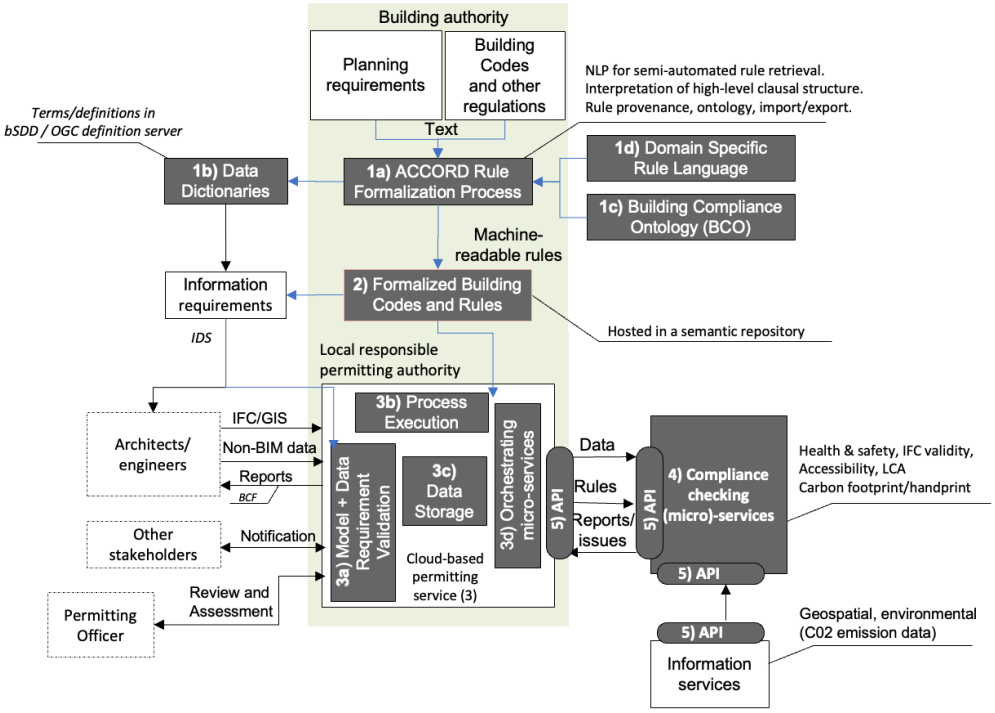
ACCORD Framework and User Requirements Specification

July 31, 2023



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Executive summary

This deliverable will document the results of the ACCORD project's task *1.3 ACCORD Framework and User Requirements Specification*. This task belongs to work package 1 Requirements for digitalising permitting and compliance processes. The results support meeting the sixth objective of WP1 'to develop and formally document the ACCORD semantic framework and user requirements specification'. User requirements elicitation will be supported by digitization scenarios which will be further developed in work package 3 in task 3.1.

Task 1.3 will define the ACCORD framework based on semantics, along with its user requirements specification. This specification will be supported by modelling activities, including the product of UML use case and sequence diagrams. The task will also produce a specification of the project's demonstration deployments, including eliciting any demonstration-specific requirements.

The task also includes the identification of relevant standards for the storing, processing, analysis, and retrieval of administrative and regulatory information related to construction, renovation and demolition works. The project advisory board has validated the ACCORD framework.

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Terminology

Accord to-be process	Explains the process which will be tested during the ACCORD demos. It is defined with help of usage scenario process diagrams, a process map and storyline (task chain and roles). It is used to extract user requirements.
As-is process	Explains today's process in digital building permitting in the demo countries (Germany, Spain, UK, Finland, and Estonia). The as-is process is defined with help of a process map, which is based on interviews. These processes are described in detail in ACCORD's D1.1 Landscape Review Report.
BCF	BIM Collaboration Format (BCF) is a file format allowing BIM applications to communicate model-based issues with each other. BCF is a Building Smart International standard.
IDS	An Information Delivery Specification (IDS) is a document that defines the Exchange Requirements of model-based exchange. The document is a computer interpretable. IDS is a Building Smart International standard.
IFC	Industry Foundation Classes is a standardized, digital description of buildings and civil infrastructure.
LOIN	With the introduction of EN 17412-1, the concept of Level of Information Need (LOIN) replaces the previously common concept of Level of Detail (LOD) in BIM planning.
MVD	Model View Definition (MVD) is a specific implementation level of IFC to facilitate a specific use or workflow. MVD is a Building Smart International standard.
Process diagram	A freely visualized lay-out for a specific purpose.
Process map	A flowchart map, showing roles as "swimming lanes" and role-related task. It shows information tools, platforms, and databases as roles in the process. It also shows the relation between tasks and the information transfer between tasks.
Process map, modelled with BPMN	A formal way to describe integrated information chain with tasks, roles, and information management components (platforms/ tools/ databases), based on a standardized process modelling notation BPMN.
Semantic Framework	A framework of software components
To-be process	Explains the possible future to-be process or elements of it. It is defined with the help of a visionary scenario and narrative.
Usage scenario	Describes the way someone uses an existing product or system. Formal specifications of processes, tools, inputs & outputs, and users.
User requirements	Informally defined user expectations of needed tools and their usability.
User requirements analyse	Eliciting user requirement for the novel building permitting to-be process. Analysing methods and steps may vary, however resulting a list of key user requirement.
Visionary scenario	One analysing and defining method for capturing the to-be process. Visionary scenarios may use example stories/ narratives/ storylines about what happened in the future. These describe examples of future actions for various stakeholders, and how they can use ACCORD models, methods, and tools in their practical work in the digital (semi-automated/ automated) building permitting process.

1 Introduction

1.1 The ACCORD Project

The ACCORD project's 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 conducted a landscape review and analysis of the current adoption of the concept of digitalisation of building permitting and compliance checking, including a survey into the attitudes of stakeholders to the prospective digitalisation of this domain in a range of European countries. This work was reported in D1.1 Landscape Review Report that focused on a) academic projects and methods, b) relevant software tools and technologies, and c) national adoption efforts in the field.

This solid basis will pave the way for a framework that has the potential to achieve real change and drive forward the digitalisation 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 the results of ACCORD's Task 1.3 ACCORD Framework and User Requirements Specification. This task belongs to WP1 Requirements for digitalising permitting and compliance processes. The results support meeting the sixth objective of WP1 'To develop and formally document the ACCORD semantic framework and user requirements specification'. User requirements elicitation will be supported by digitization scenarios which will be further developed in Task 3.1.

Task 1.3 will define the ACCORD framework, based on semantics, along with its user requirements specification. This specification will be supported by modelling activities, including the product of the UML use case and sequence diagrams. The task will also produce a specification of the project's demonstration deployments, including eliciting any demonstration-specific requirements.

The task also includes the identification of relevant standards for the storing, processing, analysis, and retrieval of administrative and regulatory information related to construction, renovation and demolition works. The ACCORD framework is validated by the project advisory board.

2 Methodology

This section will outline the methodology being followed by the remainder of this document. Firstly, it will present an overall view of the methodology, then presenting each phase in more detail.

2.1 Overall view

The primary focus of this task is defining the ACCORD framework, which will be supported by high-level end user requirements and formalized UML models. This process involves reviewing and refining the ACCORD vision presented in the project proposal.

To enable the consideration of multiple aspects as part of this process, this work will adopt a hybrid *top-down* and *bottom-up* methodology. The methodology is *top-down*, in that it takes the global inputs from; (a) the consortium's past experiences and previous projects identified from the landscape review (conducted in D1.1), and (b) feedback from the ACCORD survey (conducted in D1.1). The methodology is *bottom-up* in that will consider the as-is processes in the ACCORD demo countries as well as each countries own vision for the future of digitised building permitting. This overall methodology is shown in Figure 1, in this figure yellow indicates the top-down elements of the methodology and blue indicated bottom-up elements of the methodology.

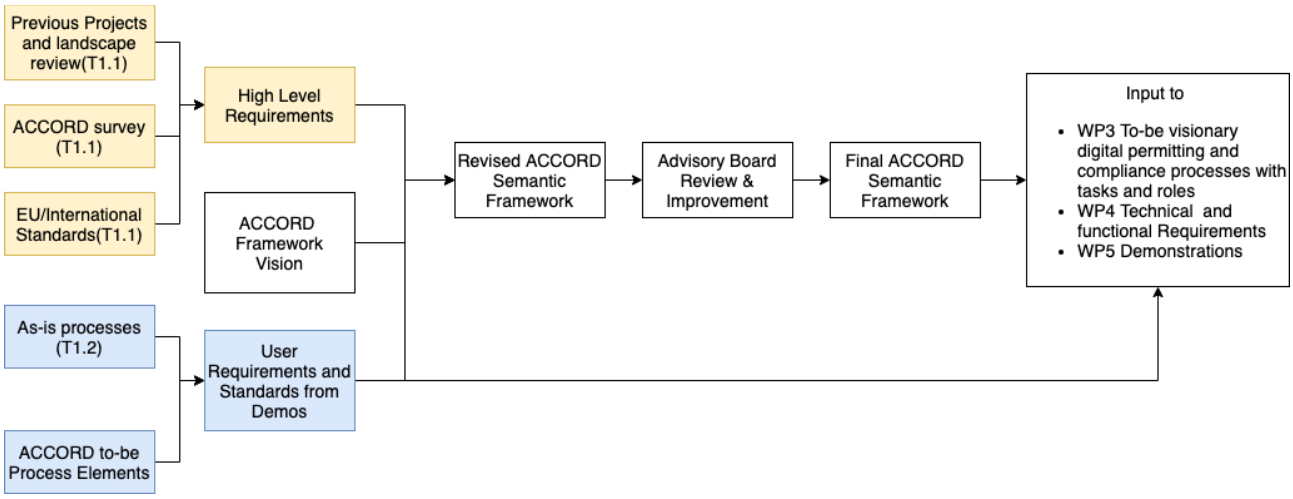

Figure 1. The methodology followed in refining the ACCORD framework.

In the remainder of this section each element of the methodology is described in more detail.

2.2 ACCORD Framework Vision

The ACCORD vision for digitised building permitting was originally proposed in the ACCORD proposal. As the starting point for this deliverable, the vision will be described and explained (as originally presented) in Section 3. The remaining element of this methodology will then further elaborate and refine this vision.

2.3 Eliciting High Level Requirements

This element of the methodology will focus on eliciting a set of user requirements, using a top-down approach that draws from several sources. These sources include:

1. **Previous projects and the landscape review:** previous projects conducted by consortium members and those identified in the landscape review will be analysed examining the approach taken and the lessons learnt. These will then be utilised to extract user requirements for the ACCORD project.
2. **The ACCORD survey:** as part of the accord survey many respondents submitted comments and free text responses that contain suggestions for the ACCORD framework. These comments will be analysed a set of user requirements extracted.
3. **Existing Standards:** Applicable EU/International standards will also be revised (based on the list of standards elicited in D1.1) to determine applicable standards that the ACCORD Framework should adopt.

Following the analysis of these sources of information a set of high-level user requirements will be presented (removing any duplicates or conflicts between the three items above), these user requirements will then feed into the elicitation of the ACCORD framework specification. This element of the methodology is described in Section 4 High-level Requirements.

2.4 Eliciting Demo-specific User Requirements

Demo-specific user requirements will be collected in all country demonstrations using three approaches. First, the current as-is building permit process will be analysed. Then, a digitization scenario/storyline will be described, and finally, a visionary to-be building permit process will be modelled. These approaches are shortly described in the following sub-chapters.

1) Analysis of Existing Process Models

The analysis of the existing building permit processes of the demonstration countries is documented in ACCORD's D1.1 Landscape Review Report. In this deliverable D1.2, the focus is on a selected process phase, which include compliance checking. Each demo country will identify the user requirements based on the selected process phase (See Section 5 Demo User Requirements).

2) Digitization Scenarios/Storylines for Demos

Digitization scenarios are example stories about what will happen in the future. In this deliverable, these stories will describe examples of future actions for various building permit process stakeholders, and how they can use ACCORD methods and tools in their practical work. The visionary scenarios itself are examples only and may not cover all the necessary ways of using the ACCORD tools. The whole set of visionary scenarios will not be implemented in the ACCORD project, but they set the path towards the long-term targeted stage, and some parts of the scenarios are developed already during the project.

One method for extracting digitization scenarios is based on identifying innovative approaches that affect information management processes of the users, often the building permit applicant and permit author. The idea is to foresee (imagine) what could be possible from the technological viewpoint and what could be desired from the stakeholders (or the society). The narrative storyline explains the interaction between the information management tasks, stakeholders and use of tools, platforms, and databases in the future. From this storyline, the demo-specific user requirements will be extracted and presented.

3) Visionary to-be Process.

Finally, the visionary to-be process will be modelled in each demonstration country. The following steps will be followed:

1) brainstorm the to-be process (stakeholders, tasks, information flows, and decision-making points) when new ACCORD software components are in use,
2) outline the sequence of tasks and information flows,
3) identify the process stakeholders (also possible new roles),
4) model the to-be process following the Business Process Modelling Notation or UML method.

2.5 Eliciting the ACCORD Framework Specification

Following the development of a set of top-down and bottom-up user requirements in the previous two steps, the final step will be to produce the specification of the ACCORD framework. This will be done through the following steps:

1. **Requirement Rationalisation:** The set of top-down and bottom-up requirements will be analysed and rationalised, removing duplicates and resolving any conflicts to form an integrated user requirements specification.
2. **Specification of Required ACCORD Framework Components:** The user requirement specification will be analysed, and the set of ACCORD components will be validated / refined. Each of the user requirements, where applicable will then be allocated to one of the ACCORD defined components.
3. **UML Modelling:** The ACCORD specification will then be illustrated through formalized UML modelling. Specifically, use case and sequence diagrams will be produced illustrated how the ACCORD framework meets and can support the scenarios elicited from the ACCORD demo countries.

This element of the methodology is described in Section 6.

2.6 Revision / Validation Through Project External Advisory Board

The final element of the methodology is a review / validation with the ACCORD external advisory board. To achieve this, a meeting will be arranged enabling the ACCORD consortium to present the requirements specification and allowing external advisory board members to provide feedback.

In the meeting, the feedback will be suggested around the following key discussion points:

- Any general questions or feedback about the framework.
- Does the framework have the potential to deliver building permitting and automated compliance checking.
- Do attendees think the framework once developed could help in their specific use cases?
- Are there any technologies/tools that exist that ACCORD should specifically target.
- Are there any standards ACCORD should specifically adopt.

For external advisory board members that cannot attend the meeting a video will be provided along with a form enabling them to submit their comments. The form will be structured following the set of keys points described above.

3 ACCORD Vision

As part of the ACCORD proposal a high-level vision of what the ACCORD project will achieve was presented:

ACCORD will develop a semantic framework that consists of building compliance and information services - integrated using open APIs - and a rule formalisation tool to ease the creation of machine-readable rules from text-based regulation. The ACCORD services will improve and automate the design, building and authorizing of construction works.

It is envisioned that this semantic framework, that will allow and encourage open innovation, will enable the development of a new generation of semantically aware digital permitting and automated compliance tools that can scale digital permitting and compliance processes from national, isolated efforts to a whole-European scale. In the ACCORD proposal several information flows - from the building authority's regulations to automatically checked compliance were elicited.

These are presented in Figure 2 and are described briefly below:

- **From Building Codes to Machine Readable Rules:** This information flow focuses on how a human readable building code/regulation can be digitised so that it can become machine readable and executable by the ACCORD framework.
- **From Architects/Engineers to Building Permitting Services:** This information flow focuses on how Architects/Engineers submit information to the ACCORD framework. This is primarily foreseen in three streams: BIM data and other machine-readable non-BIM data i.e., GIS data.
- **From Building Permitting Services to Architects/Engineers:** This information flow focuses on how the ACCORD framework will communicate with Architects/Engineers, through user interfaces and the provision of reporting in both human and machine-readable formats.
- **Between Compliance Checking Services:** This information flow focuses on internal communication between components within the ACCORD framework primarily using the API and exchanging data in standardised formats.

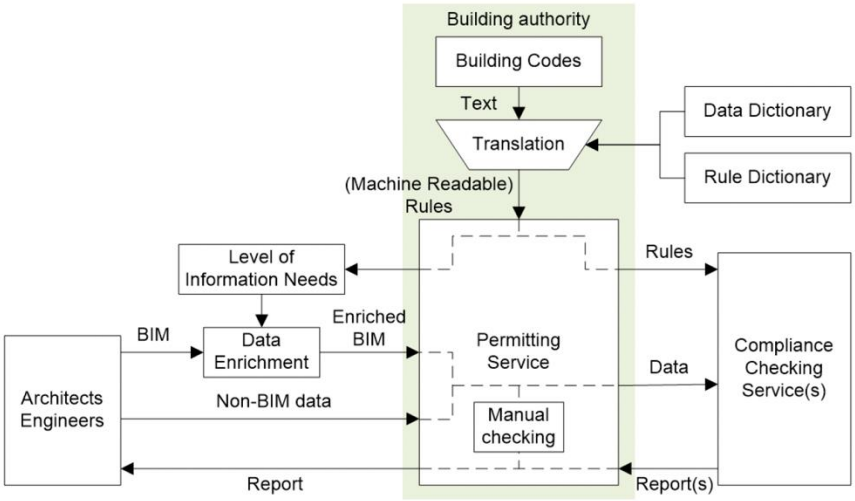

Figure 2. ACCORD Conceptual Information flows.

Based on these information flows the ACCORD framework was further elaborated with a more detailed specification of components. How these components fit into the overall framework is shown in Figure 3 and the individual components are listed below:

- **Rule Formalization Tool:** A tool that will allow regulations experts to digitise building codes/regulations in a formalized way, guiding them through the process to go from human readable building codes to machine readable building codes.
- **Ruleset Database:** A database that will store digitised building codes/regulations in a semantic form.
- **Data Dictionaries:** A set of dictionaries that will provide mapping classifications, properties, and values to identify how they can be represented in machine readable data formats.
- **Rule Dictionary:** A dataset of digitised codes/regulations formalized as rules.
- **Ontologies:** A set of abstract ontologies defining conceptually the concepts employed by the ACCORD framework.
- **Cloud Permitting Service:** A centralised service that will manage the overall process of building permitting.
- **Compliance Checking Microservices:** A set of services that will perform the concrete individual determinations as required by the overall building permitting process.

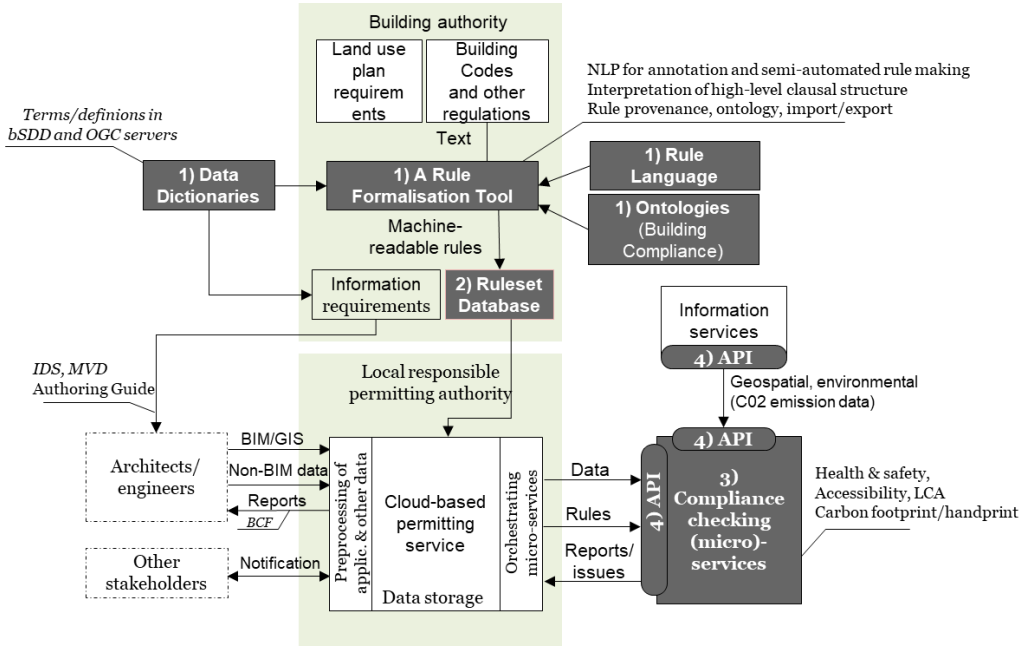

Figure 3. ACCORD Framework.

The ACCORD proposal did not explicitly specify any user requirements; however, it did document some functionality that the ACCORD framework should have and ways in which it would need to move beyond the state of the art to achieve the project objectives. These elements are important as key early requirements of the ACCORD framework. Table 1 summarises them.

Table 1. Requirements Derived from ACCORD Proposal.

Requirement Number	**Description**
V1	Provide a platform to provide digitised building permitting processes.
V2	Provide automated compliance checking.
V3	Support both Geospatial and BIM data input.
V4	Provide sufficient customisation ability such that formally specified processes are generic enough to be scaled to the European level but flexible enough to allow the specific nature of each nation's permitting processes to be considered.
V5	Provide a method to allow regulation experts to digitise building codes/regulations and embed rules within them, without the need to write code.
V6	Provide the ability to store a database of rules.
V7	Provide the ability to extract the information requirements for digital building permitting and compliance processes.
V8	Should be a dynamic system with the ability to add and removable modules.
V9	Should support integration of data dictionaries.
V10	Should be able to leverage emerging Artificial Intelligence techniques, such as semantic deep learning Natural Language Processing (NLP).
V11	Should provide a set of microservices, with tools and solutions for digital permitting and automated compliance checking of buildings.

V12	Should provide open standardized application programming interfaces.

This section has recapped and summarised the presentation of the ACCORD vision in the proposal. This will be used as a starting point for the ACCORD user requirement specification, being extended and revision with both the top-down user requirements elicited in Section 4 High-level Requirements, and the bottom-up user requirements elicited in Section 5 Demo User Requirements.

4 High-level Requirements

This section will describe the process of eliciting the high-level requirements in a top-down manner. The three key aspects of this process will be discussed in turn; (a) requirement extraction from previous projects and the landscape review, (b) requirement extraction from the ACCORD survey and (c) required lists of standards to be adopted by the ACCORD framework.

4.1 Analysis of Previous Projects / Landscape Review

From an analysis of the landscape review the following previous work was identified as having outputs or lessons learnt that could generate requirements for the ACCORD project. This is summarised in Table 2.

Table 2. Lessons learnt.

Project/Academic Work	**Reference**	**Lessons/Learnt Outputs**
DesignCheck	(Ding et al., 2006)	Support Data dictionaries to enable mappings between regulatory terms and data schemas.
Eastman et al.	(Eastman et al., 2009),	Ensure rules can be written at a high enough level to be accessible to regulation experts.
Greenwood et al.	(Greenwood et al., 2010)	Machine interpretable rules should be understandable by regulation authors. Rules should be independent of model format. Open standards should be favoured
BERA	(Lee, 2011)	Ensure rules are accessible to regulation experts by providing a domain specific language using concepts familiar to them.
RASE	(Eilif Hjelseth & Nick Nisbet, 2011)	Digitisation of regulations should be done in as user friendly and intuitive way as possible.
Krijnen et al.	(Krijnen & Van Berlo, 2016).	Should integrate classification systems, concept libraries, and model data.
Zhang et al.	(Z. Zhang et al., 2023)	Formalization of regulatory concepts in an ontology can add value to the compliance checking process by providing additional contextual information on the items being considered.
Fauth et al	(Fauth et al., 2023)	Formalization and digitisation of the high-level process aspects of building permitting and automated compliance checking, as opposed to individual sub-processes only, this is an import step to achieving complete digitisation of this area.

