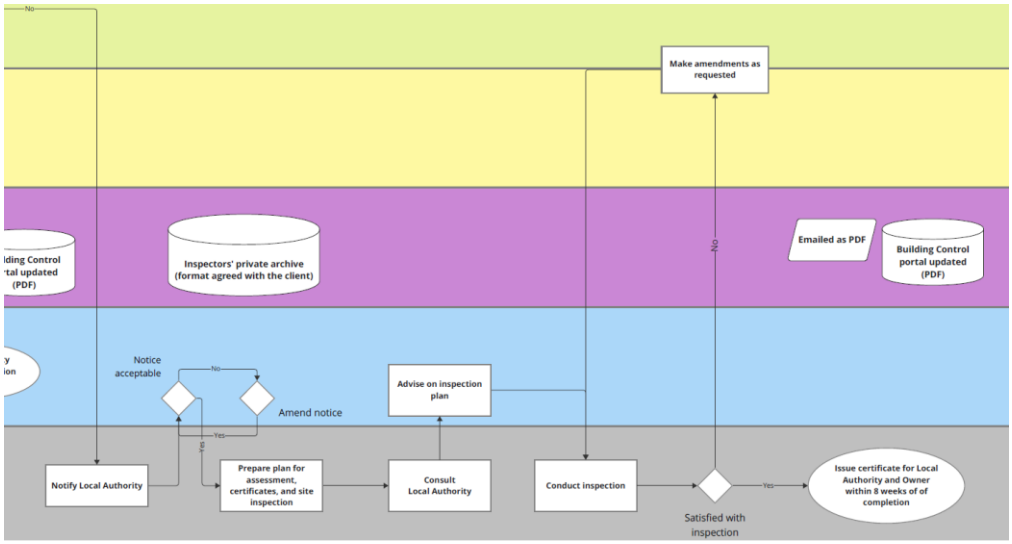
If the application includes works that are more extensive, the owner is likely to seek certification via the Local Authority Building Control (LABC) or a licenced private building investigator. Either is an option and the decision can be undertaken based on market parameters, such as the respective costs, timeframes, and professional relationships between the owners, designers, and investigators.

Should the owner decide to proceed with the LABC service, they need to submit the full plans, typically in PDF form to the relevant BC portal. However, progressive release of documents is also allowed. LABC will assess plans and details and consult specific authorities (such as the local Fire Service) if needed (Figures below).


Submit full plans to Local Authority
Yes
Notify Local Authority within 30 days of completion
Inform Loc in line Inspection
essive release of ments allowed
Building Control portal (PDF)
No
Plan and details satisfactory
Assess Plans and Details
Consult other authorities
Yes
Provide Inspection Framework
Fire Authority
Sewerage Undertaker
Utilities companies
Conservation authorities
Assess Plans and Details


Make amendments as requested
Inform Local Authority in line with the Inspection Framework
No
Emailed as PDF or mailed as hard copy
Building Control portal updated (PDF)
Provide Inspection Framework
Undertake Inspections
Yes
Local Authority issues completion certificate
Inspection satisfied

If a licenced private building inspector is employed, the process is similar, but it still does involve the Local Authority. On receiving the commission, the LPBI should inform the local authority, which can ask for amendments to the inspection plan, if deemed necessary (Figure below).



The rest of the process is similar, with the private inspector conducting the necessary inspections, and asking for amendments if the work is not to their satisfaction. Once the inspections are deemed to have concluded in a satisfactory manner, the private inspector issues certificates which are then sent to both the owner and to LABC (typically emailed in PDF format). LABC then updates the respective online BC portal.

It should be noted that this is an overview of the process. For specific projects that adopt new construction methods, there are additional stakeholders and approval needs. One such case in the UK is the use of modern methods of construction such as modular construction. The ACCORD project has a UK case study, which is based on light weight cold-rolled steel modular house construction. A more detailed process diagram will be shown in the future report of the UK case study in Work Package 5

Annex I: Spanish Building Permit Related Laws and Regulations

Building permits in Spain are carried out in agreement with regulations LPAC[86], ROAS[87], at national level, and the applicable urban regulations, at regional level. Whereas a technical project is required for granting a building permit in accordance with LOE[88] and CTE[89], the applicable local ordinances or regulations are at the regional level.