RegBIM	Partner previous experience / (Beach et al., 2015)	Creation of monolithic single component systems is not scalable to the complexity of built environment compliance checking.
DCOM	Partner previous experience[1]	That the adoption of an ecosystem approach to compliance checking automation systems can provide advantages in both the amount of compliance checks that are automatable, but also the extensibility of the system.

4.2 Eliciting Survey Requirements from Industry Survey

The ACCORD survey (described in D1.1) asked respondents several questions related to requirement elicitation. These questions explored the technological, commercial, and political requirements of achieving digital building permitting. Additionally, respondents were given the opportunity to provide free text responses.

There was a total of 472 responses to the survey and 43 free text responses. These have been analysed, considering the respondents views and a final list of suggested requirements is presented below:

- Provide a standardised data schema to formally document building permitting processes.
- Provide the ability to pre-check for compliance prior to formal submission.
- Provide data requirements for building permitting as a standardised data schema.
- Support standardised model formats for building data submission.
- Provide auditable rule processes to track decisions.
- Provide ability to link building permitting processes, applicable legislation and building data standards.
- Provide open access to limited data about building permitting assessments.
- Provide a standardised submission process.
- Provide the ability to link BIM and GIS datasets.
- Have an intuitive user-friendly user interface.
- Should retain the ability for manual human input.
- Should provide robust and secure data infrastructure.
- Should adopt and support Open APIs.
- Should enable collection of suitable evidence to complement assessments.
- Provide the generation of human readable and machine-readable reporting based on submissions.
- Should ensure correlation between passes/failures and regulations.
- Should provide suitable security models to differentiate between users to enable selection of

[1] https://www.dcom.org.uk/

an appropriate user to assess a given regulation.

- Should support and enable direct communication between the submitter and regulator.

4.3 Standards, Classifications, and Guidelines

This section will document the high-level requirements for the adoption of standards, classifications, and guidance. D1.1 reviewed many standards related to the ACCORD project. However, this section will only consider standards that will impact the specification of the system from the user's perspective, not standards that could be used to implement the system from a technical perspective. These technical standards are covered in D2.1.

Based on an analysis of the standards in D1.1, the following list of requirements was elicited:

- **BIM:** Support the standardisation of BIM data through the adoption of at least one of the IFC data standards. Supporting the standardisation of integrated, interoperable information management based on building information modelling (BIM) by using the standards: IFC schema, IDS, IDM, ER, MVD and tools/microservices/APIs implementing these standards.

- **Classification**: Support at least one classification schema as appropriate to each of the demonstration cases

- **GIS**: Support at least one standard GIS data format as appropriate to the demonstration cases.

- **Data Dictionaries**: Utilise standard technologies such as the buildingSMART Data Dictionary (bSDD) to store any required data dictionaries.

- **Information Exchange**: Adopt buildingSMART Information Delivery specifications, such as the IDS (Information Delivery Specification)

This set of requirements aligns with the EU rolling plan for ICT standardisation. Covering the key areas for construction[2]:

- **EN ISO 12006-2** - *aligned through our adoption of classification systems appropriate to the ACCORD demo cases.*

- **EN ISO 12006-3, EN ISO 23386 -** *aligned through our adoption of bSDD.*

- **EN ISO 16739-1**– *aligned through our adoption of IFC standards.*

- **EN ISO 29481-1&2, EN 17412-1 –** *aligned through our adoption of Information Exchange Specifications*

[2] https://joinup.ec.europa.eu/collection/rolling-plan-ict-standardisation/rolling-plan-2023

4.4 Summary of Requirements Elicited

Following the elicitation of high-level requirements in the previous sections, a complete list has been derived removing any duplicates and resolving any conflictions between requirements. This is shown in Table 3.

Table 3. High Level Requirements.

Number	Description	Source
H1	The process and output of digitisation building codes/regulations should still be understandable by regulation authors.	S4.1
H2	Digitisation of building codes/regulations should be done in as user friendly and intuitive way as possible.	S4.1, S4.2
H3	The digitised format of building/codes regulations should be independent of any specific building modelling format.	S4.1
H4	Open standards should be adopted	S4.1
H5	Should support integration with data dictionaries to enable mappings between regulatory terms and data schemas.	S4.1, S4.3
H6	Should support the use of classification systems	S4.1, S4.3
H7	Should provide the formalization of concepts from building codes/regulations in an ontology.	S4.1
H8	Support the formalization of building permitting processes and expose this using a standardised way.	S4.1, S4.2
H9	Allow for the integration of multiple compliance checking services, each capable of performing the concrete compliance checks needed to enable digital building permitting.	S4.1
H11	Support the IFC schema.	S4.2, S4.3
H12	Provide data requirements for building permitting as a standardised data schema using BuildingSMART standards (i.e., IDS).	S4.2, S4.3
H13	Support at least one standard GIS data format	S4.2, S4.3
H14	Provide the ability to pre-check for compliance prior to formal submission.	S4.2
H15	Provide auditable rule processes to track decisions.	S4.2
H16	Provide the ability to link building permitting processes, applicable legislation and building data standards.	S4.2
H17	Provide open access to limited data about building permitting assessments.	S4.2
H18	Provide a standardised submission process.	S4.2
H19	Should support and enable direct communication between the submitter and regulator.	S4.2
H20	Should provide suitable security models to differentiate between users to enable selection of an appropriate user to assess a given regulation.	S4.2
H21	Should ensure correlation between passes/failures and regulations	S4.2

H22	Provide the generation of human readable and machine-readable reporting based on submissions.	S4.2
H22	Should enable collection of suitable evidence to complement assessments	S4.2
H24	Should adopt and support Open APIs.	S4.2
H25	Should retain the ability for manual human input.	S4.2

These requirements will now feed into the overall ACCORD framework specification, together with the requirements gathered from the demo cases that are presented in the following section.

5 Demo User Requirements

5.1 User Requirements for the German Demo's Use Cases

5.1.1 Analysis of Existing Process Models

The German as-is building permit process at macro level, as described in D1.2, includes the outline- or preliminary building permission ("Bauvorbescheid") and the building permit ("Baugenehmigung"). Starting point of the German as-is building permit process is the Online Access Act Reference Implementation "Digital Building Permit" which is based on the use of XPlanung- and XBau standards. Future or to-be building permit processes drafted in this chapter will consider the implementation of Building Information Modelling (BIM). The standards for the storing, processing, analysis and retrieval of data relevant for the German demonstrator are described in Section 6.4.

Process phases and activities

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")[3]. The following service phases and activities are relevant for the building permit procedure:

1 - Basic evaluation

- Basic investigations of the building project.

2 - Preliminary planning

- Preliminary planning
- Registration and first request to the construction portal
- Compilation of (application) documents
- Application for preliminary building permit
- Inspection of preliminary building application
- Decision and granting of **preliminary building permit**
- Entry into force.

3 - Design planning

- Design planning
- Coordination with the specialist planners
- Negotiations with the authorities about the approvability.

4 - Approval planning

- Approval planning
- Preparation of the building (application) documents

[3] HHH GbR, 2023. "Übersicht der Leistungsphasen nach HOAI". Online, available at: https://www.hoai.de/hoai/leistungsphasen (accessed on 15/03/2023) and HHH GbR, 2023. "HOAI 2021 Volltext". Online, available at: https://www.hoai.de/hoai/volltext/hoai-2021 (accessed on 15/03/2023).

- Application for building permit
- Inspection of building application according to planning law
- Inspection of building application according to German State Building Codes
- Consultation of specialised authorities
- Hearing of neighbours.and other relevant parties
- Decision and granting of **building permit**
- Entry into force.

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

Actors

The German as-is process considers different options applying for the role of the "building permit applicant" in accordance with German State Building Codes. At macro level, the following actors are defined for the German building permit process:

- *Building permit applicant:*
  - Building owner or
  - Architect/ 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
- Design Review Engineers
- Neighbours.

Analysis of as-is processes

Introducing the "digital building permit" was foreseen in Germany until the end of 2022. Currently, 15 out of 16 German Federal States reuse the Online Access Act Reference Implementation "Digital Building Permit"[4] and relevant services (SaaS) following the One for All ("Einer für Alle - EfA") principle.[5] The implementation level of processes and technologies differs widely throughout the country. Although the implementation of XPlanung and XBau standards was required until the end of February 2023, those and other standards of the German public administration ("XÖV") are not being implemented by all contributing municipalities.

On the other hand, research and pilot projects in selected Federal States and municipalities are paving the way for BIM-based building permit processes in Germany: The project "BIM-based

[4] brain-SCC GmbH, 2023a. "OZG-Referenzimplementierung Digitale Baugenehmigung". Online, available at: https://www.digitale-baugenehmigung.de/de/baugenehmigung.html (accessed on 30/06/2023).
[5] Implementing the Online Access Act and based on the idea of "one-for-all", German Federal States can share or reuse a developed online service provided by another state. These "EfA services" are published on the FIT-Store marketplace, see FITKO, 2023. Online available at: https://www.fitko.de/produktmanagement/fit-store (accessed on 02/06/2023).

building permit"[6] delivered first results and led to the very first BIM-based building permit issued in the municipality of Dortmund in 2021. A current research project is dedicated to the digitalization of the Model Building Code[7], and a national Gaia-X project develops solutions for the BIM-based digitized inspection of the proof of stability required during the building permit process[8]. Additional pilot projects are ongoing.

For federal building projects, BIM implementation is introduced by the Masterplan and Implementation Strategy "BIM for Federal Buildings".[9] The first step of Level I - BIM implementation for complex building projects - is mandatory in Germany as of 1st July 2023. The Implementation Strategy defines BIM processes, roles and responsibilities, uses cases - amongst others the use case "permit process"- Information Requirements (according to Level of Information Need - LOIN) and technical demands and provides stakeholders with a sample BIM Execution Plan (BEP) and Employer's Information Requirements (EIR).

A parallel initiative supporting the introduction of "BIM for Federal Buildings" in Germany is the so called "BIM Portal".[10] The platform will support all actors with the uniform processing of federal construction projects. Public building owners will be provided with digital templates facilitating the definition of Information Requirements (IR) for all Services Phases. The first implementation stage of the portal is currently running, gathering IR of federal authorities being reconciled and made available in a standardized manner. These IR are forming the basis for the creation of project specific EIRs. Templates and options for configuring EIRs are part of the second implementation stage. In the third stage of development, tools are made available to the Federal authorities to check whether the requested information has been correctly recorded during planning, construction and operation.[11]

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[6] Ruhr-Universität Bochum, 2018. "BIM-basierter Bauantrag - Konzept für die nahtlose Integration von Building Information Modeling (BIM) in das behördliche Bauantragsverfahren: Ergebnisse". Online, available at: https://bim-bauantrag.blogs.ruhr-uni-bochum.de/projektergebnisse/ (accessed on 02/06/2023).

[7] Ruhr-Universität Bochum, 2023. "Digitalisierung der Musterbauordnung (MBO2BIM) - Aufbereitung der MBO für BIM-basierte Prüfwerkzeuge: Ergebnisse". Online, available at: https://mbo2bim.de/ergebnisse (accessed on 02/06/2023).

[8] RIB Software GmbH, 2023. "Digitalisierte Prüfung des Standsicherheitsnachweises – Prüfung goes BIM. Online, available at: https://ieco-gaiax.de/use-cases-variante-2/ (accessed on 02/06/2023).

[9] BIM Deutschland, 2023. "Umsetzungsstrategie 'BIM für Bundesbauten' veröffentlicht". Online, available at: https://www.bimdeutschland.de/service/presse/detail/umsetzungsstrategie-bim-fuer-bundesbauten-veroeffentlicht (accessed on 04/07/2023). So called "impact building projects" on federal level currently function as a test bed for validating the Implementation Strategy.

[10] The "BIM Portal" is headed by "BIM Deutschland - Zentrum für die Digitalisierung des Bauwesens", a centre dedicated to the digitalization of the German construction sector represented and operated by "planen-bauen 4.0 GmbH". This enterprise was established as an initiative of associations and chamber organizations in the value chain of planning, construction and operation supporting national efforts towards BIM implementation.

[11] The "BIM Portal" organizes the tasks of diverse actors by offering the following modules: (1) Attributes - management, maintenance and provision of uniform attributes and attribute groups for public tenders, (2) EIR - definition and generation of EIRs using standardized templates, (3) Object Templates – provision of EIR-compliant semantic object templates for integration into BIM authoring tools, (4) Checking Tools - EIR-compliant compliance checking tools for BIM quality assurance by public building owners. In the future, a federally coordinated agency will be managing and maintaining the uniform attributes and attribute groups that are forming the basis of the definition of EIRs and associated object templates. Checking rules are to be developed supporting the automated compliance checking of EIRs by public commissioners and contractors. A REST-API allows for the retrieval of publicly available attributes and attribute groups by selected authorities.

The following inhibiting factors for the introduction of BIM-based building permits in Germany were identified:

- The mandatory implementation of digital building permits is ongoing. The federal structure of Germany is slowing down the speed of implementation.
- BIM implementation is mandatory for public building owners, but still at a very early stage.
- Efforts of Federal authorities are missing towards the alignment of attributes, attribute groups, object templates and EIRs that are to be provided via the “BIM Portal”.
- The Implementation Strategy “BIM for Federal Buildings” and the “BIM Portal” initiative are not aligned.
- There hasn’t been a decision on the technical solution for the “Checking Tool” module provided via the “BIM Portal”.
- BIM implementation is voluntary for private building owners and therefore not being frequently made.
- The German construction sector is characterized by small and medium sized enterprises (SMEs) which are, to a large amount, still struggling and lacking knowledge, personal, time and money when it comes to the digitalization of processes and BIM implementation.
- Expertise in BIM-based construction projects and awarding is still missing among actors involved in building permit processes.

5.1.2 Digitization Scenarios/Storylines

The digitalization scenarios for the German building permit processes at macro level apply to the Preliminary Building Permission (Service Phase 2, HOAI 2021), the Building Permit (Service Phase 4, HOAI 2021) and the Life-Cycle-Assessment (LCA) for Green Building Certification. In detail, the German demonstrator develops solutions for the following three use cases:

- Use Case 1 “Land use permitting“
- Use Case 2 “Environmental Compliance”
- Use Case 3 “Type approval for timber construction systems“

Use case-specific to-be processes will be further developed in WP3 based on the here mentioned scenarios.

Processes and phases

The visionary scenarios of German building permit procedures are based on the mandatory implementation of e-governmental and digital building permit processes and standards following the Online Access Act. Visioning goes from digital to BIM-based and automated building permit processes based on results of recent research and pilot projects and making references to the Implementation Strategy “BIM for Federal Buildings“ and the “BIM Portal” initiative (see previous Section).

To answer the needs of BIM-based building projects as well as those applying to Green Building Certification, an additional project development phase is proposed previously to the Service Phase 1 - “Basic Evaluation” according to HOAI 2021: the “Requirements planning” phase. This phase, frequently called “phase 0”, can be further subdivided into:

0.1 - Requirement planning

- Requirement planning for the building project

0.2 - BIM project planning - Awarding

- BIM project planning
- Awarding of construction works.

Actors

In Germany, BIM-specific roles in federal construction projects are defined by the Implementation Strategy "BIM for Federal Buildings".[12] These roles were incorporated in the definition of actors in the German to-be building permit processes at macro level.[13] A summary of those actors is presented in the following overview, highlighted those being relevant for the drafting visionary scenarios.

- **Building owner**
- **Applicant**
  - Green Building Certification: Building owner
  - Preliminary building permission: Building owner, architect/ engineer, or any interested party.
  - Building permit: Building owner or architect/engineer authorized to submit building permits.
- **BIM management**
- **Main architect**
  - including General BIM coordination[14], BIM coordination and BIM authors
- **Specialist planners**
  - from various disciplines: structural engineering, HVAC planning, electrical planning, planning of conveying technology, and others.
  - including BIM coordination and BIM authors
  - Experts and Consultants
  - fire safety, acoustic, energy-efficiency, building physics, and others.
- **Building permit authority** (administrator[15] at)
  - the Construction Supervision ("Bauaufsichtsbehörde") or
  - the Lower building authority ("Untere Bauaufsichtsbehörde")
  - Internal inspection unit
- External inspection unit - spezialized authorities ("Fachbehörde")

[12] BIM Deutschland, 2023. "Umsetzungsstrategie BIM für Bundesbauten - Anlage A: BIM-Rollen im Bundesbau". Online available at: https://www.bimdeutschland.de/fileadmin/user_upload/Umsetzungsstrategie_BIM_Anlage_A_Rollen.pdf (accessed on 14/07/2023).

[13] The BIM-strategy and BIM-specific roles of the public building owner Tegel Projekt GmbH will be considered at a later stage, namely for validating the use-case specific to-be processes developed in WP3. Consultations with the Senate Department for Urban Development and Housing, Berlin and the German Sustainable Building Council (DGNB e.V.) representing the checking- and certifying authority are intended.

[14] For simplification, the role of the General BIM coordinator is incorporated into the actor of the main architect representing the most common case in BIM-based construction projects.

[15] In the future, establishing new roles and responsibilities at building permit authorities will be a necessary task to comply with the needs arising from the change to BIM-based building permit processes and the implementation of new technologies and tools.

- Design Review Engineer
- Other authority
- Municipality and/or higher administrative authority
- Neighbours.

Additional roles and responsibilities may apply for use case-specific to-be processes at meso level. For use case 2 “LCA for Green Building Certification” these are:

- Applicant: Building owner
  - Decides for assessment process, initialisation and sustainability certification system and ambition
- DGNB Auditor[16]
  - The responsible actor for the project’s compliance with certification requirements and for generating the documents required for certification.
  - Performs project registration and submission.
- Sustainability expert (LCA modeller)
  - Hired by the auditor to perform the environmental assessment in compliance with the rules arising from the applied certification system.
  - Usually uses a LCA software deriving data from various sources manually.
- Certifying authority (DGNB)
  - The private authority in charge of issuing sustainability certificates.
  - The Sustainable Building Quality Seal (“QNG Seal”)[17] requires accreditation by the German Accreditation Body (“Deutsche Akkreditierungsstelle GmbH - DakkS”)[18], available for DGNB.
  - Provides calculation rules and a supporting framework.

Technological implementation

The visionary scenarios of the German building permit processes at macro level build upon the following technological solutions:

- Online Access Act Reference Implementation “Digital Building Permit” providing a “Construction Portal” (“Vorgangsraum”) as an intra-agency IT infrastructure[19].
  The “Construction Portal“ functions as a data storage and communication platform for authorised users. Application data is stored before being submitted to the building permit authority.

[16] DGNB: Abbrevation for the German Sustainable Building Council (DGNB e.V.).
[17] Bundesministerium für Wohnen, Stadtentwicklung und Bauwesen, 2023. “Nachhaltiges Bauen”. Online, available at: https://www.bmwsb.bund.de/Webs/BMWSB/DE/themen/bauen/bauwesen/nachhaltiges-bauen/nachhaltiges-bauen-artikel.html;jsessionid=47312E57206259594EDC8BD838734445.1_cid287 (accessed on 28/06/2023).
[18] DakkS, 2023. “Deutsche Akkreditierungsstelle GmbH - DakkS”. Online, available at: https://www.dakks.de/de/home.html (accessed on 30/06/2023).
[19] brain-SCC GmbH, 2023a. “OZG-Referenzimplementierung Digitale Baugenehmigung”. Online, available at: https://www.digitale-baugenehmigung.de/de/baugenehmigung.html (accessed on 30/06/2023); brain-SCC GmbH, 2023b. “OZG-Referenzimplementierung Digitale Baugenehmigung - Vorgangsraum”. Online, available at: https://www.digitale-baugenehmigung.de/de/vorgangsraum.html (accessed on 30/06/2023).

- E-government IT interoperability and security standards of the Federal Republique of Germany ("XÖV Standard")[20] including XPlanung, XBau and OSCI/ XTA standards.
- ELBA - Digital interface developed by the Federal Association of Design Review Engineers allowing for the digital exchange of construction documents subject to inspection[21]
- GENERIS® LCA-web software.

Storyline for the building permit process at macro level

Table 4. The user requirements from the information management point of viewdescribes the storyline of the German building permit process at macro level by defining tasks and related user requirements of the main actors in the process. For simplification, no distinctions are made between the preliminary building permit and the building permit proper.

Information Requirements

The process is starting earlier, with the first registration of the building owner at the "Construction Portal" during the requirements planning phase. The building owner or authorized contractors send a first request to the building permit authority containing all relevant information on the construction project being relevant for the configuration of Information Requirements (IR) and BIM modelling guidelines according to applicable legislation, permit type(s) and other requirements, which are to be provided by the building permit authority in the next step. In addition, IRs and templates are provided for XBau messages, e.g. the XBau 0200 "Building Application" message.

The building permit authority uses a **Building Permit Information Requirements Service** allowing to configurate and generate IRs and BIM modelling guidelines appying for individual construction projects, permit types and applicable legislation. The services accesses IRs for federally owned buildings via the "BIM Portal".

Pre-checking

The building owner, the applicant and authorized contractors are able to pre-check at any stage during the process if the data to be delivered and uploaded on the „Construction Portal" -being it designBIM-, permitBIM models, 2D plans or documentation- and XBau messages-, meet with the IRs and allow for compliance checking against relevant regulations and issuing the (preliminary) building permit at a later stage. In addition, 2D plans and documents are machine-interpretable, filterable and can be located in the BIM model.

Compliance Checking

The "Construction Portal" functions as a data storage and communication platform for the users. Application data (BIM models, BCF files, reports and XBau messages) is stored before being submitted to the building permit authority.

Different services support the building permit authority in the management of processes and data for inspections and decisions on building permit applications based on BIM-based and automated compliance checking:

[20] List of mandatory IT interoperability and security standards for the German public administration (e-government), see FITKO, 2023. "Standards". Online, available at: https://www.it-planungsrat.de/produkte-standards/standards (accessed on 30/06/2023).
[21] BVPI, 2023. "Die elektronische bautechnische Prüfakte – ELBA". Online, available at https://bvpi.de/bvpi/de/aktuelles/elba.php (accessed on 30/06/2023).

- **Building Permit Decision Support Service** allowing for the management of processes, data, inspections and decisions on building permit applications. The service provides access to diverse building permit services, databases and a data archive.
- **Building Permit Rule Configuration Service** allowing to access, configurate and manage rules and rule sets for the BIM-based compliance checking of individual construction projects according to permit type and applicable legislation. The service accesses IRs in BIM modelling guidelines created by the *Building Permit IR Service*. It provides access to databases, to the *ACCORD Rule Formalization Tool* and to other services. There is also the option to review and manage configurated rules and rulesets stored in the *Ruleset Database*.
- **Building Permit Application Checking Service** allowing for the compliance checking of XBau messages (XBauXML format) and BIM models (IFC format) against predefined IRs applying for the individual construction project, permit type(s) and applicable legislation.
- **Land use Compliance Checking Service** allowing for the compliance checking of urban- and BIM models (CityGML and IFC format) against land use requirements (XPlanXML and INSPIRE format). The service offers a BIM viewer, accesses the ***XPlan Database*** and exchanges with other services (e.g. offering geospatial encoding rules).
- **XPlan Conversion Service** allowing for the (semi-)automated conversion of land-use plans into the standardised data format XPlanGML.
- **Building Permit Compliance Checking Service** including a BIM viewer for the visual examination of BIM models. The service accesses the ***Ruleset Database***, allows to select rules, to define tolerances for each rule, rule sets and the order of checking. Reports and BCF files can be created and managed. This service is also used for the pre-checking of application data before final submission.
- **Type permit compliance checking service** allowing to approve the certification of timber construction systems before starting the type permit compliance checking of application data.

In addition, the main architect is supported by

- **LCA and Green Building Compliance Checking Service** providing BIM-based Life Cycle Assessments for Green Building Certification in different design phases of the construction project.
- **XBau Building Application Messaging Service** providing the main architect with digital assistance for creating an XBau 0200 „Building Application“ message for the construction project. The services accesses the ***XBau Template Database***.

The building permit application process starts with submitting the “formal application“ by the applicant. With the introduction of BIM-based building permits also this process will be automized: Inspite of submitting an application in Pdf format, all relevant information is extracted from a dedicated XBau message and BIM model (in IFC model) after having passed previous compliance checks. The final application can be viewed by all relevant stakeholders.

Automated compliance checking of BIM models is excecuted for diverse checking types (completness of data, geomtry, information, consistency, integrity) in a determined order - from basic checks to complex- and integral checks. Additional modules will be providing automated 2D plan and document checking functionalities.

Predefined rules for different permit types distinguish between checks for formal- and material inspection. The checking is running simultaniously for diverse inspection types. In this way, the checking process does not have to be stopped for each case an IFC-model does not comply with the requirements. Each time a BIM model does not pass a check being relevant for the excecution

of the next one wihtin the inspection type, the checking process is stopped, a report and BCF files are created and forwarded to the applicant via XBau message.

Relevant application data (including BIM models and/or extracted data) is further provided to internal- and external inspection units (spezialized authorities), other authorities and Design Review Engineers for compliance checking during the material inspection phase.

Consultation

In cases where the consultation of municipalities and/or higher administrative authorities is required, relevant application data is provided for further compliance checking.

Table 4. The user requirements from the information management point of view.

Stakeholder	Task	User requirements
Requirement Planning		
Building owner	Requirement planning of the building project • Analyses site and property • Defines project goals: Costs, deadlines, qualities • Plans requirements and describes the task: Programming (use, space, functions) BIM specific: • Decides on the use of the BIM method • Early defines the planning team for the construction project	• Needs competences or consultancy concerning BIM implementation • Needs digital assistance facilitating the requirement assessment (including programming of use, space, functions, equipment and costs).
	BIM project planning - Awarding BIM project planning an awarding of construction works. Prerequisite: BIM strategy, organisational structure and BIM roles on building owner's side are defined • Selects appropriate award type • Adapts service specifications for contractors • Awarding/ Contracting: Provides BIM awarding and contract documents	• Public building owner: Requires information and teaching material on how to adapt data provided by the "BIM Portal" (BIM object templates, EIRs and others) to individual needs for the awarding • Private building owner: Requires information and teaching material on how to develop a BIM strategy and BIM specific awarding and contract documents
Start of the building project (Basic evaluation - Service Phase 1 or Preliminary Planning - Service Phase 2, HOAI 2021)		
Building owner	• Registers to the „Construction Portal" • *Optional:* Assigns access rights to contractors	
Building owner, applicant and other contractors	• Use enhanced functionalities provided by the "Construction Portal" for BIM-based building permit processes	• Require information and teaching material on BIM-based building permit processes and the use of the "Construction Portal" • Need support on behalf of the building permit authority • Need digital assistance according to the assigned role guiding through single process

		steps as well as the entire BIM-based building permit procedure
Building owner/ applicant/ BIM management or main architect	• Sends a first request to the building permit authority (XBau message)	• Wants to obtain a set of IRs (following LOIN standard) and BIM modelling guidelines for the construction project according to the specific requirements applying for the Federal State, municipality, type of permit, lot, building type and other criteria.
Building permit authority	• Manages processes, data, inspections and building permit relevant decisions	• Needs digital assistance for the management of processes, data, inspections and decisions on building permit applications based on BIM-based and automated compliance checking
	• Receives all information on the intended construction project and permit type(s) (via XBau message) that is required to configure IRs and BIM modelling guidelines • Provides IRs and BIM modelling guidelines for the specific construction project and permit type (appendix to XBau message)	• Needs digital assistance to configure IRs and BIM modelling guidelines for the construction project according to requirements applying for the Federal State, municipality, type of permit, lot, building type and other criteria. • Needs to provide structured IRs and BIM modelling guidelines in an adequate data format (public building owners: alignment with IRs provided by the “BIM Portal”) • Needs to store and access IRs and BIM modelling guidelines of current and archived projects.
Building owner/ applicant/ BIM management or main architect	• Obtains IRs and BIM modelling guidelines for the specific construction project and permit type (appendix to XBau message)	• Needs to access stored IRs and BIM modelling guidelines of current projects in the “Construction Portal”.
BIM management	• Includes IRs and BIM modelling guidelines for the specific construction project (and permit type) in the development of the BIM Execution Plan (BEP) in cooperation with the BIM planning team.	• Needs direct access to the “Construction Portal” or provision of IRs and BIM modelling guidelines by another actor
Preparation of the building application (Service Phases 4, HOAI 2021)		
Building owner	• *Optional:* Assigns access rights to contractors	
Main architect and specialised engineers	• Deliver BIM models (in IFC format), 2D plans and documentation in accordance with requirements in all design stages Design of the building in accordance with: (1) the requirements and conditions of the project provided by the building owner or client, (2) public building and planning law, (technical) building regulations, technical norms and standards etc. BIM models, 2D plans and documentation in accordance with (3) BIM requirements of the building owner, (4) IRs and BIM modelling guidelines for the construction project provided by the building permit authority.	• Need and established workflow and technical solution to integrate IRs in BIM modelling activities • Need direct access to the “Construction Portal” provision of IRs and BIM modelling guidelines • Want to exchange on errors in submitted data with authority • Need digital assistance for BIM-based Life Cycle Assessments of the construction project design for Green Building Certification.

Applicant or main architect	• Generates an XBau 0200 “Building Application” message by using a SaaS solution **or** a service provided via the “Construction Portal” • Submits XBau “Building Application” message, BIM model(s) and other files for pre-checking	• Needs to receive a notification of entrance • Needs digital assistance for the the pre-checking of application data previous to its final submission
Building permit authority	• Sends a notification of entrance	
	• Configurates rules and rulesets for the (BIM-based) compliance checking of application data for the individual construction project and permit type. • Stores the ruleset in a database	• Needs digital assistance for the configuration of rules and rulesets for the (BIM-based) compliance checking of application data for the individual construction project and permit type • Needs a ruleset database
	• Provides the pre-checking of application data (BIM models, documents, XBau messages etc.) to applicants	• Needs digital assistance for the compliance checking of application data (BIM models, documents, XBau messages etc.) • Needs digital assistance for the conversion of land-use plans (2D plans with text, PDF format) into XPlanXML data format • Needs digital assistance for the compliance checking of BIM models (IFC files) against land use requirements (XPlanXML and INSPIRE format) • Needs a BIM viewer, a report- and a BCF creator • Needs a document viewer
	• Provides a report on positive or negative checking results. • Provides BCF-files describing errors and change requests in BIM models • Submits the checking results to the applicant via XBau message (report and BCF-files as appendix)	• Needs digital assistance in creating a report and BCF files • Negative checking result: the report should describe errors in submitted data • Needs to store and manage BCF files • Needs a data archive for application data
Applicant, main architect and specialised engineers	• Receives notification on the checking result (XBau message) • Downloads checking report (and BCF files) from the “Construction Portal”	• Wants to pre-view the checking results via the “Construction Portal” • Needs a structured checking report describing errors in submitted data and BCF-files describing errors and change requests in BIM models
	Negative checking result -> Correction of errors -> Iterative process until checking is passed	
	• Views report as well as BCF files (via BIM authoring tool) • Corrects errors and changes/adds geometry and/or information to BIM-models and/or documentation	
	• Uploads new files at the “Construction Portal” and submits them to the building permit authority	• Needs to receive an entrance notification • Needs an easy-to-handle user interface and accessibility to a structured data storage in the “Construction Portal” for submitted and received data and messages • Needs to view meta data of uploaded files • Wants to filter uploaded files

Building permit authority	• Sends an entrance notification (XBau message) • Starts the pre-checking of application data (BIM models, documents, XBau messages etc.) • Send notification on positive results (XBau message)	*See above*
Submission of the building permit application (Service Phases 4, HOAI 2021)		
Applicant	• Submits building permit application: • Submits the XBau 0200 "Building Application" message and BIM models, 2D plans and documents as an appendix to the building permit authority	• Wants to receive a notification on the submission • Wants to follow-up the status and result of single process- and compliance checking steps online via the “Construction Portal”
Building permit authority	• Is notified about the ingoing building permit application • Starts the building permit compliance checking process • Sends a notification on the submission to the applicant (XBau message)	• Needs digital assistance for the management of processes, data, inspections and decisions on building permit applications based on BIM-based and automated compliance checking
Applicant	• Receives a notification on the submission (XBau message)	
Checking of the building permit application		
Formal Inspection		
Building permit authority	• Starts the compliance checking of XBau messages (in XBauXML format) and BIM models (in IFC format) against predefined IRs applying for the individual construction project, permit type(s) and applicable legislation.	• Needs digital assistance for the compliance checking of XBau messages (in XBauXML format) and BIM models (in IFC format) against predefined IRs applying for the individual construction project, permit type(s) and applicable legislation • Needs digital assistance allowing for the automated creation of building permit application • Need digital assistance allowing to approve the certification of timber construction systems required to start type permit application and compliance checking processes • Wants to view the application
	Negative checking result -> Correction of errors -> Iterative process until checking is passed	*See above*
	• Undertakes the formal inspection of the automatically created building permit application	• Wants digital assistance for the formal inspection of the automatically created building permit application
Applicant	• Receives a notification on the results of the formal inspection (XBau message)	• Wants to view the automatically generated application via the “Construction Portal”
Material Inspection		
	• Starts the compliance checking of application data for material inspections.	• Needs digital assistance for the compliance checking of BIM models (IFC format) against predefined IRs applying for the individual

Building permit authority		construction project, permit type(s) and applicable legislation • Needs digital assistance for the compliance checking of urban- and BIM models (CityGML and IFC files) against land use requirements (XPlanXML and INSPIRE format) • Need digital assistance for the type permit compliance checking of certified timber construction systems • Needs a BIM viewer, a report- and a BCF creator • Needs a document viewer
	• Provides a report on positive or negative checking results. • Provides BCF-files describing errors and change requests in BIM models • Submits the checking results to the applicant (XBau message, report and BCF-files as appendix)	• Needs digital assistance in creating a report and BCF files • Negative checking result: the report should describe errors in submitted data • Needs to store and manage BCF files • Needs a data archive for application data
Applicant, main architect and specialised engineers	• Receives notification on the checking result (XBau message) • Downloads checking report (and BCF files) from the “Construction Portal”	• Wants to pre-view the checking results via the “Construction Portal” • Needs a structured checking report describing errors in submitted data and BCF-files describing errors and change requests in BIM models
	Negative checking result -> Correction of errors -> Iterative process until checking is passed	*See above*
Building permit authority	• Review results of the material inspection • Sends notification on positive results (XBau message)	• Needs digital assistance for the management of processes, data, inspections and decisions on building permit applications based on BIM-based and automated compliance checking
Consultation		
Building permit authority	• Forwards application data (including BIM models and/or extracted data) to internal and external inspection units, specialised authorities and Design Review Engineers	• Wants to receive an entrance notification
Internal inspection units	• Send an entrance notification • Undertakes inspection of application data • Delivers consultation results to the building permit authority	
External inspection units, Design Review Engineers	• Send an entrance notification • Undertakes inspection of application data • Deliver consultation results to the building permit authority	
Building permit authority	• Reviews consultation results • Receives technical report provided Design Review Engineers	• Needs digital assistance for the management of processes, data, inspections and decisions on building permit applications based on BIM-based and automated compliance checking
Approval or refusal of the building permit application (Service Phase 4, HOAI 2021)		
Building permit authority	• Makes final decision on the approval or refusal of the building permit application • Sends notification on the approval or refusal including justification (XBau message)	

Applicant	• Receives notification on the building permit approval/ refusal including justification (XBau message)	

5.1.3 Visionary To-be Process

The German visionary to-be process focusses on the "building permit proper" including actors, phases, processes, activities and data exchange workflows as described in the previous chapter. The vision builds upon the readiness of German Federal States to reuse and implement services following the "one for all" principle.[22] In an ideal scenario, all German Federal States will agree to reuse and implement services to be offered for BIM-based building permit processes.

The three use cases of the German demonstrator -Land use permitting, Environmental Compliance and Type permit for timber construction systems-, will be further described in Section 5.1.4.

The developed digitization scenarios and storyline allowed to define processes, new technologies, preliminary technical requirements of (existing or new) components and user requirements for the visionary to-be building permit process at macro level.

New technologies involved to automate BIM-based building permit processes

- Building Permit Decision Support Service
- Building Permit Information Requirements Service
- Building Permit Rule Configuration Service
- Building Permit Application Checking Service
- XPlan Conversion Service
- Land Use Compliance Checking Service
- Building Permit Compliance Checking Service
- Type Permit Compliance Checking Service
- LCA and Green Building Compliance Checking Service
- XBau Building Application Messaging Service
- Databases:
    - XBau Template Database
    - XPlan Database
    - Ruleset Database.

User requirements from the actors' point of view

<u>The building owner needs to be able to:</u>

- Develop a BIM strategy and BIM specific awarding and contract documents
- Easily run BIM-based building permit application processes guided by information and teaching material and/or a digital assistance
- Easily use the functionalities of the "Construction Portal"
- Access a structured data storage in the "Construction Portal" for uploaded and submitted building application data
- View meta data and filter uploaded files
- Receive entrance notification on the submission of application data

[22] Currently, the State of Berlin is the only Federal State not reusing the service "Digtial Building Permit".

- Receive notification on the approval/refusal of the building permit application.

Building owner and/or BIM Management need to be able to:

- Receive IRs and BIM modelling guidelines applicable to the specific construction project that can be integrated in the development of BIM Execution Plans (BEP) by the planning team.

The applicant needs to be able to:

- Easily run BIM-based building permit application processes guided by information and teaching material and/or a digital assistance
- Easily use the functionalities of the “Construction Portal”
- Access a structured data storage in the “Construction Portal” for uploaded and submitted building application data
- View meta data and filter uploaded files
- Receive entrance notification on the submission of application data
- Follow-up the status and result of single process- and compliance checking steps via the “Construction Portal”
- Receive a checking report describing errors in submitted data and BCF-files describing errors and change requests for BIM models
- Pre-view checking results via the “Construction Portal”
- Receive notification on the approval/refusal of the building permit application.

The main architect and engineers need to be able to:

- Create BIM-based Life Cycle Assessments for Green Building Certification in different design phases of the construction project and required documentation for the building permit application
- Easily run BIM-based building permit application processes guided by information and teaching material and/or a digital assistance
- Easily use the functionalities of the “Construction Portal”
- Access a structured data storage in the “Construction Portal” for uploaded and submitted building application data
- View meta data and filter uploaded files
- Deliver BIM models, 2D plans and documentation meeting the building permit IRs and BIM modelling guidelines for the specific project
- Receive a checking report describing errors in submitted data and BCF-files describing errors and change requests for BIM models
- Create an XBau 0200 “Building Application” message.

The building permit authority needs to be able to:

- Manage processes, data, inspections and decisions on building permit applications based on BIM-based and automated compliance checking
- Make decisions upon the approval/refusal of the building permit applications during diverse inspection phases based on the results of visual examination, automated and BIM-based compliance checking of application data

- Easily run through the steps of BIM-based building permit processes including different inspection phases, decision-making by diverse internal and external inspection units as well as the consultation of external authorities
- Use diverse services fascilitating the automated and BIM-based building compliance checking of application data
- Access an intra-agency data storage and data archive
- Undertake compliance checking of XBau messages (XBauXML format) and BIM models (IFC format) against predefined IRs applying for the individual construction project, permit type(s) and applicable legislation
- Automatically create building permit applications from XBau messages and IFC files and view those applications
- Undertake compliance checking of automatically created building permit applications during the formal inspection phase
- Automatically approve the certification of timber construction systems before starting the type permit application and compliance checking processes
- Undertake compliance checking of BIM models (IFC format) against predefined IRs applying for the individual construction project, permit type(s) and applicable legislation
- Convert land-use plans (2D plans with text) into the standardised data format XPlanGML.
- Undertake compliance checking of urban- and BIM models (CityGML and IFC files) against land use requirements (XPlanXML and INSPIRE format)
- Undertake type permit compliance checking of certified timber construction systems
- View BIM models
- Create a report and BCF files in the case of errors and change requests to application data
- View documents
- Store and manage BCF files
- Forward (extracted) building application data to internal- and external inspection units, Design Review Engineers, municipalities and other authorties during material inspection- and final consultation phase.

Preliminary technical Requirements of selected components

<u>“Construction Portal”</u>

The “Construction Portal” functions as a data storage and communication platform for authorized users. Building application data is stored before being submitted to the building permit authority.

- Integrates enhanced functionalities and services allowing to proceed BIM-based building permit applications.

<u>Building Permit Decision Support Service</u>

- Allows the user (building permit auhtority) to manage processes, data, inspections and decisions on building permit applications
- Provides the user with functionalities and information fascilitating the individual decision-making
- Provides the user with digital assistance and guidance through the steps of BIM-based building permit processes including different inspection phases, decision-making by diverse internal and external inspection units as well as the consultation of external authorities

- Provides acess to diverse services fascilitating the automated and BIM-based building compliance checking of application data
- Provides access to an intra-agency data storage and data archive.

Building Permit Information Requirements Service

- Allows the user (building permit authority) to configure and generate IRs (based on LOIN standard) and BIM modelling guidelines applying for individual construction projects, permit types and applicable legislation
- Accesses IRs for federally owned buildings provided by the “BIM Portal“.

Building Permit Rule Configuration Service

- Allows the user (building permit authority) to access, configurate and manage rules and rulesets for the BIM-based compliance checking of individual construction projects according to permit type(s) and applicable legislation
- Provides access to *XBau Template Database*
- Provides access to IRs and BIM modelling guidelines created by the *Building Permit Information Requirements Service*
- Provides access to the *ACCORD Rule Formalization Tool*
- Provides access to other services and databases
- Allows to review and manage configurated rules and rulesets
- Allows to store rules and rulesets in the *Ruleset Database*
- Allows to archive outdated rules and rulesets including contextual information.

Building Permit Application Checking Service

- Allows the user (building permit authority) to configure and execute compliance checks of XBau messages (XBauXML format) and BIM models (IFC format) against predefined IRs applying for the individual construction project according to permit type(s) and applicable legislation.
- Accesses rules and rulsets provided through the *Ruleset Database*
- Allows for the automated creation of building permit applications
- Allows to view building permit applications
- Offers automated compliance checks of building applications against requirements during the formal inspection phase
- Allows to provide (extracted) building application data to other services and to internal and external expection units.

XPlan Conversion Service

- Allows the user (building permit authority) to convert land-use plans into the standardised XPlanXML data format
- Facilites the (semi)-automated conversion of land-use plans (2D plans with text)
- Stores XPlanXML files in the *XPlan Database.*

Land Use Compliance Checking Service

- Allows the user (building permit authority) to configure and execute compliance checks of urban and BIM models (CityGML and IFC format) against land use requirements (XPlanXML and INSPIRE format)
- Provides the user with a BIM viewer for visual examination of urban- and BIM models
- Accesses the *XPlan Data Storage*
- Allows the user to exchange with other services (e.g. offering geospatial encoding rules)
- Allows the user to exchange data between intra-agency service applications.

Building Permit Compliance Checking Service

- Provides the user (building permit authority) with a BIM viewer for the visual examination of BIM models
- Accesses rules and rulsets provided through the *Ruleset Database*
- Allows the user to select and configure rules and rulesets, to define tolerances and the order of BIM-based compliance checks according to the requirements arising for the construction project, permit- and inspection type and applicable legislation
- Allows the user to undertake automated, BIM-based compliance checks of submitted building application data
- Allows the user to configure, create and manage reports and BCF files
- Allows for the pre-checking of application data before final submission
- Allows the user to exchange data between intra-agency service applications.

Type Permit Compliance Checking Service

- Allows to automatically approve the certification of timber construction systems
- provides the user (building permit authority) with a BIM viewer for the visual examination of BIM models
- Accesses rules and rulsets through the *Ruleset Database*
- Allows the user to select and configure rules and rulesets, to define tolerances and the order of BIM-based compliance checks according to the requirements arising for material inspections for the type approval of construction projects using certified timber construction systems
- Allows the user to configure, create and manage reports and BCF files
- Allows for the the pre-checking of application data before final submission
- Allows the user to exchange data between intra-agency service applications.

LCA and Green Building Compliance Checking Service

- Provides the user (main architect) BIM-based Life Cycle Assessments for Green Building Certification in different design phases of the construction project.
- Accesses external databases.

XBau Building Application Messaging Service

- Provides the user (main architect) with digital assistance for creating an XBau 0200 ”Building Application“ message for the construction project.

End-user requirements for the German visionary to-be process

The end-user requirements specific to the German visionary to-be process are summerized as follows:

1) Allow for the configuration of varying requirements for BIM models (modelling guidelines and Level of Information Needs) required for differing submission stages and building permit types.
2) Provide ability to generate documentation of BIM model requirements for differing submission stages and building permit types and to adapt to locally differing sets of predefined requirements.
3) Be able to extract building and spatial information from CityGML and IFC-files and check against requirements provided in standardised data format (XPlanXML in German context/ INSPIRE PLU in European context).
4) Be able to extract required information for the formal building permit application from IFC-files and convert it into XBau standard (XBauXML files).
5) Be able to support XBauXML files as an input format.
6) Provide integration with a microservice to provide Lifecycle Assessment for Green Building Certification.
7) Provide integration with a microservice to provide checking of timber construction systems.