LPAC: Ley de Procedimiento Administrativo Común

The Common Administrative Procedure law sets out the rules and procedures that public administrations in Spain must follow to conduct administrative procedures. It regulates the relationship between citizens and the administration, establishing the principles of administrative action, including efficiency, effectiveness, transparency, and the protection of citizens' rights.

This law also establishes the procedures for challenging administrative decisions and appealing them to higher authorities. Overall, LPAC aims to ensure that administrative procedures are carried out in a transparent, efficient, and fair manner, while protecting citizens' rights and ensuring legal certainty.

ROAS: Reglamento de Obras, Actividades y Servicios de los Entes Locales

The Regulation of Works, Activities, and Services of Local Entities is a Spanish law that regulates the activities and services carried out by local entities, such as municipalities and provinces. The law establishes the procedures and requirements that local entities must follow when carrying out construction works, conducting activities, or providing services within their territories. It sets out specific requirements related to environmental impact, public safety, and urban planning, among others. The law also establishes the obligation of local entities to obtain licenses and permits before carrying out certain activities or works.

Overall, the ROAS seeks to ensure that local entities act responsibly and sustainably in carrying out their activities, while protecting the interests of citizens and the environment.

LOE: Ley de Ordenación de la Edificación

The building planning Law (Ley de Ordenación de la Edificación, LOE, in Spanish) regulates the construction of buildings, from the planning and design stages to the final construction and delivery of the building to its owners. The law establishes the rights and obligations of all parties involved in the construction process, including builders, architects, engineers, and buyers. It also establishes the procedures and requirements for obtaining licenses and permits, carrying out inspections, and ensuring compliance with safety, quality, and environmental standards.

The law requires builders to provide a 10-year guarantee of the structural safety and stability of the building, as well as a 1-year guarantee for any defects in the construction work. The LOE aims to ensure that the construction of buildings in Spain is carried out in a safe and sustainable manner, protecting the rights and interests of all parties involved in the process.

CTE: the Spanish Building Code

The technical building code regulation (Código Técnico de la Edificación, CTE, in Spanish) establishes the minimum requirements for the construction of buildings. It covers aspects such as

[86] Spanish Law 1st of October of the Common Administrative Procedure of Public Administrations (39/2015), available: https://www.boe.es/buscar/act.php?id=BOE-A-2015-10565, accessed 15.03.2023.
[87] DECREE 179/1995, 13th of June approving the Regulations for works, activities and services of local bodies, available: https://portaljuridic.gencat.cat/ca/document-del-pjur/?documentId=119847, accessed 15.03.2023.
[88] Spanish Law 5th of November on Building Regulation (38/1999), available: https://www.boe.es/buscar/act.php?id=BOE-A-1999-21567, accessed 15.03.2023.
[89] Royal Decree 314/2006, of March 17, approving the Technical Building Code, available: https://www.boe.es/buscar/doc.php?id=BOE-A-2006-5515, accessed 15.03.2023.

structural safety, fire protection, acoustics, energy efficiency, and accessibility for people with disabilities. The CTE is a set of technical standards that aim to ensure that buildings are constructed to a high level of quality and safety, while promoting sustainability and energy efficiency.

The CTE applies to all new constructions, as well as major renovations of existing buildings. It is updated periodically to reflect new technological advancements and changes in building regulations. The CTE is an important tool for architects, builders, and other professionals involved in the construction industry to ensure that their projects meet the necessary technical standards and legal requirements.

Ordinances in municipalities or other local entities

Ordinances are regulations passed by municipalities and other local entities in Spain that are aimed at regulating local activities and behaviours within their jurisdiction. These entities are empowered by the Spanish Constitution and the Spanish Local administration laws to issue ordinances. Such ordinances may cover a wide range of issues, including public safety, urban planning, waste management, transportation, and public health, among others. The process for enacting an ordinance typically involves the preparation of a draft text, public consultation, and approval by the local council or governing body. Once an ordinance is approved, it becomes legally binding within the jurisdiction of the issuing entity.

Violations of ordinances may result in fines or other penalties, and enforcement is typically carried out by local authorities such as police or regulatory agencies. Overall, ordinances are an important tool for municipalities and local entities to ensure the proper functioning of their communities and to promote the welfare of citizens.

Urban regulations by Autonomous communities

Urban regulations in Spain related to building permits are designed to regulate the construction and use of buildings within urban areas. These regulations vary depending on the region or municipality in which the building is located. In general, building permits are required for all new constructions, major renovations, and changes in use of buildings.

Overall, these regulations are designed to ensure that buildings in urban areas are constructed and used in a safe and sustainable manner, while promoting the welfare of local communities.

National-level regulations related to building permits in Spain.

- Ley 39/2015 de 1 de octubre del Procedimiento Administrativo Común de las Administraciones Públicas.
- Ley 3/2012, del 22 de febrero, de modificación de texto refundido de la ley de urbanismo, aprobado por el Decreto legislativo 1/2010, de 3 de agosto.
- Ley 3/2010, de 18 de febrero, de prevención y seguridad en materia de incendios en establecimientos, actividades, infraestructuras y edificios.
- Real Decreto 105/2008, de 1 de febrero, por el que se regula la producción y gestión de los residuos de construcción y demolición.
- Ley 18/2007, de 28 de diciembre, del derecho a la Vivienda.
- Real Decreto 314/2006, de 17 de marzo, por el que se aprueba el Código Técnico de la Edificación, y posteriores modificaciones.
- Real Decreto 2267/2004, de 3 de diciembre, por el que se aprueba el Reglamento de seguridad contra incendios en establecimientos industriales.
- Real Decreto 842/2002, de 2 de agosto, por el que se aprueba el Reglamento electrotécnico de baja tensión.
- Ley 38/1999, de 5 de noviembre, de Ordenación de la Edificación.
- Real Decreto 1627/97, de 24 de octubre, por el que se establecen disposiciones mínimas de seguridad y de salud en las obras de construcción (BOE del 10/25/1997).
- Real Decreto Ley 1/98, de 27 de febrero, sobre infraestructuras comunes en los edificios para el acceso a los servicios de telecomunicación (BOE del 28/02/1998).

- Orden de 29 de mayo de 1989 sobre Estadísticas de Edificación y Vivienda (BOE 129 de 05/31/1989).
- Decreto de 17 de junio de 1955 por el que se aprueba el Reglamento de Servicios de las Corporaciones locales

Regional-level (Catalonia) regulations related to building permits in Spain.

- Decreto 179/1995, de 13 de junio, por el que se aprueba el Reglamento de obras, actividades y servicios de los entes locales.
- Decreto 64/2014, de 13 de mayo, por el que se aprueba el Reglamento sobre protección de la legalidad urbanística.
- Decreto 141/2012, de 30 de octubre, por el que se regulan las condiciones mínimas de habitabilidad de las viviendas y la cédula de habitabilidad.
- Decreto 89/2010, de 29 de junio, por el que se aprueba el Programa de gestión de residuos de la construcción de Cataluña (PROGROC), se regula la producción y gestión de los residuos de la construcción y demolición, y el canon sobre la deposición controlada de los residuos de la construcción.
- Decreto 13/2010, de 2 de febrero, del Plan para el derecho a la vivienda de 2009-2012.
- Decreto Legislativo 1/2010, de 3 de agosto, por el que se aprueba el Texto refundido de la Ley de urbanismo.
- Decreto Legislativo 1/2009, de 21 de julio, por el que se aprueba el Texto refundido de la Ley reguladora de los residuos.
- Decreto 305/2006, de 18 de julio, por el que se aprueba el Reglamento de la Ley de urbanismo.
- Decreto 21/2006, de 14 de febrero, por el que se regula la adopción de criterios ambientales y de ecoeficiencia en los edificios (DOGC 4574 de 16/02/2006).
- Decreto 135/1995, de 24 de marzo, de desarrollo de la ley 20/1991 de 25 de noviembre, de promoción de la accesibilidad y de supresión de barreras arquitectónicas y de aprobación del Código de Accesibilidad.

Municipal-level (Malgrat de Mar, Barcelona, Madrid) regulations related to building permits in Spain.

- Ordenança reguladora de la tramitació dels expedients urbanístics, de Malgrat de mar, 30 d'abril de 2009.
- Ordenança reguladora dels procediments d'intervenció municipal en les obres (ORPIMO), de Barcelona, 28 d'octubre de 2022.
- Ordenanza 6/2022, de Licencias y Declaraciones Responsables Urbanísticas del Ayuntamiento de Madrid, de 26 de abril.
- There are other regulations and standards in force according to the legal framework of the building works and depending on the industrial sectors.