5.1.4 German Demo-specific Deployments

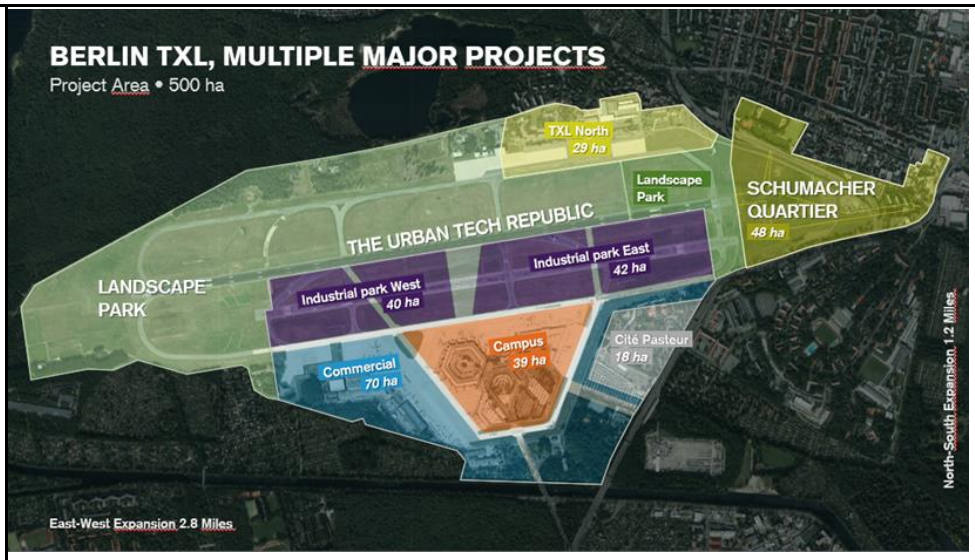
The German demonstration will focus on automating compliance checking for three uses cases arising for the renovation, adaptive reuse, and new planning of buildings on the ground of the former Airport Berlin Tegel: (1) Land use permitting, (2) Environmental compliance and (3) Type approval for timber construction systems.

The TEGEL Project GmbH is owner of “Berlin TXL” providing its demo partners with digital building models for all use cases. The area of “Berlin TXL” comprises the “Urban Tech Republic” dedicated to the adaptive reuse of existing buildings or new planning, and the “Schumacher Quarter” making an important contribution to Berlin’s strategy for timber housing and urban development in a large scale.

Table 5. German demo- and use case-specific deploymentsTable 5 shows a short summary of the German demo and use case-specific deployments.

Table 5. German demo- and use case-specific deployments.

Location	Berlin, Germany
Ownership	TEGEL Project GmbH[23] (public building owner)
Development Area	“Berlin TXL” comprising the “Urban Tech Republic” and the “Schumacher Quartier”

Site Plan	
Use Case 1	**Land use permitting**
Building	Terminal B (former public airport building)
Building Type	Public building (renovation and adaptive reuse of existing building)
Photo	
Land-use Plan	Land Use Plan “Urban Tech Republic”
Compliance Check/ Permit Type	• **Building permit**
Checking authority	• The Senate Department for Urban Development and Housing, Berlin
Use Case Aims	• Transforming land-use plans into the standardised German data format XPlanGML

	• Convert land use plans and other regulations into appropriate data formats conforming to geospatial encoding rules published by the Open Geospatial Consortium (OGC). • Implement APIs designed by OGC for selected pre-checks of building designs (BIM models, IFC format) against land use requirements. • Read and automatically extract required information according to the Building Documents Ordinance Berlin from the submitted IFC file and convert it into XBauXML-format for compliance checking during formal building permit procedures. • Perform automatic compliance checking of submitted building models (IFC) against selected regulations. • Orchestration of individual microservices.
Use case Description	Use case 1 will use digital models of the former public airport building "Terminal B". It defines information requirements according to the Building Documents Ordinance Berlin from submitted IFC files to be converted into XBauXML-format for compliance checking as part of the formal building permit procedures. The Coordination Office for Semantic Standardisation in Planning and Building at the Agency for Geoinformation and Surveying Hamburg (LGV) supports this use case by transforming land-use plans into the standardised German data format XPlanGML and by converting those and other regulations into appropriate data formats conforming to geospatial encoding rules published by the Open Geospatial Consortium (OGC). The office implements APIs designed by OGC for selected pre-checks of building designs (BIM models, IFC format) against land use requirements and supports microservice orchestration. Additionally, the use case will test and validate developed solutions upon the regulatory framework applying to the "Schumacher Quartier".
Design stage	Concept design- and preliminary design phase
Data Formats	IFC, CityXML, XPlanXML, INSPIRE Planned Land Use
Regulations Targeted	• Federal Building Code • Federal Land Utilisation Ordinance • Preparatory land-use plan • Binding land-use plan • State Building Code Berlin • Building Documents Ordinance Berlin
Use Case 2	**Environmental compliance**
Building	"Energiezentrale E1" (former center of energy)
Building Type	Public building (renovation and adaptive reuse of existing building)

Photo	
Compliance Check/ Permit Type	• **Life Cycle Assessment (LCA) for Green Building Certification**
Checking authority	• German Sustainable Building Council (DGNB e.V.)
Use Case Aims	• Develop APIs to the GENERIS® web software for BIM-based Lifecycle Assessment and Green Building Certification making use of enriched BIM models. • Perform automatic compliance checking of building models (IFC) against selected regulations
Use case Description	Solution to be developed by use case 2 will allow for environmental compliance of renovation and adaptive reuse measures applying to the former energy centre in the “Urban Tech Republic”. The German Sustainable Building Council’s (DGNB e.V.) certification requirements will be made machine executable. The Fraunhofer-Institute for Building Physics IBP will develop interfaces to the GENERIS® web software for BIM-based Lifecycle Assessment and Green Building Certification making use of enriched BIM models.
Design stage	Concept design-, preliminary design- and design phase
Data Formats	IFC, XML
Regulations Targeted	• German Sustainable Building Council (DGNB e.V.) Certification scheme • Sustainable Building Quality Seal (QNG)

Use Case 3	Type approval for timber construction systems
Building	"FUTR HUT", new timber-structure building; BIM-models and data sets for modular timber construction
Building Type	"FUTR HUT": Public building; Schumacher Quartier: Housing (new construction)
Photo	
Land-use Plan	Land Use Plan "Urban Tech Republic" Land Use Plan "Schumacher Quartier"
Compliance Check/ Permit Type	• **Type approval** **- LCA for Green Building Certification** **- Preliminary building permit** **- Building permit**
Checking authority	• German Sustainable Building Council (DGNB e.V.) • The Senate Department for Urban Development and Housing, Berlin
Use Case Aims	• Transforming land-use plans into the standardised German data format XPlanGML • Convert land use plans and other regulations into appropriate data formats conforming to geospatial encoding rules published by the Open Geospatial Consortium (OGC). • Read and automatically extract required information according to the Building Documents Ordinance Berlin from the submitted IFC file and convert it into XBauXML-format for compliance checking during formal building permit procedures. • Implement APIs designed by OGC for selected pre-checks of building designs (BIM models, IFC file) against land use requirements. • Implement APIs designed by Fraunhofer GENERIS® (see use case 1) • Perform automatic compliance checking of building models (IFC) against selected regulations as well as against newly defined criteria for timber construction systems based on existing regulations. • Develop and reuse services being compliant to Gaia-X standards.

	• Orchestration of individual microservices.
Use case Description	Use case 3 applies to the new wooden construction “FUTR HUT”. Solutions to be developed will be paving the way for an accelerated and simplified BIM-based building permit process (type approval) for industrialized timber construction systems. The Fraunhofer-Institute for Building Physics IBP is in charge of selecting relevant regulations to be made machine-executable pertaining to built-up area, timber construction (system) or environmental requirements and of developing BIM-based building permit checking services facilitating the transformation at national level. In addition, the company LiWooD AG will provide additional sample data sets for modular timber construction which will be used to test and validate developed solutions upon the regulatory framework applying to the “Schumacher Quartier”.
Design stage	Concept design-, preliminary design-, design- and approval design phase
Data Formats	IFC, XML, CityXML, XPlanXML, XBauXML (and others)
Regulations Targeted	• German Sustainable Building Council (DGNB e.V.) Certification scheme • Sustainable Building Quality Seal (QNG) • Model Building Code • Federal Building Code • Federal Land Utilisation Ordinance • Preparatory land-use plan • Binding land-use plan • State Building Code Berlin • Building Documents Ordinance Berlin • Model Administrative Provisions - Technical Building Rules • Sample timber construction guideline • Eurocode 5
German demo | All Use Cases	
Stakeholders	• Fraunhofer Institute for Building Physics IBP (FhG): Demo Leader/Coordinator, use case 2 “Environmental compliance” - API development for GENERIS® LCA-software, use case 3 “Type approval for timber construction systems”. • Coordination Office for Semantic Standardization in Planning and Building Hamburg (HAM): Use case 1 “Land use permitting” - Providing requirements and knowhow. • Tegel Projekt GmbH (TEGEL): Ownership of TXL Berlin, demo site and buildings of the former airport Tegel; representing the building permit applicant; providing sample data sets for all use cases; supporting all use cases. • Sirma Group (Ontotext): Semantic data integration, rule implementation • Open Geospacial Consortium (OGC): Support standardized (3D) GIS use (standard data models and formats) and integration with BIM

	• The Senate Department for Urban Development and Housing, Berlin: Construction supervision/ Local building control authority, validation of to-be processes. • German Sustainable Building Council (DGNB e.V.): Checking authority, validation of to-be processes. • The German Federal Environmental Foundation (DBU): Offering information and advice. • LiWood AG: providing additional BIM-models and data sets for modular timber construction

5.2 User Requirements for the Spain Demo's Use Cases

5.2.1 Analysis of Existing Process Models

The Spanish demonstration will focus on one case: Automated Checking of Compliance (ACC) with Urban Regulations, which involves the part of the process of granting permits for the construction of public and private works by municipal authorities.

The process of issuing a construction permit requires an analysis of the requirements established in 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).

The part of the checking of urban regulations takes place in the preliminary project application phase of the permitting process. This is currently done manually by the local building control authority in two moments of this phase: (1) in the pre-consultation stage, and (2) in the preliminary project delivery stage (see Figure 4, red circles). In the first check, basic aspects are reviewed to guide the initial design within acceptable limits from the point of view of urban planning, while in the second check all the parameters are validated. Requirements on urban regulations are no longer checked in later phases of the permitting process, for example, when the executive project is delivered.

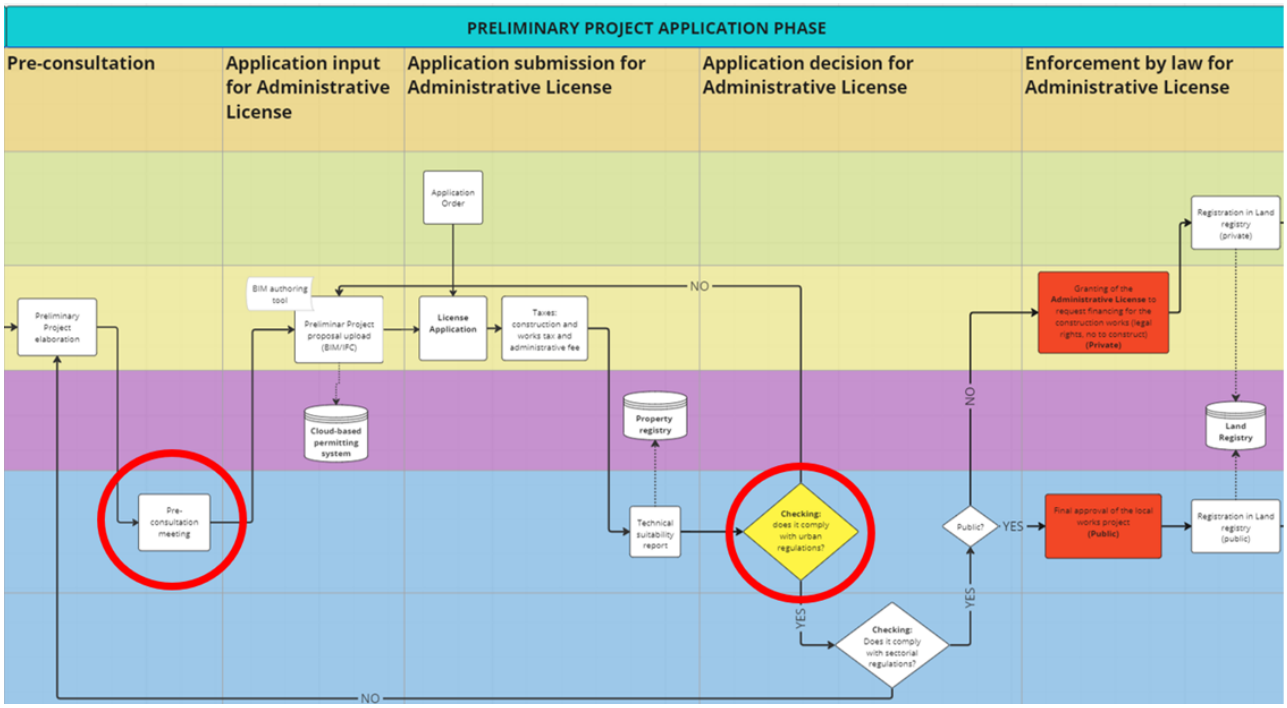


Figure 4. Part of the permit granting process that reflects the two moments where the compliance checking with urban regulations is carried out by the local building control authority.

The following text describes the Spanish process models in more detail.

Actors

Local building control authority actors (checker: blue zone in Figure 4):

- **Municipal architect:** (can also be a technician competent in urban regulations), oversees carrying out the ACC process, namely, the user of the microservice used to carry out the checking of the urban regulations, who interacts through its interface facilitating the IFC model. Is responsible for generating a technical report based on the result obtained from the checking, additionally to the BCF file, to indicate and explain to the client where the problem really is and how it should be solved.
- **Municipal lawyer**: this actor does not specifically intervene in the checking process of the urban regulations, oversees legal elements within the administrative procedure. Provides the legal framework to validate that the project complies with all the regulations that apply to it according to current legislation.
- **Alderman:** this actor does not specifically intervene in the checking process of the urban regulations; the role assumes the responsibility and provides the signature in the approval of the permit.
- **Other authorities:** such as associations of architects and the regional government land department whose responsibility is to check the sectoral regulations.

Building permit applicant actors (private client: yellow zone in Figure 4):

- **Main architect (can also be a technician competent in building works):** is directly responsible for creating the design in BIM of the building project, delivered in IFC format, which must include all the necessary details that allow its evaluation and checking.

- **Owner:** is responsible for commissioning the project. Although he/she does not specifically intervene in the checking process of the urban regulations, he/she assumes final responsibility for compliance with all regulations.

Building permit applicant actors (public client: blue zone on Figure 4):

- **Alderman:** assumes the responsibility for commissioning the project as its promoter in public buildings.
- **Mayor:** is responsible for approving the building project proposal.
- **Architect or designer** is directly responsible for creating the design in BIM of the building project, delivered in IFC format, which must include all the necessary details that allows its evaluation and checking.

Current stages involved in the urban checking process.

As indicated before, during the preliminary project application phase (Figure 4), the local building control authority checks if the project complies with urban regulations in two stages:

- **Pre-consultation stage:** in this phase, a very simple BIM model of the building project is delivered for its checking against basic requirements of urban regulations. In this phase, five main rules of urban regulations (urban use class, minimum plot, maximum occupancy, buildability, and maximum height) are considered that must be satisfied to avoid that the subsequent development of the project is based on invalid parameters that may imply its further design is in vain.
- **Application for Administrative License stage:** in this phase, a BIM model of the preliminary project is delivered, which must be checked against the complete list of urban regulation regulations.

The automation of compliance checking within urban regulations in a building project requires three previous steps: (1) identify the *geographical location* of the plot of the project for which the construction license is requested to be granted, (2) identify the urban '*usage class*' that affects the plot of the project to be built, and (3) selection of *urban parameters* to be used for the checking according to the 'use class'. This part of the process is performed through platforms and websites (e.g., https://geo.bcn.cat/bcnpic) that can be used by the local building control authorities to obtain plot information and the cadastre reference. Some of them are specific to some cities. With this information it is possible to obtain the urban use class necessary to identify the urban parameters to be checked.

Technologies involved in the compliance checking process involves BIM tools such as BIM authoring tools, BIM viewers, BIM model checkers, etc.

5.2.2 Digitization Scenarios/Storylines

The two scenarios to be digitized in the Spanish use case involve the two stages of the preliminary project application phase (Figure 4) where compliance of the preliminary project with urban regulations is checked. The digitalization process is based on automating the compliance checking through two versions of the project design provided as a BIM model in IFC format, one corresponding to the verification needs of each stage. These designs must be provided by the applicant. Figure 5 shows the high-level data flows in the digitization of such scenarios. The flowchart also includes the

checking part of the sectoral regulations carried out by collaborating entities of the administration, but which is not included in the use case.

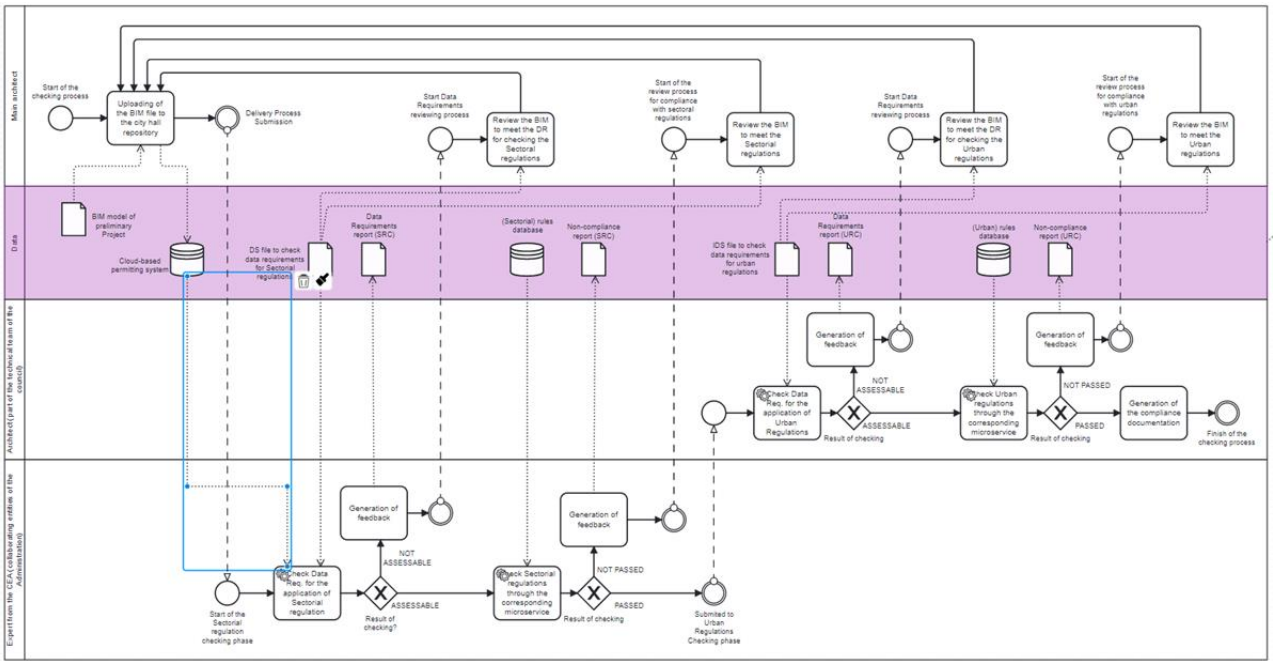


Figure 5. Flowchart depicting the tasks in the digitization of the two scenarios.

Storyline and related user requirements in the digitization scenarios for automated compliance checking within urban regulations

The user requirement analysis is conducted through the storyline method. The process is described below and then provided in tabular form (see Table 6) which provides more technical information.

Considering the entire preliminary project application phase, the process begins when an interested party in obtaining a building permit to build a construction - perhaps a promoter, owner, heir, or legal representative - requests to initiate the procedures for obtaining the building permit to the city hall. Previously, the interested party has downloaded all the legal regulations from the city hall's website (documents in PDF format), including the planning regulations and a map of the urban use class for each area of the municipality with the corresponding planning parameters that affect each one.

With this information, the interested party develops a basic BIM design of its construction project. This model is delivered to the permitting platform (in IFC format) which alerts the city council technician that a delivery file has been made that needs to be checked. An additional option can be that the interested party can have direct access to the service to be able to check his design for himself as many times as necessary, without human intervention, before delivering it. The service could give the interested party information on: (1) If the model is suitable for checking by the service (including all the required data), and (2) if in compliance with point 1, it complies with the urban planning requirements depending on the checking level required (basic or full). Therefore, since there are two moments where the design is evaluated (through the delivery of a basic and preliminary BIM model), the service must consider the necessary urban planning requirements to be met in each case.

Once delivered, the permitting platform notifies the City Council technician that a delivery has been made that needs to be validated. To do this, the technician has an interface that allows them to: (1) select and load the IFC file delivered by the interested party, (2) select the urban use class that affects the project from a list available, and (3) indicate the type of check (basic or full). An intermediate system is responsible for making the necessary translation to generalize the check requests towards the microservice.

Once the check has been carried out, the service will provide the result based on a self-generated report that the technician can complete with their knowledge and experience.

Table 6. The user requirements from the information management point of view.

Stakeholder	Task	User requirements
Building permit applicant (Architect)	Produce a design in BIM in accordance with: (1) the needs and conditions of the project provided by owners / promoters, and (2) that complies with current building codes and regulations.	Competence in BIM modelling. Need for a guidance document on how to model the design according to the needs of the permitting process.
	Export of a BIM model in IFC format from a BIM authoring tool according to the needs described in an IDS file.	Need for a guidance document on how to check IFC models against IDS files.
	Load an IFC file into the permitting platform.	Need for a document that described the uploading and acceptance procedure through the permitting platform.
Permitting platform service	Store the IFC file uploaded by the user.	Ensure that the process has been carried out correctly, informing the user in both cases if it has been carried out correctly or not and why.
Building permit applicant (Architect)	Upload and validate the IFC model using the BIM model checking service.	Select the regulation and the urban use class. Ensure that the chosen regulation is correct and that the urban use class is the corresponding one for the project. Provide a report on the result of the checking indicating if it has been passed, and if not, indicate the rules that have not been satisfied with the corresponding explanations / indications.
	Receive the result of the checking from the service and interpret the results. This task involves downloading a PDF document detailing the results. And if the checking is not passed, the user must also download a BCF file.	Receive a report with the results of the check with all the information necessary to understand, in case the design does not comply with one or more rules, why and how the redesign should be carried out to ensure compliance with all the rules. Competence to understand design inconsistencies in terms of regulatory compliance and to know how to provide a suitable alternative to comply with all the rules.

		Competence to manage BCF files and how to apply its indications in the BIM model within the BIM authoring tool.

Description of the process

- In both phases, two types of checking are involved: (1) verifying that the model has the required data to guarantee its correct checking, and (2) the actual checking of the rules of the regulations. For the first case, a file that contains the data requirements is used where the requirements are described in the IDS standard.
- In both phases, a BIM model is delivered defined in the IFC standard, although it is not decided if it will be in the 2x4 or 4.X version, or compatible for both.
- In the case of noncompliance, the system generates a feedback report, indicating what is the part of the design that does not meet the requirements and why, depending on the type of checking (data requirements or regulations). In the case of checking the regulations, the affected regulations are also included in the report.
- The reports should guide building designers in making the necessary adjustments to ensure compliance with data requirements and urban regulations.

New technologies involved to automate the compliance checking process

- **Compliance checking service (*microservice*):** a service used to check urban regulations given a BIM model and contextual information.
- **Platforms:** permitting platform service, where the microservice is hosted, among others microservices that can be useful / necessary.
- **Databases:** Ruleset database where the rules are stored and accessed by the microservice to retrieve the ones it needs; Contextual database which provides all the necessary data context to be able to translate the checking needs to the exact rules to be applied on the BIM model by the microservice.