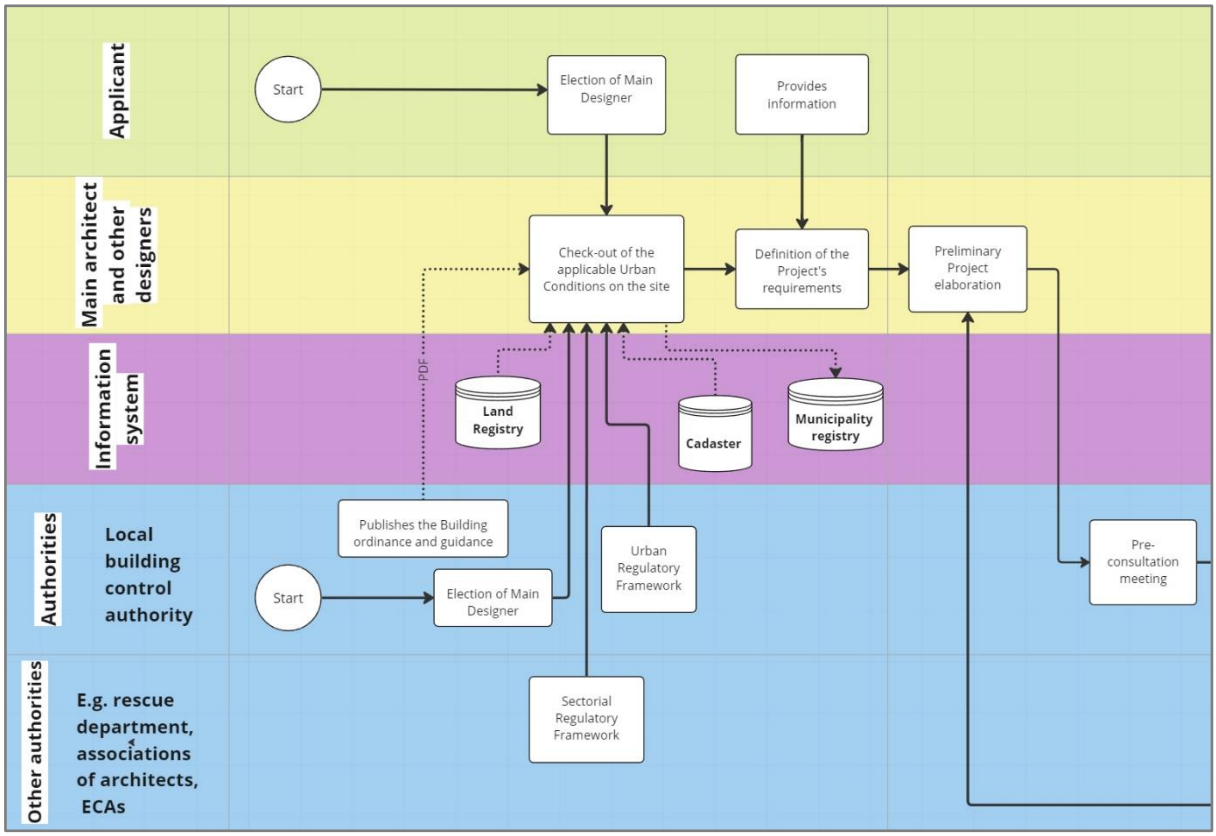
Annex J: Spanish Detailed Process Descriptions

Conceptual project application phase

A building permit process starts when an applicant wants permission to carry out, mainly, a new construction or rehabilitation project in a municipality. In the case of private works projects, the applicant is responsible for starting the process, while the local building control authority is the responsible for initiating the process in public works.

The first step for the issuance of a construction permit consists of an analysis of the requirements that are established in the municipal laws. These laws are specific to each municipality and are normally specified in the Municipal urban planning plans (Plans d'Ordenació Urbanística Municipal, POUM, in Catalan). In the region of Catalonia, for example, the documents of each POUM are public and can be accessed through the Catalonia Planning Registry under the category of the territorial planning commission to which they belong.

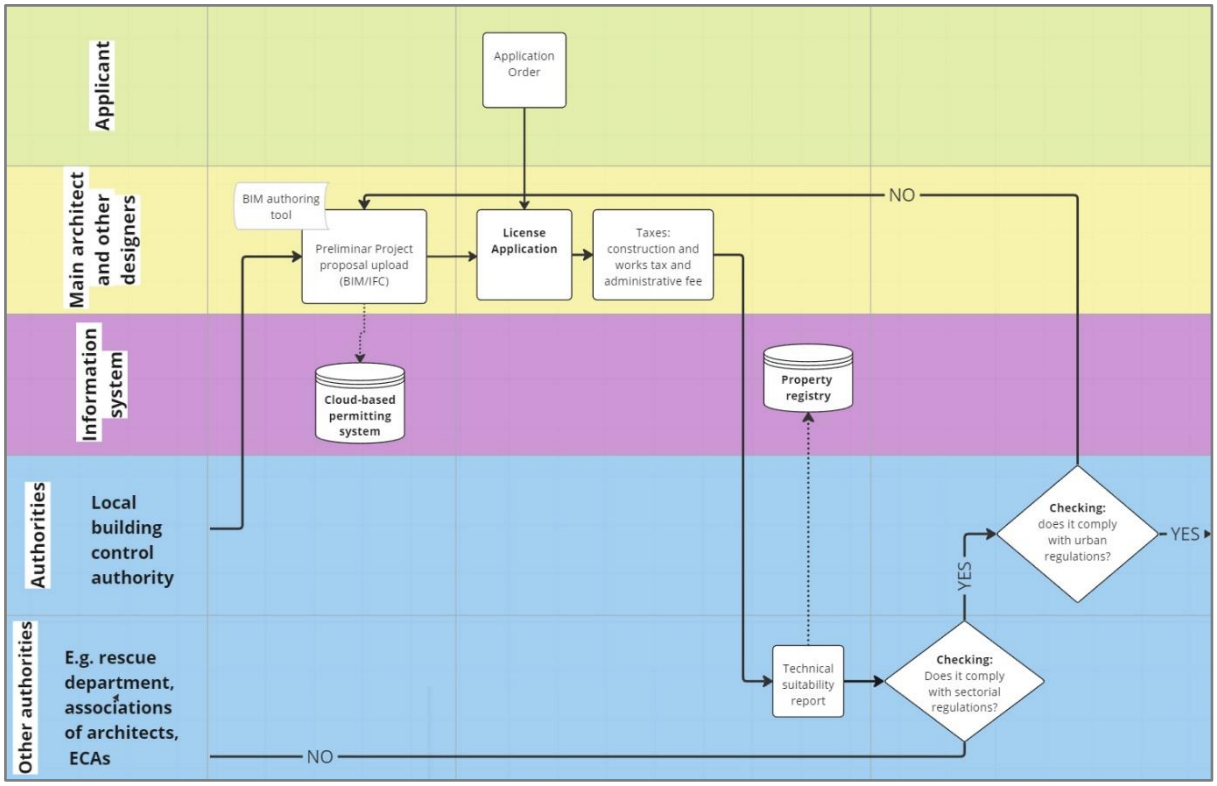
As depicted in the next figure, at the beginning of this phase the applicant (e.g., the authorized main designer or architect) gathers the necessary initial information from the municipal and cadastre records. Then, the local authorities guide the applicants in defining the project requirements according to the applicable urban conditions on the site, and in submitting the application. Finally, in the pre-consultation, the local building control authority has a meeting to guide the applicant and assess the effects of the urban setting. The preliminary design proposal and the specific needs of the permitting process and technical requirements are analysed.