5.2.3 Visionary To-be Process

Figure 6 illustrates the Spanish to-be process on a higher level. The process includes the following actors, platforms, and tools: building permit applicant, building control authority, building control authority, cloud-based permitting service, data sources, and the compliance checking service(s). The expectation is that in an ideal scenario any type of building project can be checked automatically.

In a visionary to-be process, applicants should be able to check the model on their own as many times as they wish through the checking service, each time obtaining feedback, so they figure out why the design is not compliant and how to fix it. This also includes aspects regarding the construction method and so on. This process should be dynamic regardless of any administrative procedure until the applicant makes the final submission.

User requirements from the actors' point of view

Building permit applicant needs to be able to:

- Upload an IFC file to the permitting platform.
- Request checking of whether the uploaded model meets the data requirements for a specific regulation (in this case, urban regulation).
- Request checking of whether the uploaded model meets with urban regulations.
- Informed users when a request for checking is finished.
- View the errors from the checking by downloading the corresponding report (PDF)
- Provide a BCF file in case of error being identified.

Cloud-based permitting service needs to be able to:

- Authenticate the applicant as a valid user of the service.
- Retrieve the IFC file uploaded by the applicant.
- Store the IFC file to be checked in a cloud-service environment.
- Obtain the regulation "ID" and the "type of checking" (Data Requirement or regulation compliance checking) from the applicant by selecting the corresponding options.
- Receive the results and provide them to the local building authority.
- Exchange data between databases and the compliance checking service.

Building control authority needs to be able to:

- View the results of the compliance checking.
- Be able to carry out a visual inspection of the BIM model in IFC format in case of doubt.
- Provide the granting of the administrative license (in case of private projects).
- Provide the final approval of the works (in case of public projects).

The compliance checking service(s) needs to be able to:

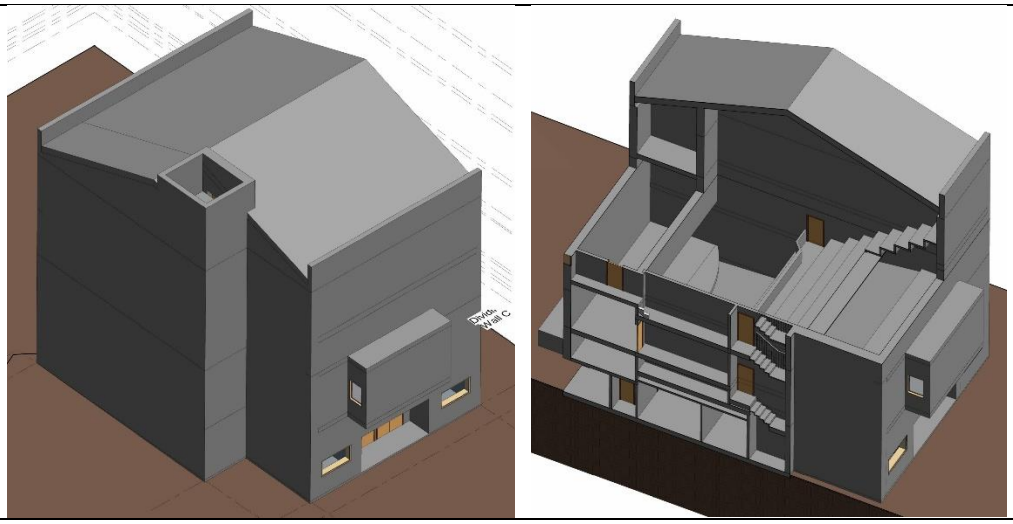
- Be notified about when to start a checking process and what type (data requirement or regulation compliance checking).
- Use the regulation ID send by the cloud-based permitting service to retrieve the rules to be applied in the checking from the ruleset database.
- Run the selected checking process (data requirement or regulation compliance checking).
- Generate and store a report from the checking result.
- Generate and store a BCF file from the checking result in case there are errors.
- Inform the cloud-based permitting service that the checking process is complete.

5.2.4 Spanish Demo-specific Deployments

Table 7 and Table 8 provide the basic information on the specific deployments of the Spanish demonstration for the use case of Automated Checking of Compliance with Urban Regulations.

Table 7. Spanish demo-specific deployments: Renovation of a cultural centre.

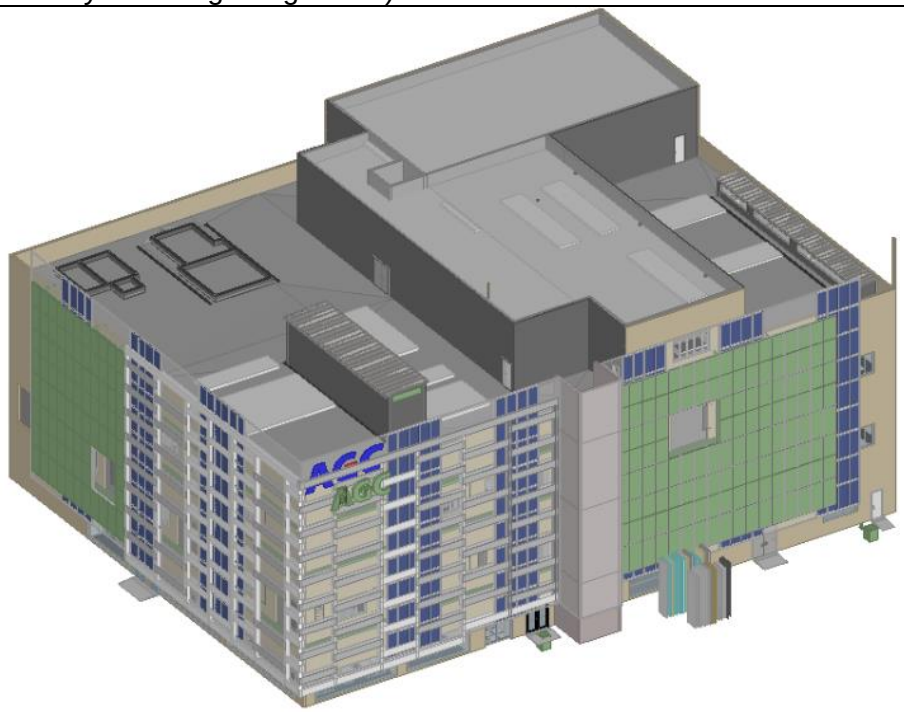
Demo Name	Spanish demo 1: Renovation of a cultural centre

Image	
Building owner	Malgrat de Mar City Hall
Demo Aims	Perform an automated compliance checking with the urban regulations of a public work project using a BIM file in IFC format as a part of the process to obtain the building permit.
Demo Description	In this demonstration, a building permit applicant (Architect) applies a BIM model in IFC format with the proposal of a design for the renovation project of a cultural centre in which the model will be checked for compliance with urban regulations. An ACC service will be used.

Stakeholders	• Main architect
	• BIM designer
	• Local building control authority:
	  ○ Municipal architect
	  ○ Municipal lawyer
	  ○ Alderman
	• ACCORD partners: FUNITEC, ITeC, AMM, Ontotext, Solibri, OGC

Geographic Location	Carrer del Carme, 26, 08380, Malgrat de Mar, Barcelona, Catalonia, Spain
Building Type	Public building, cultural building
Data Formats	IFC
Regulations Targeted	Municipal urban planning plan (Plà d'Ordenació Urbanística Municipal, POUM, in Catalan).
Outline Plan for the Demo Use Cases	1. Digitization of urban regulations through the rule formalization tool. 2. Identify the data requirements that the IFC model must meet so that each formalized rule can be applied correctly. 3. Generation of the data requirements to make the rules applicable to the IFC model to be checked. 4. Translation of the data requirements to be satisfied by the IFC model to the IDS format. 5. Translation of the data requirements to be satisfied by the IFC model to the current IFC model to make it valid for the checking. 6. Develop API integration of urban regulation checking tool. 7. Develop a guideline for authorities to manage use case specific permit process.

Table 8. Spanish demo-specific deployments: Expansion of the production plant of the company AGC (Formerly Boehringer Ingelheim).

Demo Name	Spanish demo 2: Expansion of the production plant of the company AGC (Formerly Boehringer Ingelheim)
Photo	
Building owner	AGC Company
Demo Aims	Perform an automated compliance checking with the urban regulations of a private work project using a BIM file in IFC format as a part of the process to obtain the building permit.
Demo Description	The building permit applicant (Architect) creates and submits a BIM model with the proposal of a project design of the expansion of the production plant of the company AGC (Formerly Boehringer Ingelheim).

Stakeholders	• Main architect
	• BIM coordinator
	• Local building control authority:
	  ○ Municipal architect
	  ○ Municipal lawyer
	  ○ Alderman
	• ACCORD partners: FUNITEC, ITeC, AMM, Ontotext, Solibri? OGC?

Geographic Location	Camí de la Pomereda, 13, 08380, Malgrat de Mar, Barcelona, Catalonia, Spain
Building Type	Private building, Factory
Data Formats	IFC
Regulations Targeted	Municipal urban planning plan (Plà d'Ordenació Urbanística Municipal, POUM, in Catalan).
Outline Plan for the Demo Use Cases	1. Digitization of urban regulations through the rule formalization tool. 2. Identify the data requirements that the IFC model must meet so that each formalized rule can be applied correctly.

	3. Generation of the data requirements to make the rules applicable to the IFC model to be checked. 4. Translation of the data requirements to be satisfied by the IFC model to the IDS format. 5. Translation of the data requirements to be satisfied by the IFC model to the current IFC model to make it valid for the checking. 6. Develop API integration of urban regulation checking tool. 7. Develop a guideline for authorities to manage use case specific permit process.

5.3 User Requirements for the UK Demo's Use Cases

5.3.1 Analysis of Existing Process Models

The UK demonstration is focusing on a use case in which automated compliance checking is employed to verify the structural integrity of steel modular house components. The first step in drafting user requirements for this use case is to identify the key stakeholders involved in the compliance process regarding the structural integrity of steel modular houses. Then an analysis of the existing modular house structural design control process was performed. This has identified disruption potential by applying ACC. Finally, a use case of ACC for the Structural Design of Modular Houses is proposed. The remains of the text in this section introduces the UK existing process modelling in more detail.

Actors

The following are the actors involved in the structural design control process for the proposed use case, their roles in building control related to structural design, and the potential advantages they may derive from ACC:

Owner (or Client): As the project initiator, the owner or client appoints designers and builders and is the ultimate beneficiary of ACC, for example, through reduced time and cost in the design check process.

Modular House Builder: This actor builds houses using proprietary modular systems, typically approved by insurers or warranty providers. ACC can assist the modular house builder in obtaining system approval concerning the structural elements of the units as well as getting building control approval.

Architect (Design Lead): The architect often serves as the design lead in a project, coordinating the work of other design consultants for tasks like planning permits and building control applications.

Structural Designer (Engineer): This role involves designing the building structure and providing necessary structural calculations for building control application. ACC can help the engineer self-check the required information and the compliance of alternative design models at various levels – the whole building, modular, and component.

Insurance and Warranty Provider: This actor underwrites the risks of construction. ACC can assist them in checking the structural integrity of the modular system.

Local Authority: They undertake plan checking, inspections, enforce building regulations, and issue completion certificates. ACC can automate some of their checks related to building plans and structural calculations for compliance with current building regulations.

Approved Inspector: Licensed private-sector companies perform plan checking, inspections, and issue completion certificates. They can potentially benefit from ACC similarly to the local authority.

Current Modular House Structural Design Control Process and disruption potential by ACC

The existing modular house structural design control process, as depicted in Figure 6, commences with the owner or client deciding to develop a site for house construction. The choice of the lead design consultant or contractor largely depends on the client's knowledge about development and construction, and their priorities. In the context of modular house construction, the client may either engage a designer specialising in modular house design or approach a modular contractor for design development, based on their need for design control. The design development process varies depending on budget, timeline, and the need for a specific modular house design. The process of obtaining approval for modular systems is vital as clients are typically unwilling to invest in housing developments that struggle to obtain insurance. Modular builders work with various designers to prepare a system approval application, which insurance and warranty providers then evaluate for compliance with building regulations and other requirements.

5.3.2 Digitization Scenarios/Storylines

The primary digitisation scenarios to be explored in the UK pilot are:

Verification of design information: This will involve the pre-checking of submitted IFC models. IFC models should be checked that they are: (a) correctly formed IFC models and (b) contain the required information to achieve checking against Eurocode regulations.

Automated checking of compliance against Eurocode regulations: This will include the validation of the submitted IFC model against selected Eurocode regulations automatically, involving the use of Finite Element Analysis tools.

5.3.3 Visionary To-be Process

The visionary process for the UK pilot mirrors the conventional approval process for modular systems and building control in terms of document requirements and applied regulations for structural integrity review. This use case aggregates the approval groups, which could be insurance and warranty providers, local authorities, or private inspectors, into a single category known as the approval body.

This use case begins with the presence of a BIM model for a modular house system. The model needs to be in IFC format and is then evaluated in two stages, 1) using IDS to validate model information and 2) using computerised rules extracted from the relevant building regulation to ensure the structural integrity standards are met. In the case of non-compliance, the ACC system generates a detailed report, highlighting areas of the design that do not meet the necessary requirements. This report can guide the structural designer in making necessary revisions to the design, ensuring compliance with all relevant standards.

Upon achieving a compliant design, the approval body reviews the ACC reports. This step streamlines the approval process as the approval body can trust the ACC system's thorough and

objective verification process. The use of ACC thus reduces the time required for manual verification and potentially accelerates the project timeline.

This use case, depicted in Figure 6, is outlined using the Business Process Model and Notation (BPMN) 2.0 convention, providing a graphical representation of the process that makes it easier to understand the workflow. From an analysis of this desired to-be process, the following user requirements are elicited:

1. The ability to perform model verification - checking that it complies with relevant modelling standards i.e., IFC.
2. The ability to perform model validation – checking that it contains the required information to perform compliance checking.
3. The ability to provide reporting of results of model verification and validation.
4. The ability to perform compliance checking that require the use of third-party tools such as finite element analysis.
5. The ability to provide reporting of outcomes of compliance checking processes.
6. The ability to share compliance results with other relevant users.

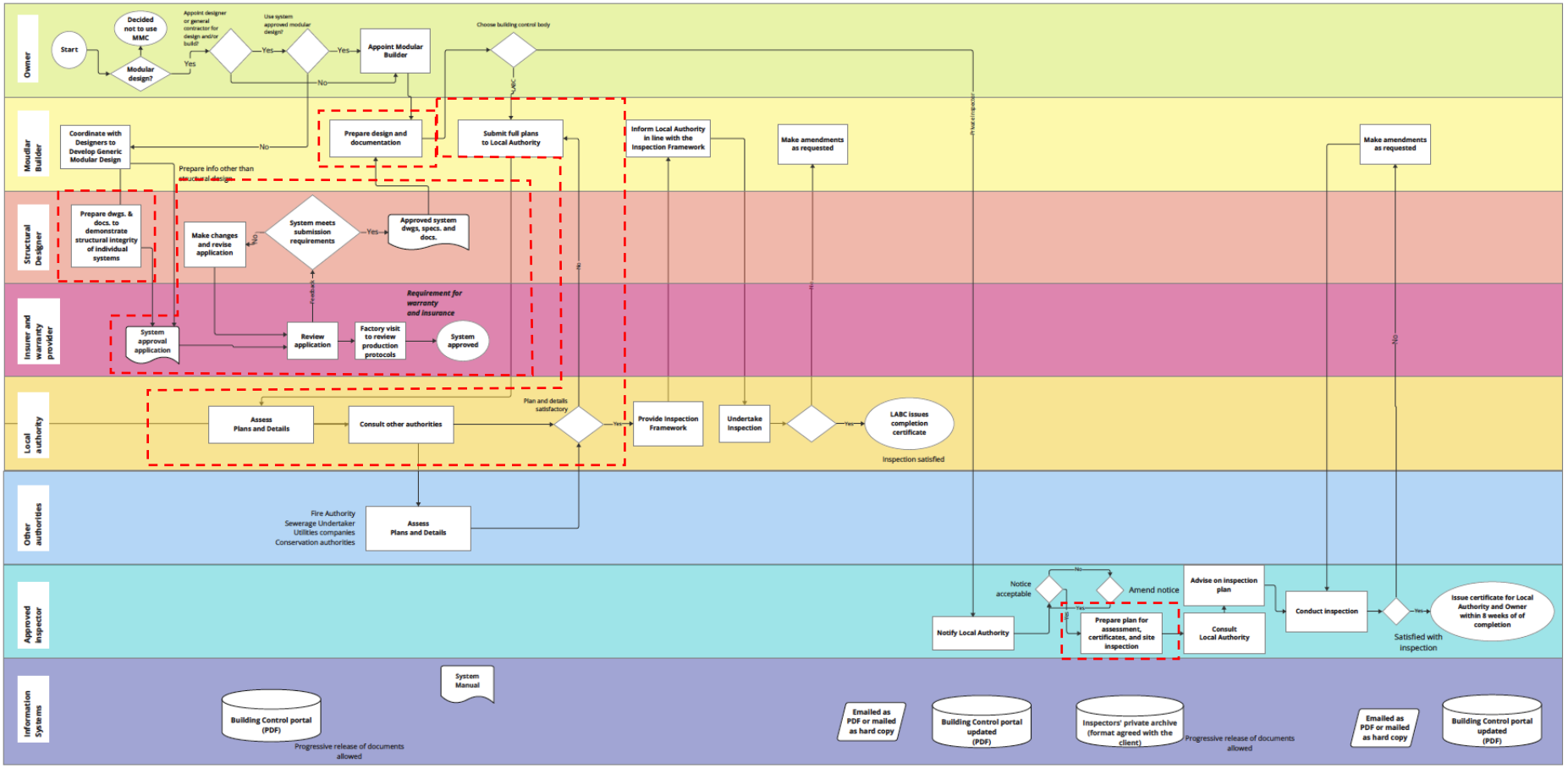


Figure 6. Current (as-is) modular house structural design control process (red dotted lines shows the potential for disruptions).

5.3.4 UK Demo-specific Deployments

Table 9 shows a summary specification of the UK demonstration.

Table 9. UK specific demonstration deployment.

Demo Name	UK Pilot Steel Modular House.
Photo	
Building owner	Hadley Group
Demo Aims	• Perform automatic validation of submitted design information. • Perform compliance checking of models of light weight steel modular houses against Eurocode Regulation.
Demo Description	Automate the compliance checking of structural components in steel modular houses. The demonstration case will draw on the combination of BIM-based inputs and Finite Element Analysis (FEA). High level compliance processes will be followed while the analysis execution will be done on an open-source FEA software and the reporting on a web-based front end.
Stakeholders	Birmingham City University– Demo Leader/Coordinator Aether Engineering – Architect Demo Implementor. Hadley Engineering – Model/Demo Provider
Location	Burnley, UK
Building Type	Domestic Property

Data Formats	IFC
Regulations Targeted	EN 1993-1-1
Outline Plan for the Demo Use Cases	1. Examine model data provided and identify missing data needed for automating structural integrity compliance of light weight steel modular house construction. 2. Prepare IDS requirements. 3. Digitize Eurocode regulations, testing feasibility of formalization tool. 4. Develop API integration of structural calculation tools. 5. Assess against following KPIs. a. Time saving to get from final design to permit, b. Saving of several conversion/exports/scans to different file formats, c. Reducing person-hours to verify the submitted documentation, d. Saving time and number of persons needed for the final physical inspection.

5.4 User Requirements for the Finnish Demo's Use Cases

5.4.1 Analysis of Existing Process Models

The Finnish demonstration will focus on four use cases: 1) Automating the retrieval of the real estate building and spatial information from an IFC file, 2) Automating the compliance checking of some parts of the accessibility regulation, 3) Automating the compliance checking of operational safety, and 4) Automating the compliance checking of building's carbon dioxide equivalent.

Currently, the information related to the first use case is manually fed into an online form when the permit applicant uses Cloudpermit's permitting service. During the application submission phase, the local building control application secretary checks whether all the required information exists in the application (Figure 7).

In the future, the idea is that the permit applicant (usually the architect) inputs the real estate building and spatial information straight to the native BIM model and inputs an IFC-file to the permitting system. Then, Cloudpermit's permitting service would export the information from the IFC model. However, there are also services that allow adding information to an IFC-file, which can also be an option if adding the information to the native model is not possible.

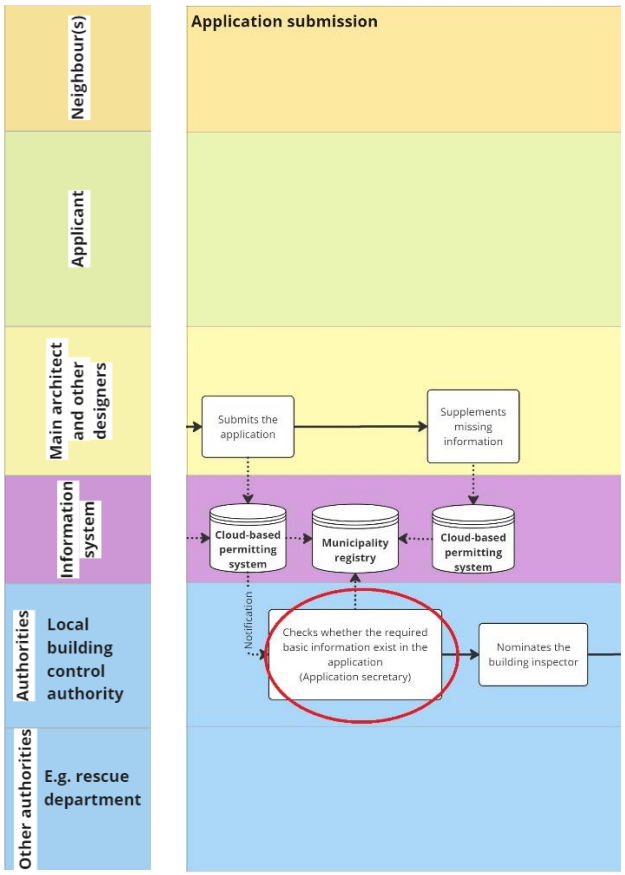


Figure 7. Checking the required basic information in the application during the application submission phase.

The other three uses are related to the application inspection phase of the Finnish building permit process (Figure 8).