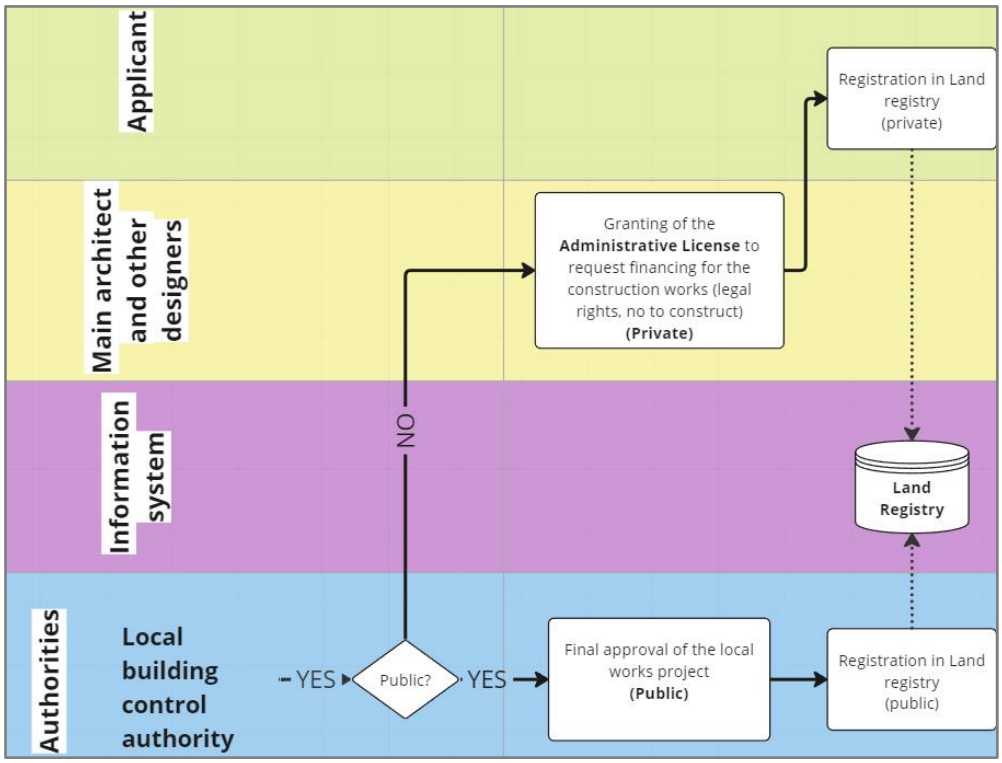
Preliminary project application phase

During the first part of the preliminary project application phase, the local building control authority checks the preliminary project with the minimum content required by law. This is basically compliance with local urban parameters and specific sectoral regulations affecting the project, in the case of national and regional authorities which may require the submission of compliance reports on their cultural, environmental, railway, etc. In Spanish practice, only the main architectural drawings are provided for permitting, and structural topics and HVAC systems are described generally. The detailed designs for these are required for next phase Application submission. This preliminary project information is provided in PDF and DWG formats. But, considering a compliance checking scenario in BIM, the model of the building must be uploaded in IFC format.

If the checking process is correct, the local authority grants the Administrative License to apply for funding of the works. Then, the applicant develops and delivers the preliminary design. This process includes the payment of the construction and works tax and the administrative fee. Then, a third party – the territorial department of the regional government of Catalonia– generates the technical suitability report indicating if it complies with sectoral regulations. In case of being favourable, the local building control authority checks if the project complies with urban regulations.



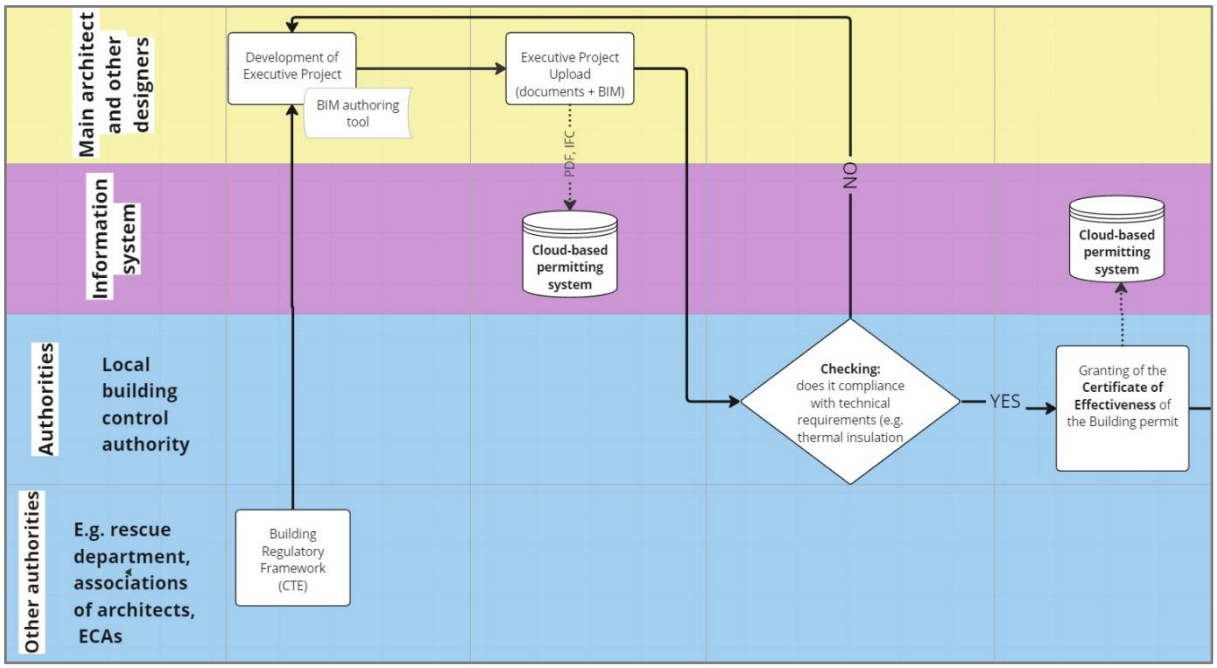
Passed this check, in case of being a private project, the applicant obtains the granting of the administrative License to request financing for the construction works. In case of being a public project, the final approval of the local works project is obtained. Finally, the next step for both cases involve registering the project in the land registry.



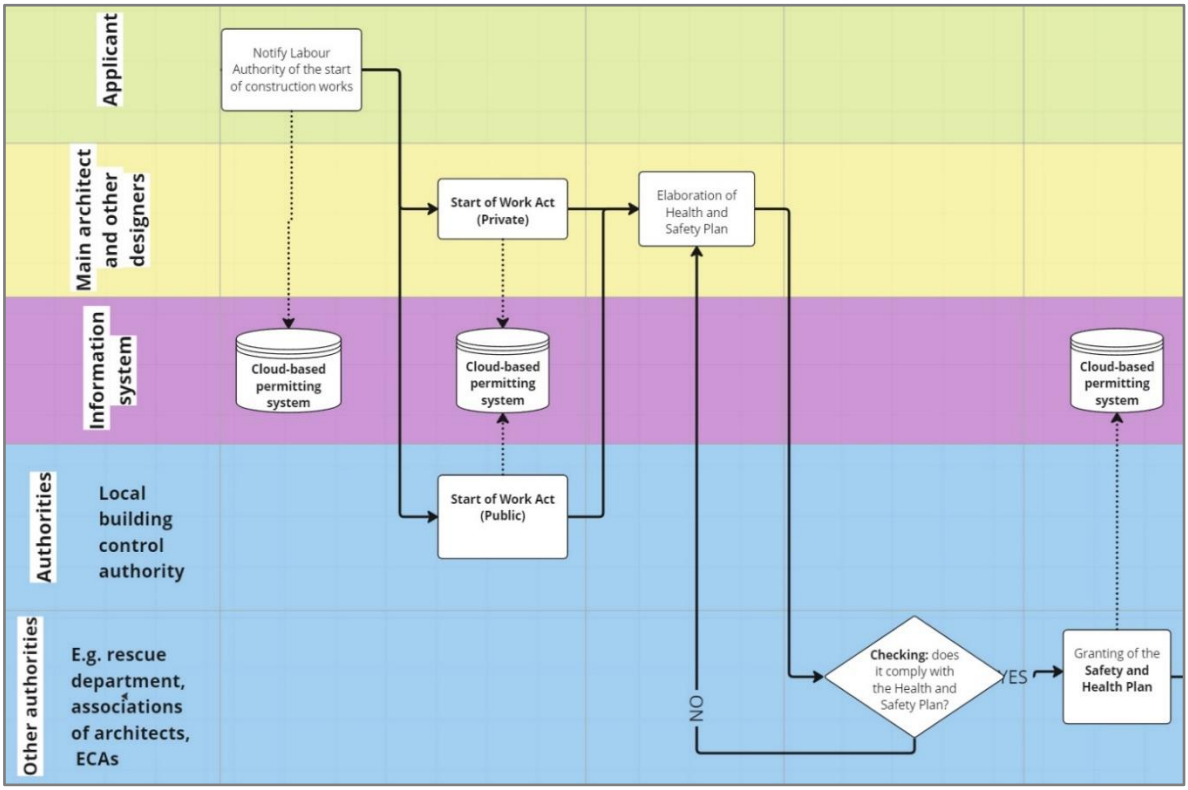
Design project application phase

In the first part of this phase, the main designer or architect develops and submits the executive project information to the local building control authority, considering its compliance with the Spanish technical building code (CTE). To do that, the applicant – the corresponding architect or architecture firm – develops the executive project, and then generates the necessary documentation to apply for the permit in the municipality's cloud-based permit service and enters and uploads the required information. Among the information to be delivered is the BIM model with the design information according to the data requirements (the part of defining the necessary data requirements is still under development by the local authority). As in the preliminary project application phase, the executive project information is usually provided in PDF and DWG formats. But, considering a compliance checking scenario in BIM, the model of the building must be uploaded in IFC format.