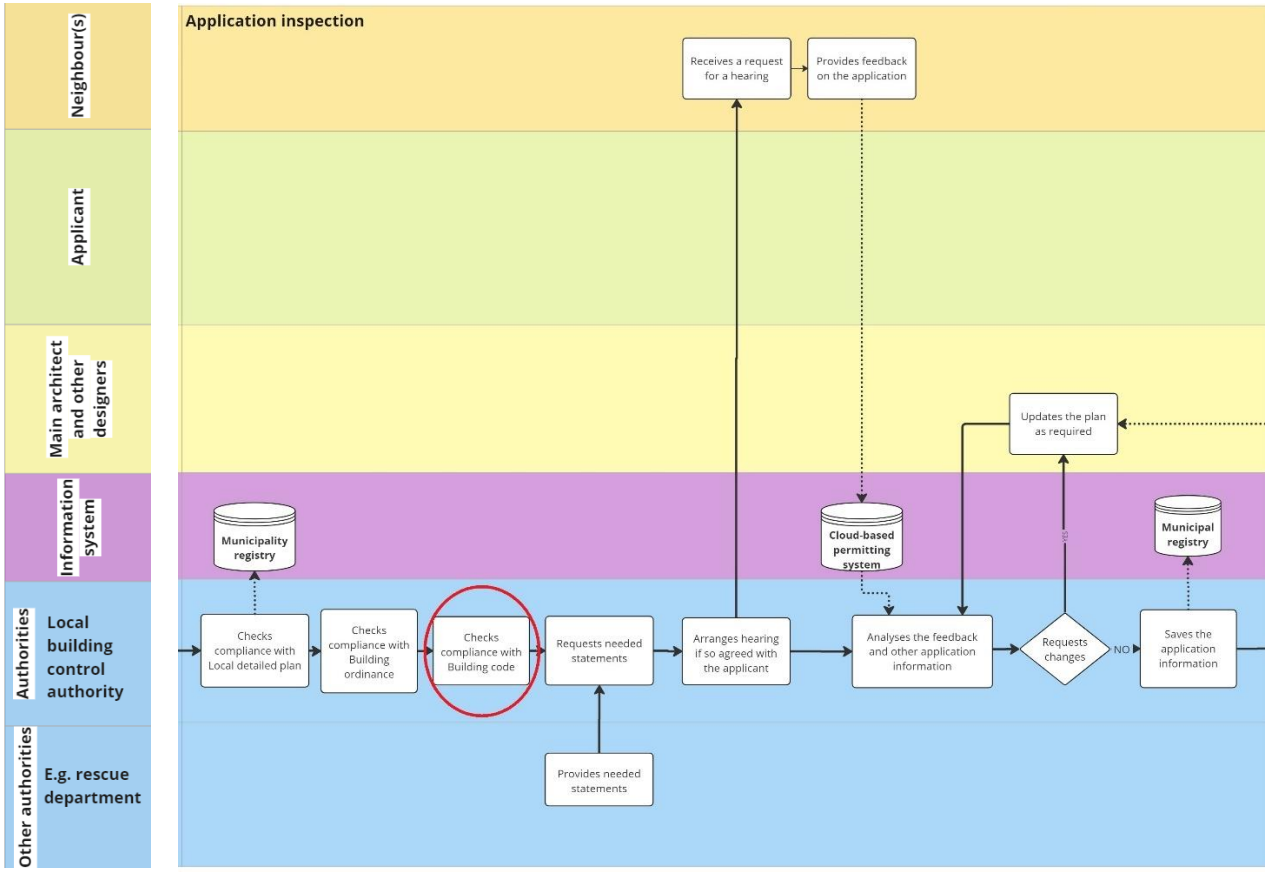


Figure 8. Compliance checking against the building code in the application inspection phase of the Finnish as-is building permit process.

Actors

The following are the actors involved in the use cases, their roles, and the potential advantages they may derive from automated compliance checking (ACC):

The building permit applicant (usually the owner of the land plot): As the project initiator, the permit applicant appoints designers and builders and is the ultimate beneficiary of ACC, for example, through reduced time and cost in the design check process.

Main architect (and other designers): The architect often serves as the design lead in a project, coordinating the work of other design consultants for tasks like planning permits and building control applications. The architect benefits from a shorter building permit process.

Local building control authority: They undertake plan checking, inspections, enforce building regulations, and issue completion certificates. ACC can automate some of their checks related to building plans for compliance with the current building code.

Other authorities: For example, the rescue department may provide its initial guidance and requirements. Also, other authorities may provide initial statements on zoning and infrastructure planning. These authorities benefit from more accurate data when the application is in IFC-format.

Neighbour(s): 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.

Current application inspection phase and disruption potential by ACC

During the current application inspection phase, the local building control authority checks the permit application's compliance with the local detailed plan. The authority also checks compliance with building ordinance and building codes. The current manual compliance checking does not cover all details, and it is based on sampling in line with the municipality's practice. In this phase, 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 the request for a hearing, which lasts two weeks. Then, the authorities may request the applicant to update the plan. Finally, the sends the application information to the municipal registry.

The disruption potential of ACC is three-fold: 1) to reduce the permit applicant' time needed for the building permit process, 2) to reduce authorities' amount of manual work in the process, and 3) to have fewer errors in the process.

Some current gaps preventing the automation of compliance checks were identified. For example, currently, many building permit applicants only submit pdf documents, but starting at the beginning of the year 2025, IFC files will need to be submitted. Another hindrance to automation is that many building permit authorities lack a compliance-checking tool.

5.4.2 Digitization Scenarios/Storylines

Figure 9 depicts the high-level data flows in the digitization scenario of the Finnish demonstration's four use cases:

1. Extracting the real estate building and spatial information from the IFC-file
2. Code compliance checking of accessibility.
3. Code compliance checking of operational safety.
4. Code compliance checking of environmental target values (building LCA)

The following technologies will be used in the digitization scenario:

- BIM tools: authoring tools, BIM viewers, model checkers
- Rule formalisation tool: NLP service, which will be developed in ACCORD.
- Code compliance checking tool by Solibri.
- Platforms: Cloudpermit's cloud-based building permitting service

The BIM authoring tools, the permitting service and model checker are using different databases:

- IDS Rulesets
- National Cadastre
- National Building regulations
- National Land use and zoning database
- Building code
- Compliance rulesets
- Local Building by-laws
- Archive systems

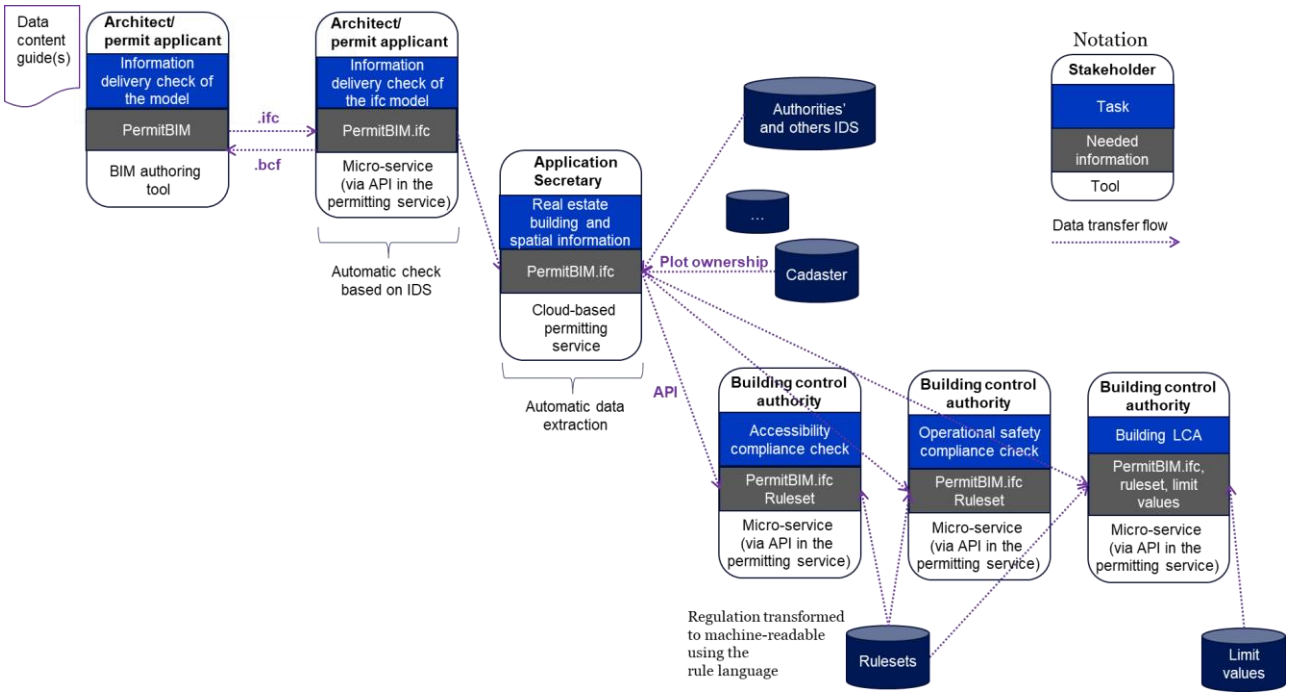


Figure 9. Compliance checking in the four use cases of the Finnish demonstration.

Based on the high-level data flows, two process flowcharts were created to depict the tasks of each stakeholder (Figure 10 and Figure 11).

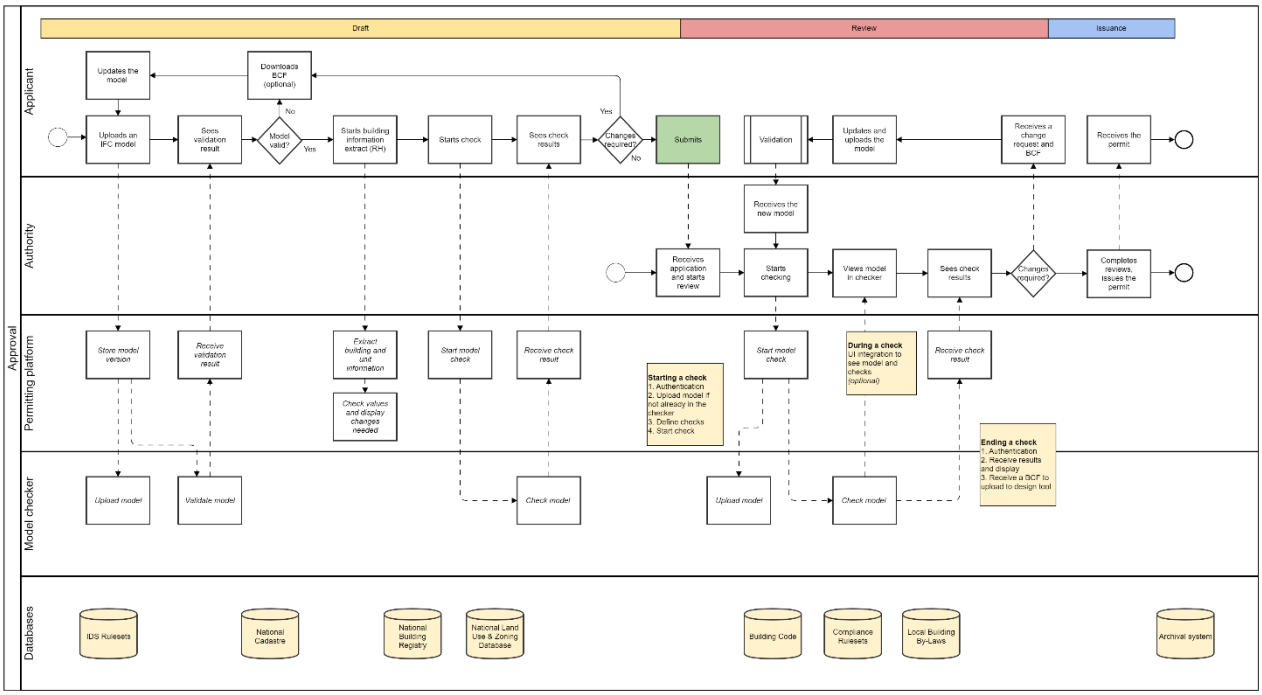


Figure 10. Flowchart depicting the tasks in the digitization scenario.

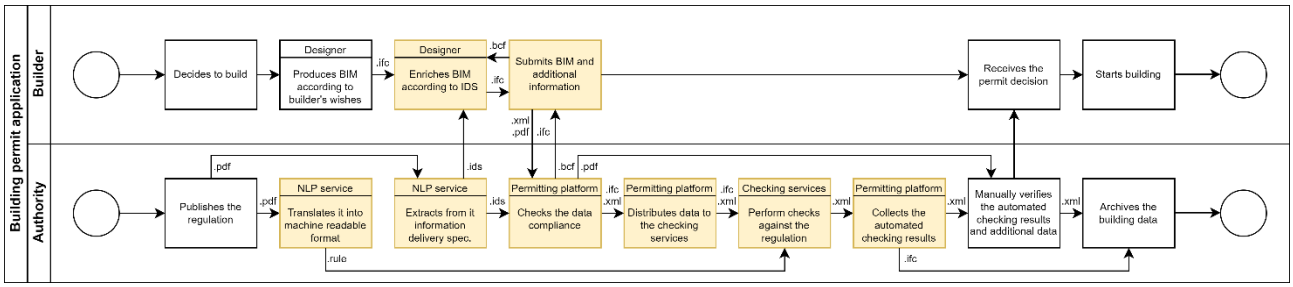


Figure 11. Dataflows in the digitization scenario.

Storyline and related user requirements in the digitization scenario of the application inspection

The user requirement analysis is conducted with the help of the storyline method. Table 10 describes the digitization storyline of the application inspection phase. Before this phase, several other process phases have been passed. In the future, the authority may publish a set of regulations with machine-readable rules for the automated building permitting process. The main stakeholders in the storyline are the building permit application (architect) and the permitting service that is connected to the model-checking tool through and API.

BIM models used in the process are partial models extracted from a bigger discipline BIM model (for this document):

- designBIM - as designed model with LOIN (level of information need)[24] for the design process at the phase of building permitting.

Partial models are specified as:

- preliminary permitBIM - enriched BIM for preliminary discussions
- permitBIM - enriched BIM for building permitting according to guideline.
- checkBIM - partial model of the permitBIM for a specific automated building code checking
- analysingBIM - partial model of the designBIM or permit BIM for ACC

All partial BIM models should have a specific BIM guideline (data content, data parameters, LOINs, practices, process map of their usage) to support integrated modelling, and an MVD- or IDS-specification for supporting interoperability.

Table 10. The user requirements from the information management point of view.

Stakeholder	Task	User requirements
Applicant (architect)	Produce BIM according to builders' wish and regulation	Competence to model designBIM. Need for a BIM guideline.
	Enrich BIM according to IDS	Competence to model permitBIM. Need for a BIM guideline.
	Extract an IFC model	Competence to model permitBIM. Need for an IFC-file manual from the application vendor.

[24] EN 17412-1:2020 Building Information Modelling - Level of Information Need - Part 1: Concepts and principles

	Upload an IFC model	Secure that all relevant data is transferred.
Permitting service	Store model version	Secure that the activity has succeeded and inform the user that the activity has succeeded.
Applicant	Upload and technically validate the model using model checker tool	Choose the validation rules for permitBIM. Secure that the validation rules are the right ones. Receive a notification that the validation has succeeded.
	Receive validation result in the permitting system and interpret the results.	Receive validation results in a visually clear way. Competence to distinguish between real errors from non-important errors. Need for a User guideline/ User manual.
	Make decision if the model is technically valid. • if no: downloads BSF and updates the model. • if yes: continues to the next task	Ability to control the activity steps while using the tool.
	Start checking the real estate building and spatial information (use case 1)	Ability to control the activity steps while using the tool.
Permitting service	Extract the real estate building and spatial information from the IFC-file	Secure that the activity succeeds and inform the user if the activity has succeeded.
Applicant	Extract building and unit information using the permitting platform	Secure that the activity has succeeded and receive a notification that the activity has succeeded.
	Check values and display changes needed	Receive validation results in a visually clear way. Competence to validate the information rightness.
	Start model checks	Ability to control the activity steps while using tool or service of the permitting platform. Ability to choose the relevant building code validation rules for the checks. Check that the building code validation rules are the right ones for the project type. Ability to see the IFC file (extracted from permitBIM).
	Check compliance checking results (use cases 2-4)	Ability to run the check: permitBIM towards Building code (and project KPIs). ACCC of the regulations of accessibility (use-case 2). ACCC of the regulation for operational safety (use-case 3). ACCC of the regulation for low carbon footprint/ environmental targets (use-case 4). Ability to run the check: the permitBIM towards the building ordinance municipality/city. Ability to run checks of any specific individual regulation on the topics.
Permitting service	Receive checking result from the compliance checking service.	Secure that checking permitBIM (IFC-file) towards Building code has succeeded. Receive a notification that the activity has succeeded. Receive validation results in a visually clear way.
Applicant	See the check results.	Ability to see the checking report in user friendly way. Ability to understand symbols used. Competence to distinguish between real errors from no important errors. Need for a User guideline/manual.
	Decision if changes are needed.	Ability to control the activity steps while using the tool

	• if yes: downloads bsf, updates the model. • if no: submit	
	Submit BIM and additional information to permitting platform	Capability to submit all needed files. Technical guideline for the submission process. Secure that information is in right format and files named as requested. Receive a notification that the submission has succeeded.
Authority	Receive application and start the review in the permitting service	Need of securing authentication. Ability to upload model if not already in the checking service.
	Select checking options.	Ability to define the checks. Ability to choose the relevant building code validation rules for the checks. Secure that the building code validation rules are the right ones for the project type.
	Start the model checking activity in the permitting service	Ability to start checks technically. Ability to control the activity steps while using tool or service of the permitting platform.
	Upload the model to compliance checking service and check it	Ability to upload model for the defined checks. Ability to read the model specification document (written by the owner of the permitBIM). Check the model quality. Run the technical validation for ACCC.
	View the model in the service	Ability to see the IFC file (extracted from permitBIM). Ability to control the activity steps while using tool or service of the permitting platform.
	Perform checks against the regulation	Ability to run the check: permitBIM towards Building code (and project KPIs). ACCC of the regulations of accessibility (use-case 2). ACCC of the regulation for operational safety (use-case 3). ACCC of the regulation for low carbon footprint (use-case 4). Ability to run the check: the permitBIM towards the building ordinance.
	View the checking results	Receive notification that the checking permitBIM (IFC-file) towards Building code has succeeded. Receive validation results in a visually clear way. Ability to see the model and checks visually integrated in a geometrical model view. Competence to evaluate the overall quality of the design.
	Make decision if changes are required	Ability to make notes and comments in the checker tool and locate the note in the model.
	Receive the check results in the permitting service	Collect other checking results. Collect the automated checking results.
	Manually verify the automated checking results and additional data.	Ability to save versions. Ability to collects the data for checking report with all results in an effective way. Ability to take still-picture from the model to clarify issues. Ability to control the collecting of checking results.
	Complete the review	Ability to close the review in the permitting platform. Ability to upload the permitting documents in another system.
	Issue the permit	Competence to define and write the permitting conditions.

	Send permitting decision to the applicant	Need to secure authentication. Ability to receive all results and display them. Ability to send a. bcf of the model.
Applicant	Receive the permit decision	Ability to see the permitting decision. Ability to receive a. bcf to upload a to design tool.
Authority	Archive the building data	Ability to upload relevant files to the Archive systems following the system ordinance. Guideline needed.

5.4.3 Visionary To-Be Process

Figure 12 illustrates the Finnish visionary to-be process on a higher level. The four use cases are marked in red in the figure. The process includes the following actors: building permit applicant, cloud-based permitting service, building control authority, external (to the permitting service and compliance checking service) data sources, and the compliance checking service(s).

User requirements from the actors' point of view

Building permit applicant needs to be able to

- upload an IFC-file (extracted from permitBIM) to the permitting service.
- view model validation results
- view errors (in a tool, using BCF)
- extract real estate, building and spatial information from IFC-file (based on the permitBIM) and review these results.
- submit the application.
- receive change request (in BCF)
- update the permitBIM and a new IFC-file.
- receive and view the building permit decision.

Cloud-based permitting service needs to be able to

- store the IFC-file (extracted applicants permit BIM model)
- receive the validation results.
- extract building and spatial information from the IFC-file and downloads necessary real estate information from databases (national cadastre and national building registry)
- authenticate users and calls for the chosen checks.
- receive the results and provide them to the authority.
- exchange data between databases
    - Databases identified for the use-cases in the Finnish demonstrations are:
    - Rulesets in IDS format
    - National Cadastre
    - National Building regulations
    - National Land use and zoning database
    - Building code
    - Compliance rulesets
    - Local Building by-laws
    - Archive systems

Building control authority needs to be able to

- receive the real estate, building and spatial information checking results.
- receive the building permit application.
- choose the compliance checks to be done to the permit application.
- view the results of the compliance checks.
- send application and model change requests to the permit applicant.
- issue the permit and archive the IFC-file it in IFC4 format.

The compliance checking service(s) needs to be able to

- upload the IFC-file (based on the permitBIM)
- validate the IFC-file.
- check the real estate, building and spatial information correctness.
- upload the updated IFC model.
- check the accessibility, operational safety and building CO2 compliance.
    - upload relevant rules from the rules database.

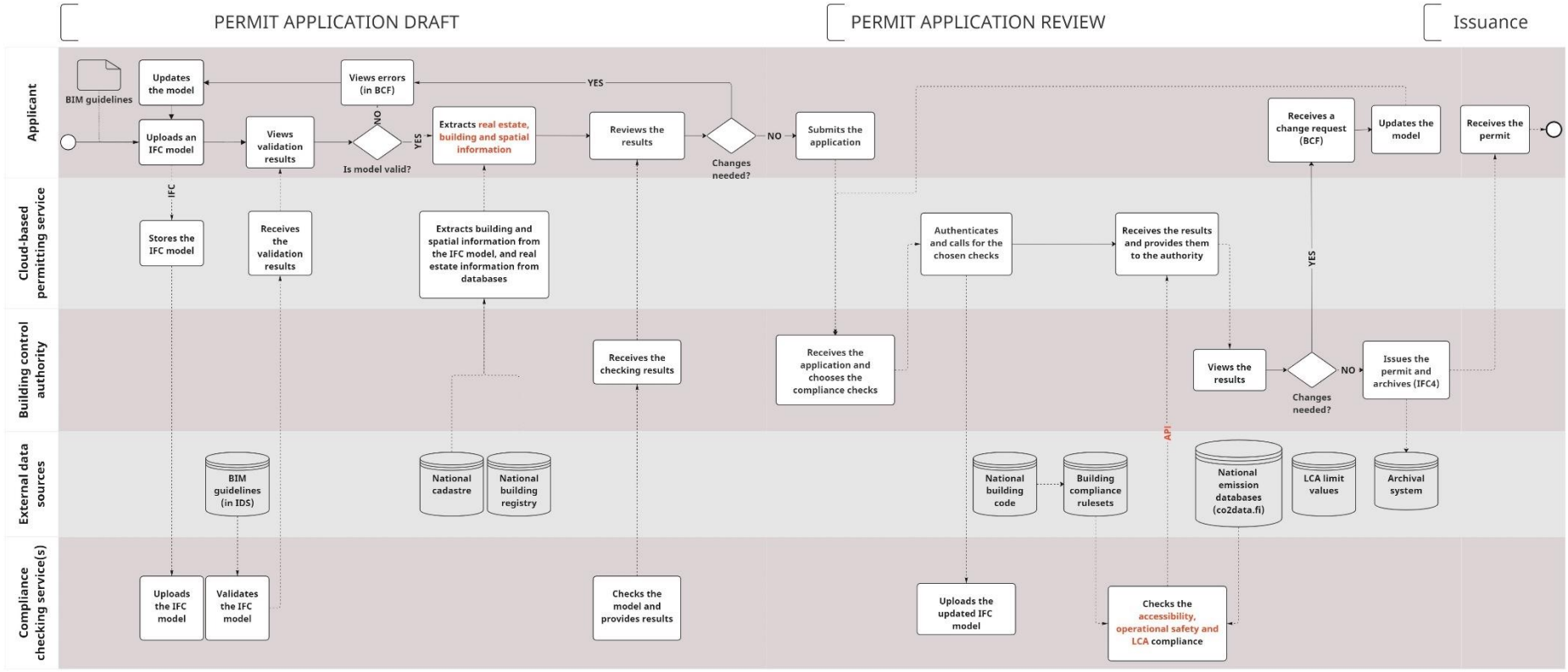
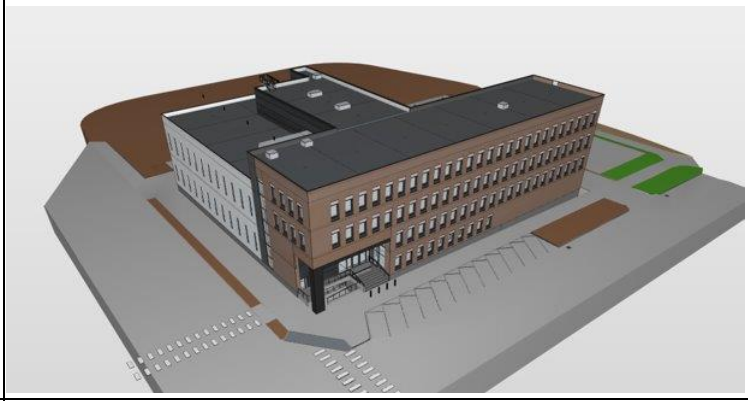


Figure 12. Visionary to-be process, focusing on the Finnish use cases.