Once the application is submitted, the local building control authority instructs the works dossier and checks compliance with the technical requirements (e.g., thermal insulation of windows). The requirements include the aspects indicated at the pre-consultation. If it does not pass, the applicant must make the necessary changes to correct the non-compliance. If passes, the local building control authority resolve completion of procedure and grants the Certificate of Effectiveness of the Building permit.

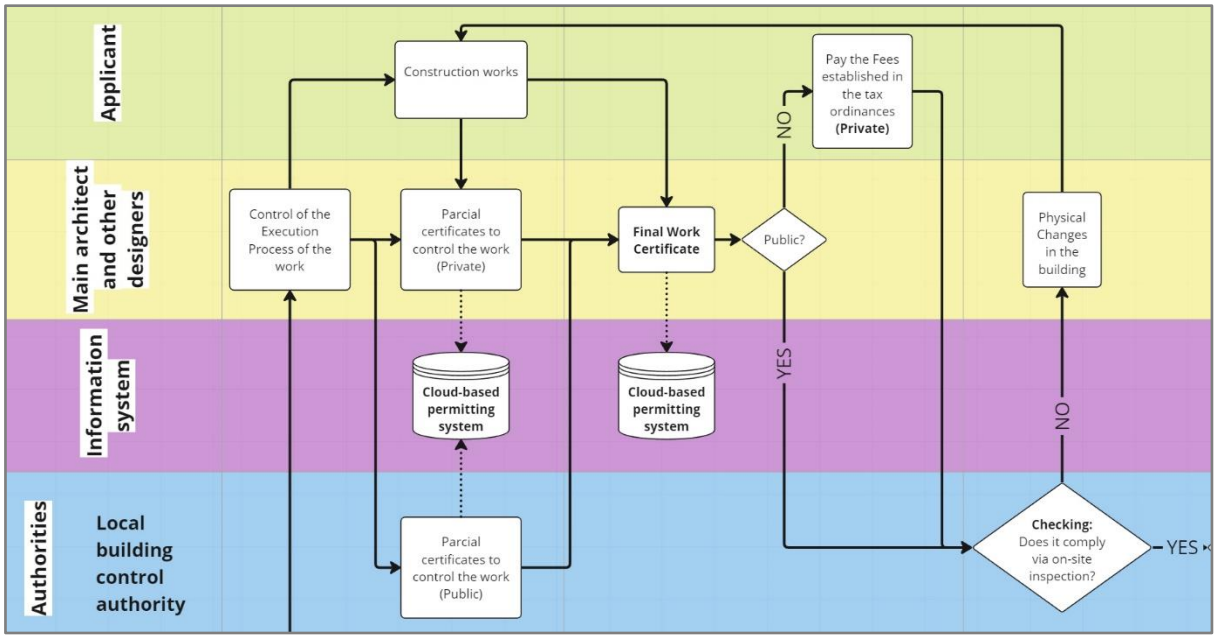


In the second part of this phase, the applicant notifies the Labour Authority, through the cloud-based permit service, that the construction works can start. This is formalized through the start of the work act. After this, the applicant must create the safety and health plan which is validated by the territorial department of the regional government of Catalonia. When approved, the applicant finally gets the granting of the Safety and Health Plan, for both public and private projects. From this moment, the applicant can legally start the construction of the building.



Construction and inspection phase

This phase starts when the safety and health plan is validated and approved by the promoters for private works, or by the local authority in the case of a public work. After this process, the construction begins until it reaches its completion. When it ends, a final work certificate is obtained. Then, the work is inspected by the local authority who decides if all the necessary requirements are met to be able to grant the first occupation permit. If the requirements are not met, all necessary modifications must be made to fix them.



Enforcement by law for first occupancy permit phase

This phase consists of the administrative process of enforcement of the law for the permit of first occupation. It starts when the first occupancy permit is granted. Then the permit information is stored in public records, such as the Municipal Registry. Also, the cadastre must be updated with the corresponding information. Not all projects require registration in the property registry or update the cadastre (e.g., small building refurbishment projects).