5.4.4 Finnish Demo-specific Deployments

Table 11 shortly describes the Finnish demo-specific deployments.

Table 11. Finnish demo-specific deployments.

Demo Name	Finnish demo: new courthouse
Photo	 
Building owner	Senate Properties[25]
Demo Aims	• Perform automatic compliance checking of selected regulations of IFC file submitted for building permitting. • Read automatically required building information from the submitted IFC file.
Demo Description	Automate the compliance checking of selected geometry-based requirements of accessibility and operational safety. Develop and test a method for carbon footprint evaluation of the building in permitting according to coming regulation. Read basic building data from IFC that are required in a national building registry.
Stakeholders	• Senate Properties' project manager and BIM/sustainability expert • Possible project management consultant • Local building control authority • Main architect • BIM modelling, consultations with authorities • BIM coordinator • ACCORD partners: VTT, SOL and CP

[25] a Finnish state-owned enterprise managing a major part of the real estate assets owned by the Republic of Finland, https://www.senaatti.fi/en/

Location	Pori, Finland
Building Type	New courthouse, public building
Data Formats	IFC
Regulations Targeted	• Use case 1: 2010/128 Valtioneuvoston asetus väestötieto-järjestelmästä (Government Decree on the Population Information System) • Use case 2: 241/2017 Government Decree on Accessibility of building. • Use case 3: Draft: National decree of Climate declaration. • Use case 4: 1007/2017 Decree of the Ministry of the Environment on the operational safety of buildings
Outline Plan for the Demo Use Cases	• Compliance checking with existing and to-be developed tools and methods (Solibri, Cloudpermit) • IFC-file is enriched with needed data with Simplebim software. • The demo will follow the national IFC definitions developed in a national Rava3Pro project. • Solibri will create the needed native Solibri Model Checker rulesets. • Cloudpermit develops IFC handling in its building permit service (Lupapiste) and data retrieval from an IFC file. • Solibri and Cloudpermit will specify the API between their services to exchange needed IFC data. • ACCORD methods and tools will be applied. • Guideline for the architect to enrich the designBIM (either IFC file or native BIM), IDS • Guideline for authorities to manage use case specific permit process

5.5 User Requirements for the Estonian Demo's Use Cases

5.5.1 Analysis of Existing Process Models

In this deliverable, the analysis of the existing Estonian building permit process focuses on the application inspection phase, where the Estonian use cases take place (Figure 13). The Estonian demonstration will focus on four use cases: 1) Automating the compliance checking of building's fire safety requirements, 2) Automating the compliance checking of some aspects of the accessibility regulation, 3) Automating the compliance checking of the carbon dioxide equivalent, and 4) Automating the compliance checking of requirements for schools and kindergartens.

The motivation to automate compliance checking of the use cases are three-fold: 1) to reduce the permit applicant' time needed for the building permit process, 2) to reduce authorities' amount of manual work in the process, and 3) have less errors in the process.

Some current gaps preventing the automation of compliance checks were identified. For example, most building permit applicants only submit pdf documents.

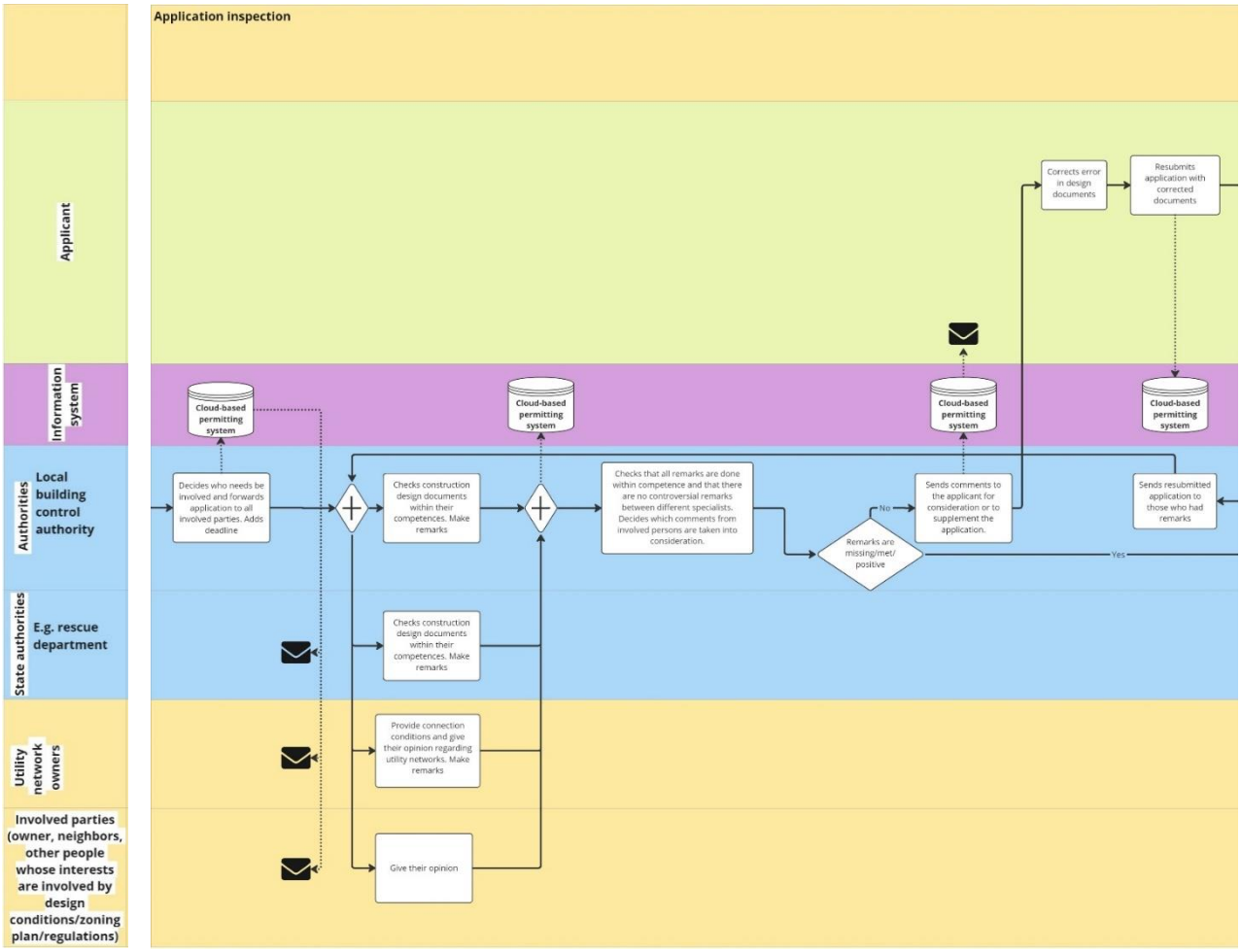


Figure 13. Application inspection phase of the Estonian as-is building permit process.

Actors

The following are the actors involved in the use cases, their roles, and the potential advantages they may derive from automated compliance checking (ACC):

The building permit applicant (usually a design company representative hired by the owner of the land plot): As the project initiator, the permit applicant is the ultimate beneficiary of ACC, for example, through reduced time and cost and increase in quality in the design check process.

Architect (and other designers): The architect often serves as the design lead in a project, coordinating the work of other design consultants for tasks like planning permits and building control applications. The architect benefits from a shorter building permit process and better quality of design due to ACC.

Local building control authority: They undertake plan checking, inspections, enforce building regulations, and issue certificates of occupancy. ACC can automate many of their checks related to building plans for compliance with the current building code. Automation leads to more unified inspection quality due to reducing human errors from not noticing some relevant information in the process.

Other authorities (State authorities): For example, the Fire Board, Health Board, Environmental Department etc. check the requirements that are in their competence, such as fire safety for Fire Board. These authorities coordinate the processes, and their input is essential for the building permit process. These authorities benefit from more accurate data when the application is in IFC-format and ACC helps them like local building control authority.

Utility network owners: They give their conditions to connect to their networks (gas, heating, water, electricity etc.) and express their opinion on the design solution regarding utility networks. In the future they can also benefit from ACC, when the process is a bit more mature, and process is changed so that external networks in the building site will be presented as a BIM model. Now site plan is 2d drawing and infraBIM models are created in later stage of building design after building permit process.

Involved parties (Neighbours, *owner of the building if he/she is not an applicant*): involved parties are sent a request to express their opinion via Building Registry, and they can provide their opinion within 10 days. Local building authority can decide whether to accept or reject their opinion. Involved parties are not benefitting from ACC, but they can see the IFC model in National Digital Twin 3D environment to get better understanding what is going to be built.

Current application inspection phase and disruption potential by ACC

During the current application inspection phase, the local building control authority checks the permit application's compliance with the local detailed zoning plan. The authority also checks compliance with building ordinance and building codes. The current manual compliance checking does not cover all details, and it is based on sampling in line with the municipality's practice. In this phase, the building inspector requests the needed statements from other authorities, and they have ten days to provide their statements. Also involved parties and utility network owners are sent the request to participate in process. They also have 10 days to express their opinion. All this process is carried out digitally in National Building Registry procedural environment. If design documents have errors or are not meeting requirements from building code, authorities send application back to the applicant to update the documents.

The disruption potential of ACC is following:

- to reduce the permit applicant' time needed for the building permit process.
- to reduce authorities' amount of manual work in the process.
- to have fewer errors in the process.
- to increase process transparency.
- possibility of quality control before application.

Some current gaps that are acting as inhibitors to the automation of compliance checks were identified:

- building permit authorities don't have BIM experience and need training to start using BIM tool.
- industry has used various BIM requirements so far and there is a need to use national common BIM requirements for ACC to work properly.

- testing of the ACC must be carried out on many BIM models to ensure checks are working correctly and the amount of false positive and false negative results is minimized – now there are very few BIM models that meet the requirements.
- There is no BIM mandate therefore, BIM based processes needs to be attractive enough for stakeholders the start voluntarily using it.

5.5.2 Digitization Scenarios/Storylines

In ACCORD project, Estonia demo will be focusing on following use cases:

1. automating the compliance checking of building's fire safety requirements.
2. automating the compliance checking of some aspects of the accessibility regulation.
3. automating the compliance checking of the carbon dioxide equivalent.
4. automating the compliance checking of requirements for schools and kindergartens.

The following technologies will be used in the digitization scenario:

- BIM tools: authoring tools, BIM viewers, model checkers
- Code compliance checking tool by Future Insight
- Platforms: Estonian national Building Registry
- Databases: ruleset database developed in ACCORD

The BIM authoring tools, the permitting platform and model checker are using different databases:

- IDS Rulesets
- National Cadastre
- National Building Registry
- BIM database
- National Land use and zoning database
- Building code
- Compliance rulesets

Storyline and related user requirements in the digitization scenario of the application inspection

The user requirement analysis is conducted with the help of the storyline method. Table 12 describes the digitization storyline of the application inspection phase. The storyline begins with submitting the application to the permitting system (Building Registry) and ends with issuing building permit. The main stakeholders in the storyline are the building permit applicant, the permitting service (Building Registry) and building authority (local government, state departments).

Table 12. The user requirements from the information management point of view.

Stakeholder	Task	User requirements
Applicant (architect)	Produce BIM according to employers' information requirements and regulation	Competence to model designBIM. Need for a BIM guideline.
	Enrich BIM according to IDS	Competence to model permitBIM. Need for a BIM guideline.
	Extract an IFC model	Competence to model permitBIM. Need for an IFC-file manual from the application vendor
	Upload an IFC model to the Building Registry	Secure that all relevant data is transferred
Building Registry	Validate IFC file	Secure that uploaded file is IFC and notify user if validation fails
	Store model version	Secure that the activity has succeeded and inform the user that the activity has succeeded.
Applicant	Start model checks against building code	Secure that the validation rules are the right ones. Receive a notification that the checks have succeeded.
	Receive checks result in the permitting system and interpret the results.	Receive validation results in a visually clear way. Competence to distinguish between real errors from no important errors. Need for a User guideline/ User manual. Ability to see the IFC file in BIM viewer.
	Make decision if the model meets the requirements. • if no: downloads BCF and updates the model. • if yes: continues to the next task	Ability to control the activity steps while using the tool Ability to see the IFC file (extracted from permitBIM).
	Comment all negative check results if they are believed to be false negative or some other accepted standard or analytical method is used to bypass requirement from building code.	Possibility to add comments to check results.
	Extract the building and spatial information from the IFC-file	Possibility to trigger extraction process.
Building Registry	Transfer extracted data to application from and lock the fields that are extracted from IFC.	Secure that the activity succeeds, and proper fields are locked.
Applicant	Fill in all necessary extra fields in the application, add non-BIM files and submit application.	Capability to submit all needed files. Technical guideline for the submission process. Secure that information is in right format and files named as requested. Receive a notification that the submission has succeeded.

Authority	Receive application and start the review in the permitting service	Need of securing authentication.
	View the checking results	Ability to see the model and checks visually integrated in a geometrical model view. Competence to evaluate the overall quality of the design.
	Make decision if changes are required	Ability to make notes and comments in the checker tool and locate the note in the model.
	Manually verify the automated checking results and additional data.	Ability to use manual tools (for example measurement) in the BIM viewer. Competence to understand automated checking mechanism and how results are produced.
	Complete the review	Ability to close the review in the permitting platform.
	Make decision if the application (or just BIM model) meets the requirements. • if no: send application back to applicant. • if yes: continues to the next task	Ability of the permitting system to create a new version and store the previous one for applicant and authority to view the latest version of BIM model and the check results and the previous version.
	Issue the permit	Competence to define and write the permitting conditions.
	Send permitting decision to the applicant	Need to secure authentication. Ability to receive all results and display them.
Applicant	Receive the permit decision	Ability to see the permitting decision. Ability to receive a. bcf to upload a to design tool.
Building Registry	Archive the building data	Ability to upload relevant files to the Archive systems following the system ordinance.

5.5.3 Visionary To-be Process

Figure 14 illustrates the Estonian visionary to-be process on a higher level from the technical point of view. The business process of building permit stays the same, all changes are technological. The process includes different microservices that are relevant in the process: Building Registry components (document, files), BIM service components (front-end, back-end, database, checking engines). Figure 15 illustrates the change of BIM service statuses throughout application and gives an understanding of different procedures in the permit process.

User requirements from the actors' point of view

<u>Building permit applicant needs to be able to</u>

- upload an IFC-file to the Building Registry
- receive model upload, validation and checking completion notifications.
- view model and check results (in a BIM viewer of Building Registry)

- download BCF file to correct check results.
- visualise check results in BIM viewer.
- extract building and spatial information from IFC-file and receive these results on the application form.
- submit the application.
- upload new IFC files and re-run checks in case of negative inspection results.
- receive and view the building permit decision.

Cloud-based permitting service (Building Registry) needs to be able to

- authenticate users.
- upload and store the IFC file.
- validate uploaded IFC files.
- visualize IFC files.
- provide building environment from national Digital Twin if IFC file is georeferenced.
- check the accessibility, fire safety, schoolhouses and kindergarten requirements and building CO2 compliance.
- extract building and spatial information from the IFC-file, transfer it to application form and then prevent manual user input respective data fields to the user.
- provide commenting option of the compliance checks for the users.
- receive the results and provide them to the authority.
- provide check management tool for administrative user for adding new checks and editing existing checks if regulations change.
- exchange data between databases
    - IDS Rulesets
    - National Cadastre
    - National Building Registry
    - BIM database
    - National Land use and zoning database
    - Building code
    - Compliance rulesets

Building control authority needs to be able to

- receive the real estate, building and spatial information.
- receive the building permit application.
- view the results of the compliance checks.
- add remarks to compliance checks.
- send application and model change requests to the permit applicant.
- issue the permit.

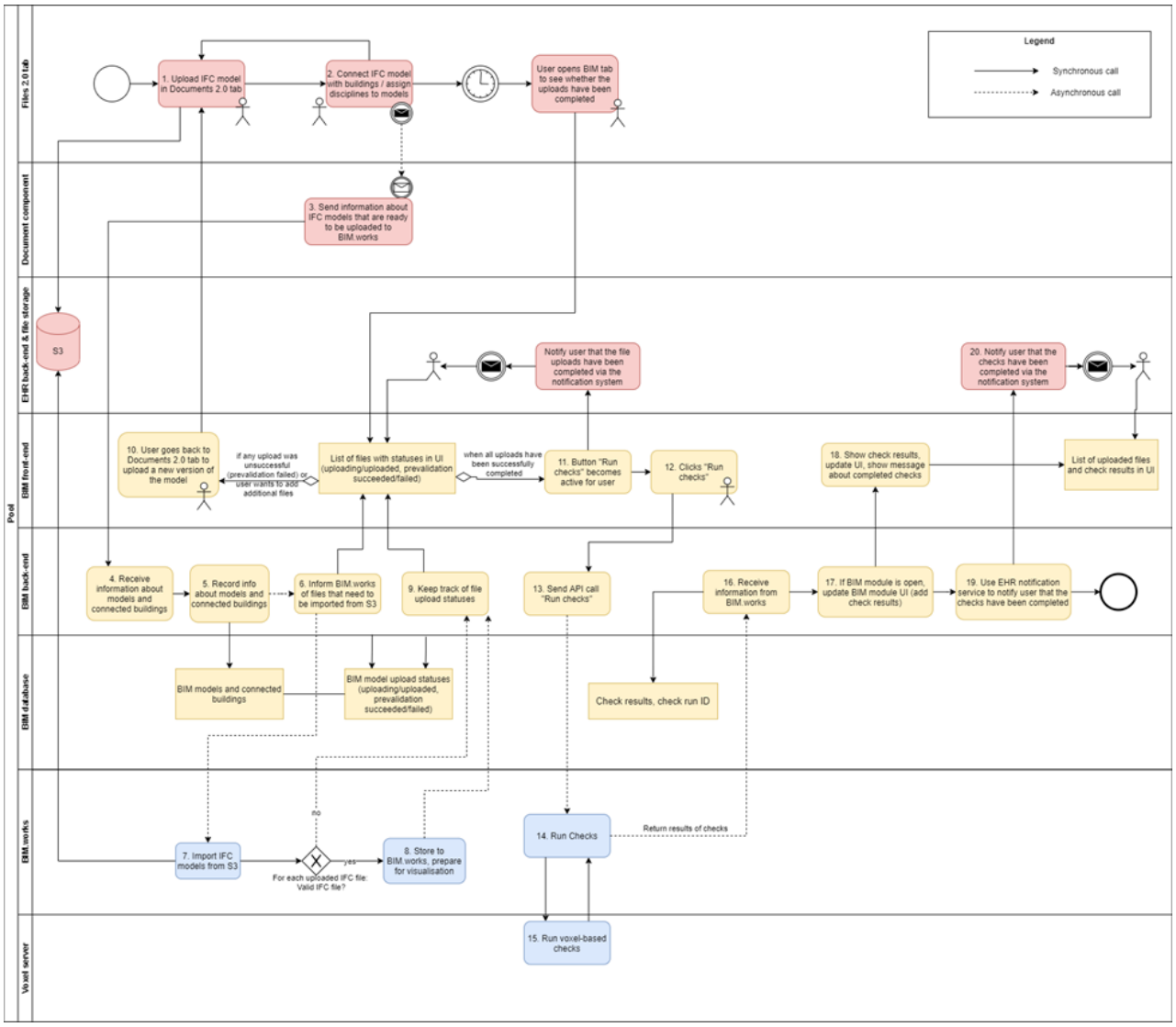


Figure 14. Visionary technical flow diagram, focusing on the Estonian BIM based solution.

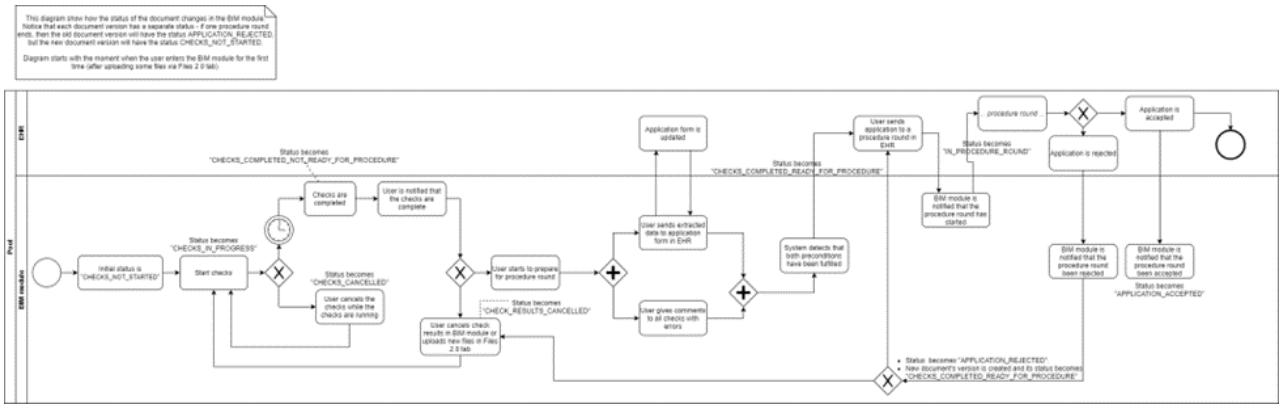
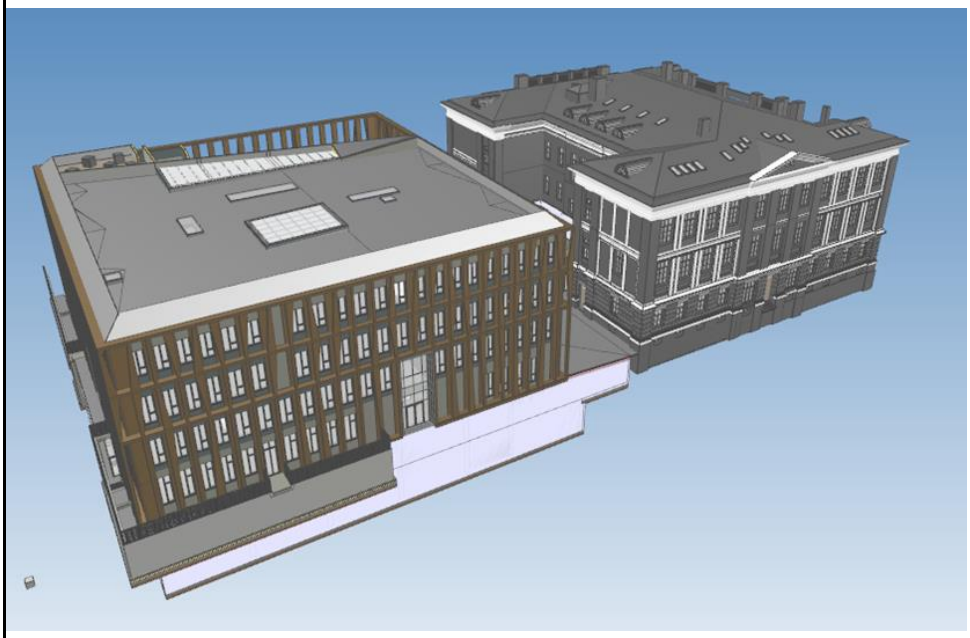


Figure 15. BIM service statuses throughout the application process.

5.5.4 Estonian Demo-specific Deployments

Table 13 shortly describes the Estonian demo-specific deployments.

Table 13. Estonian demo-specific deployments.

Demo Name	Estonian demo: Schoolhouse
Photo	 
Building owner	Tallinn Property Department[26]
Demo Aims	• Perform automatic compliance checking of selected regulations of IFC file submitted for building permitting.

[26] The field of activity of the Tallinn Property Department is urban property, construction and management of buildings, land management and land taxation, see https://www.tallinn.ee/en/tallinn-property-department

	• Read automatically required building information from the submitted IFC file.
Demo Description	Automate the compliance checking of selected geometry-based requirements of accessibility and fire safety and requirements for schools. Develop and test a method for carbon footprint evaluation of the building in permitting in partnership with Finnish demo. Read basic building data from IFC that are required in a national Building Registry.
Stakeholders	• Tallinn Property Department • Local building control authority • Main architect • BIM modelling, consultations with authorities • BIM coordinator • ACCORD partners: MKM and FUI
Location	Tallinn, Estonia
Building Type	Partly renovated and partly new schoolhouse building, public building
Data Formats	IFC
Regulations Targeted	• Use case 1: Government Decree on the Fire safety requirements for the building. • Use case 2: Government Decree on the Building requirements arise from the special needs of disabled people. • Use case 3: No regulation yet. Purpose of use case is to work out usable methodology of CO2 checking in building permit process. • Use case 4: Government Decree on the Health protection requirements for schools
Outline Plan for the Demo Use Cases	• Compliance checking with existing and to-be developed tools and methods (Future Insight) • IFC-file is enriched with needed data with Simplebim software. • The demo will follow the national IFC definitions and national BIM requirements (user defined property sets) • Future Insight will create the needed rulesets. • Estonian Building Registry is used for IFC handling in its building permit service and data transfer from an IFC file. • Future Insight will specify the API needed to exchange needed IFC data to Estonian Building Registry • ACCORD methods and tools will be applied. • Guideline for the architect to enrich the designBIM (IFC), IDS • Guideline for authorities to manage use case specific permit process

5.6 Conclusion

This section elicited the user requirements by focusing on the to-be BIM-based permitting processes in the selected use cases of the demonstration countries. Each ACCORD demo country has identified use cases for the development of digital permitting processes and automated or semi-automated code compliance checking.

Based on user requirements elicitation in sections 5.1-5.5, user requirements can be categorised on a higher level as follows:

Requirements on building project process level:

- Abilities to data creation and submission actions
- Abilities to data handovers toward decision making
- Maturity of the data flow security issues
- Maturity of tools, platforms, and databases to support the process (implemented IDS/ MVDs)
- Maturity of interoperability between tools, platforms, and databases
- Access to databases and extraction data in the right format
- Ability to communicate in BIM-based integrated process (through the tools)

Guidelines and specifications and competence:

- Need for general BIM guidelines for main disciplines (Authorities, clients, and designers)
- Need for BIM-based use case specification (data flow, data content and properties on use-case level, LOIN)
- Capabilities and competences
- Skills for using the tools

Requirements on the organisational level:

- Appropriate software and hardware
- Business services
- Data-driven approach adaptation, BIM strategy

Requirements on the policy steering level:

- In line with the steering of International and European level standards
- Laws, degrees, normative and regulatory steering for digital building permitting and ACC.
- Building code and related requirements (text) transformed to machine-readable format.
- National guidelines on BIM use case level
- National standards
    - Classification
    - Maturity of Data transfer format (IFC schema)

Requirements on an international level of information management based on integrated building information modelling.

- Maturity of the use-case level IDMs (with MVD and ER) or IDS descriptions

- Maturity of services
  - Data dictionaries (bSDD/ OGC)
  - UCM -service

6 ACCORD Framework Specification

Following the analysis performed in the previous sections of both the top-down requirements (derived from the high-level global need for the ACCORD framework) and the bottom-up requirements derived from the demonstration use cases, a complete set of user requirements has been assembled.

This section will first document and present these user requirements. Subsequently, the original framework defined in the ACCORD proposal and described in Section 3 can be refined and adapted to ensure it meets the user requirements. Finally, the detailed workings of this ACCORD framework will be described using UML use case diagrams.

6.1 ACCORD Framework User Requirements

This section will formally document the user requirements elicited for the ACCORD framework. To derive these requirements, firstly, those presented previously in the document were analysed, then duplicates were removed, and some merging of requirements was performed to integrate requirements that were describing similar things. Table 14 presents the complete list of requirements together with their origin. In the origin row V shows the requirement is from the ACCORD vision (Section 3), H shows it is a high level requirement (Section 4), G shows it is from the German demo (Section 5.1), S shows it is from the Spanish demo (Section 5.2), U from the UK demo (Section 5.3), F from the Finnish demo (Section 5.4) and E from the Estonian demo (Section 5.5).

Table 14. ACCORD User Requirements.

No	User Requirement	Origin
1	Provide a platform to provide digitised building permitting processes.	V, S, F, U, E, G
2	Provide automated compliance checking.	V, S, F, U, E, G
3	Support both Geospatial and BIM(IFC) data input.	V, H, F, S, E, G
4	Provide sufficient customisation ability such that formally specified processes are generic enough to be scaled to the European level but flexible enough to allow the specific nature of each nation's permitting processes to be considered.	V, H, S, F, U, E, G
5	Provide an intuitive method to allow regulation experts to digitise building codes/regulations and embed rules within them, without the need to write code.	V, H, S, F, U, E, G
6	Provide the ability to store a database of rules.	V, S, F, U, E, G

7	Provide the ability to extract the information requirements for digital building permitting and compliance processes and represent these as a standardised data schema using BuildingSMART standards (i.e., IDS).	V, H, S, F, U, E, G
8	Should be a dynamic system with the ability to add and removable modules.	V
9	Should support integration of data dictionaries to enable mappings between regulatory terms and data schemas.	V, H, F, S, E, U, G
10	Should be able to leverage emerging Artificial Intelligence techniques, such as semantic deep learning Natural Language Processing (NLP).	V, G
11	Should provide a set of microservices, with tools and solutions for digital permitting and automated compliance checking of buildings.	V, H, U, S, F, E, G
12	Should provide open standardized application programming interfaces and make use of open standards where applicable (i.e., from OGC, buildingSMART etc..)	V, H, G
13	The digitised format of building/codes regulations should be independent of any specific building modelling format.	H, G
14	Should support the use of classification systems	H, F, G
15	Should provide the formalization of concepts from building codes/regulations in a semantic form.	H
16	Provide the ability to pre-check for compliance prior to formal submission.	H, G
17	Provide the ability to link building permitting processes, applicable legislation and building data standards and provide audit abilities to track decisions.	H, G
18	Provide open access to limited data about building permitting assessments.	H, G
19	Provide a standardised submission process.	H, G
20	Should support and enable direct communication between the submitter and regulator.	H, F, S, E, G
21	Should provide suitable security models to differentiate between users to enable selection of an appropriate user to assess a given regulation.	H, F, S, E, G
22	Provide the generation of human readable and machine-readable (BCF) reporting based on submissions.	H, U, F, S, E, G
23	Should enable collection of suitable evidence to complement assessments	H
24	Should retain the ability for manual human input.	H, S, G
25	The ability to share compliance results with other relevant users.	U, F, S, E, G
26	Support the ability to perform model validation – checking that it contains the required information to perform compliance checking.	U, F, S, E, G

27	Support the ability to perform model verification - checking that a submission complies with relevant modelling schema.	U, F, S, E, G
28	Support integration of a Finite Element Analysis compliance checking microservice	U
29	Support providing reporting of results of model verification and validation.	U, F, S, G
30	Support upload of model files in an appropriate format	U, F, S, G
31	Provide a compliance checking microservice that can extract data from national level databases and check against it.	F, S, E, G
32	Provide ability to select the regulations against which a submission is to be checked.	F, S, G
33	Provide archival of submitted models	F, G
34	Provide integration with a microservice to check building CO2 compliance	F, E, G
35	Provide notification when building permitting is completed	S, E, G
36	Provide ability to export submitted model	S
37	Provide visualisation of BIM models	S, E, G
38	Be able to produce appropriate licenses and certificates	S, E
39	Be able to automatically determine the regulations to be checked against based on building criteria.	S
40	Be able to extract building and spatial information from IFC-file and visualize these results	E
41	Extract and check against building environmental data from national Digital Twin if IFC file is georeferenced.	E
42	Allow for the configuration of varying requirements for BIM models (modelling guidelines and Level of Information Needs) required for differing submission stages and building permit types.	G
43	Provide ability to generate documentation of BIM model requirements for differing submission stages and building permit types and to adapt to locally differing sets of predefined requirements.	G
44	Be able to extract building and spatial information from CityGML and IFC-files and check against requirements provided in standardised data format (XPlanXML in German context/ INSPIRE PLU in European context).	G
45	Be able to extract required information for the formal building permit application from IFC-files and convert it into XBau standard (XBauXML files).	G
46	Be able to support XBauXML files as an input format.	G
47	Provide integration with a microservice to provide Lifecycle Assessment for Green Building Certification.	G

48	Provide integration with a microservice to provide checking of timber construction systems.	G

6.2 Revised ACCORD Framework

Following the derivation of the final set of ACCORD user requirements (shown in Table 14), the ACCORD framework, originally developed in the ACCORD proposal and presented in Section 3, has been revised. This refinement has been done by analysing the user requirements and either adding or changing the components to ensure they are all met. Figure 16 illustrates the revised ACCORD framework. The components in this figure are divided into five groups:

1. **Rule Formalization:** Describes the components involved in the process of formalizing human readable regulations/requirements into machine-operable rules.
2. **Rule Storage:** Describes how the machine-operable rules are made available to other components of the ACCORD framework.
3. **Cloud-based Permitting:** Describes the core software components of the cloud-based permitting service that ACCORD will provide.
4. **Compliance Checking Microservices:** Describes the Compliance Checking Microservices that will perform the actual compliance checking within the ACCORD framework.
5. **APIs:** Describes the APIs by which the components of the ACCORD framework will communicate.

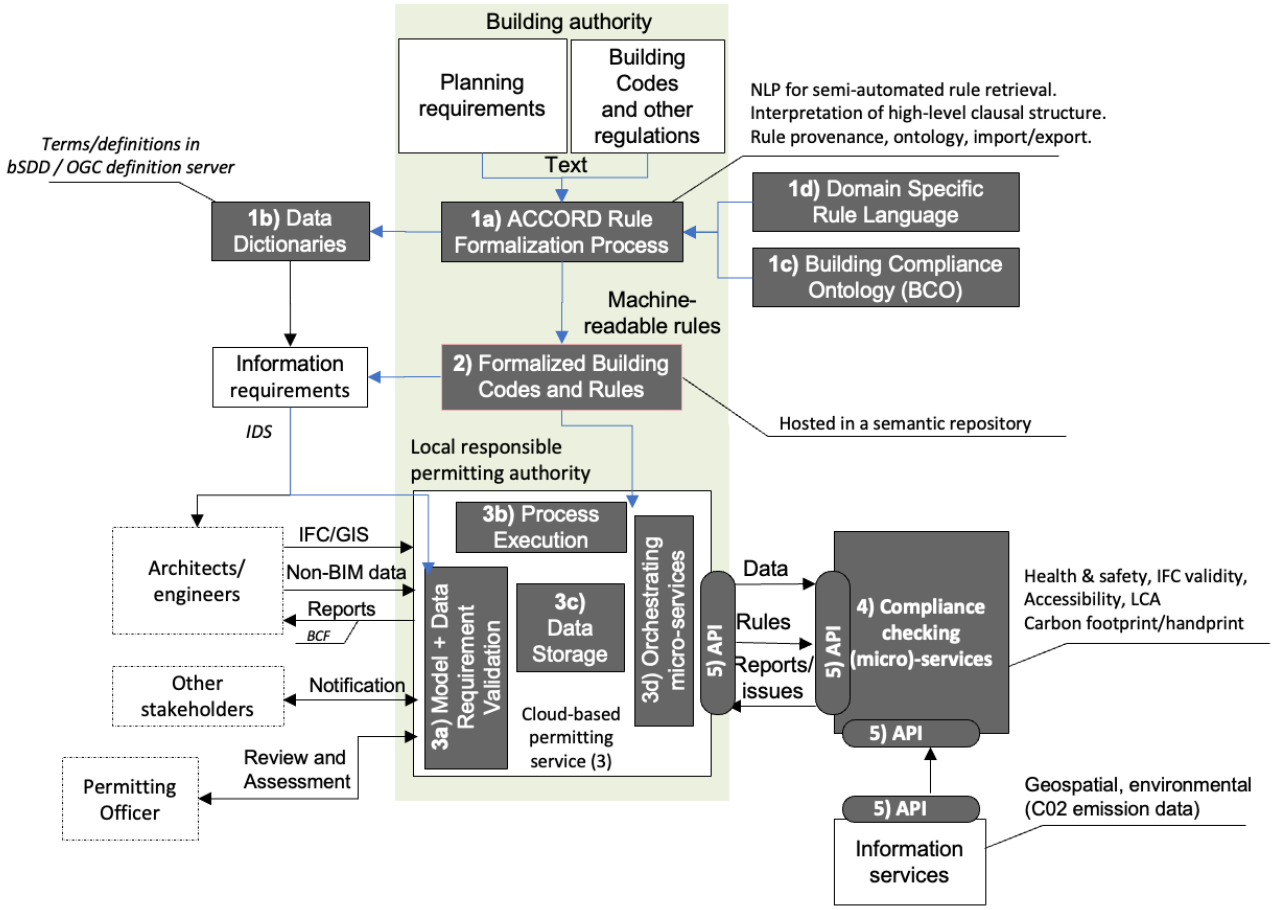


Figure 16. Revised ACCORD Framework.

Each of these components is now described below in more detail:

ACCORD Rule Formalization Process (1a): This is the process by which building codes and other regulations are formalized and made machine operable. It is envisioned that this will, at a more detailed level, consist of manual, automated (using NLP) and a hybrid process to perform this task. These processes will also be supported by a rule formalization tool. The outputs of this process will be the building code/other regulation formalized in a semantic form as well as a set of terms which will be used to populate a data dictionary.

Data Dictionaries (1b): The data dictionary component will be used to store the set of terms extracted from building codes/other regulations. It will store and organise these terms as well as manage their mappings to modelling data formats and any other metadata required.

Building Compliance Ontology (BCO) (1c): This ontology will define the abstract set of concepts and relationships between these concepts needed to formalize building codes and other rules.

Domain Specific Rule Language (1d): The domain specific rule language will provide a structured language which can define rules, making explicit the logic that is often implicit within human readable texts.

Formalized Building Codes and Rules (2): This is the formalized machine-operable set of building codes/other regulations. This will be stored in a semantic repository and, thus, made available to other components of the ACCORD framework.

Cloud Based Permitting Service User Interfaces (3): User interfaces that provide the ability for users to interact with the cloud based permitting service.

Model + Data Requirement Validation (3a): This component will firstly perform model validation, checking that the model submitted is valid. Secondly, it will perform data requirement validation, checking that the model contains the data items required to perform the building permitting process.

Process Execution (3b): This component will manage the overall execution of the building permitting process. This component will enable the selection of the rules that must be executed as well as the invocation of microservices.

Data Storage (3c): This component will provide storage of both semantic and non-semantic data required by other elements of the ACCORD framework.

Orchestrating micro-services (3d): This component will provide an orchestration framework for compliance checking microservices. This will enable other components to retrieve lists of available microservices, their information as well as the needed information for these services to be invoked.

Compliance checking (micro)-services (4): The compliance checking microservices are the components that perform the actual concrete compliance checks within the ACCORD framework. There will be many compliance checking services within the actual developed ACCORD framework. The concept of this approach is to enable the ACCORD framework to integrate compliance checking services in a dynamic fashion allowing existing tools to be integrated without the need for extensive reworking. Furthermore, it enables the more rapid development of new services that solve a single defined problem.

APIs (5): The ACCORD framework will provide a set of APIs to enable the function and communication of various components within the framework. These include: (a) a microservice API enabling the ACCORD cloud permitting services to invoke microservices and (b) a cloud permitting API enabling compliance checking microservices to make use of the functionality provided by the ACCORD cloud permitting service, i.e., data retrieval.

To ensure complete coverage of all user requirements through these components, each user requirement is now analysed to confirm it is delivered by at least one component. This is shown in Table 15.

Table 15. User Requirement / Component Matrix.

	1a	1b	1c	1d	2	3	3a	3b	3c	3d	4	5
1	■	■	■	■	■	■	■	■	■	■	■	■
2	■	■	■	■	■	■	■	■	■	■	■	■
3						■	■	■	■	■	■	
4								■	■			
5	■			■								
6					■							
7	■	■										
8										■	■	■
9	■	■										
10	■											
11										■	■	■
12												■
13	■		■	■	■							
14		■						■				
15	■		■					■				
16						■		■				
17	■		■					■				
18						■						■
19						■						■
20						■						■
21						■	■	■	■	■	■	■
22						■						■
23						■		■	■			
24						■		■	■			
25						■						■
26							■					
27							■					
28											■	
29						■						■
30						■						■
31											■	
32						■						
33									■			
34											■	
35								■				
36						■			■			■
37						■						
38						■						
39								■				
40						■						
41												■
42	■	■					■					
43	■	■				■						
44									■		■	■
45									■			
46									■			
47												■
48												■

6.3 ACCORD Framework UML Modelling

This section will describe the function of the ACCORD framework through a set of UML models. Firstly, the user requirements of each component (shown in Table 14 and Table 15) will be illustrated through a use case diagram (Figure 17). Additionally, the way in which the framework components interact are illustrated in UML sequence diagrams. Two scenarios are presented:

- **Model and Data Requirement Validation:** Shown in Figure 18.
- **Execution of Building Permitting:** This assumes the model and data have already been validated and is shown in Figure 19.

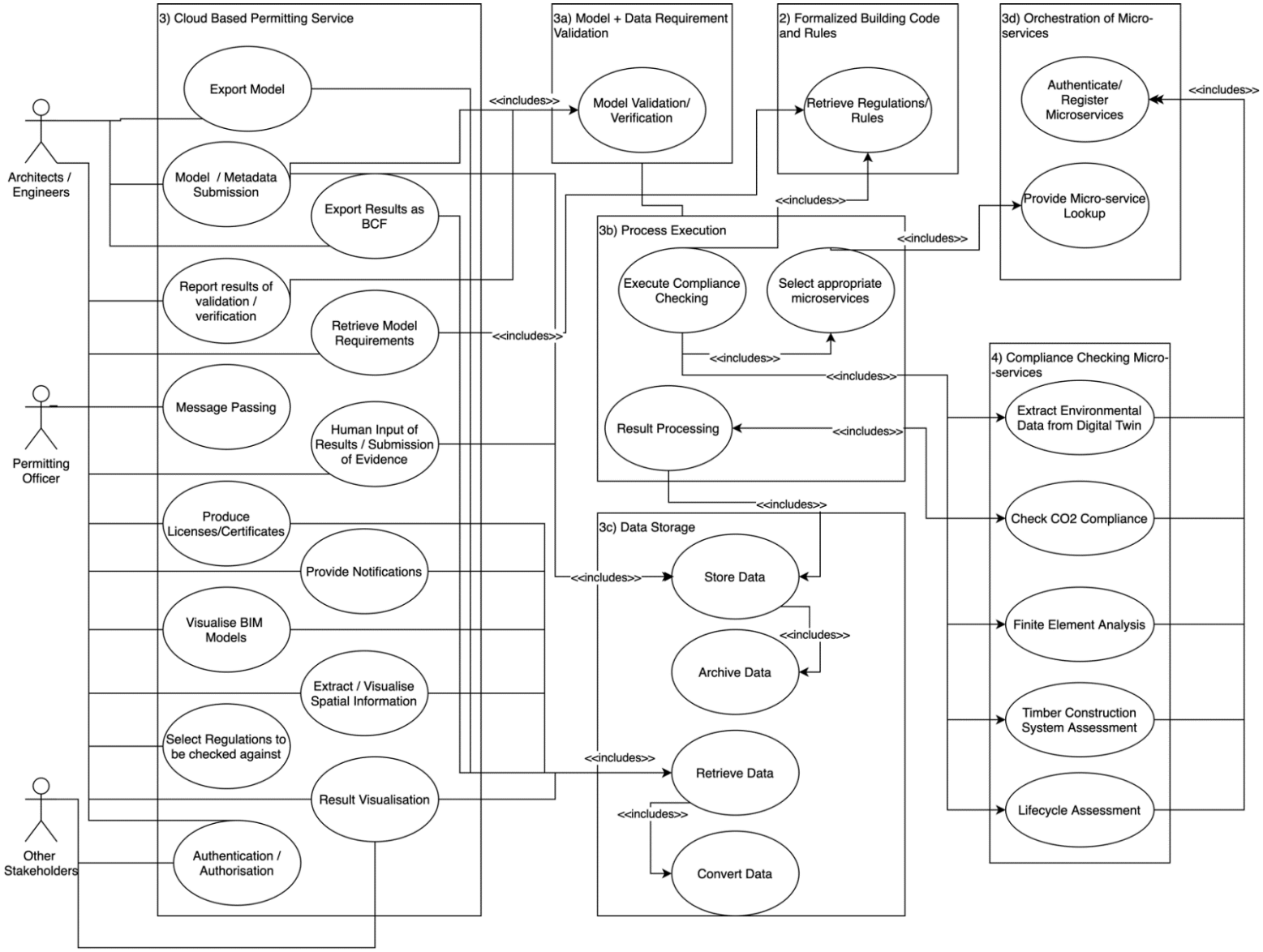


Figure 17. ACCORD Framework UML Use Case.

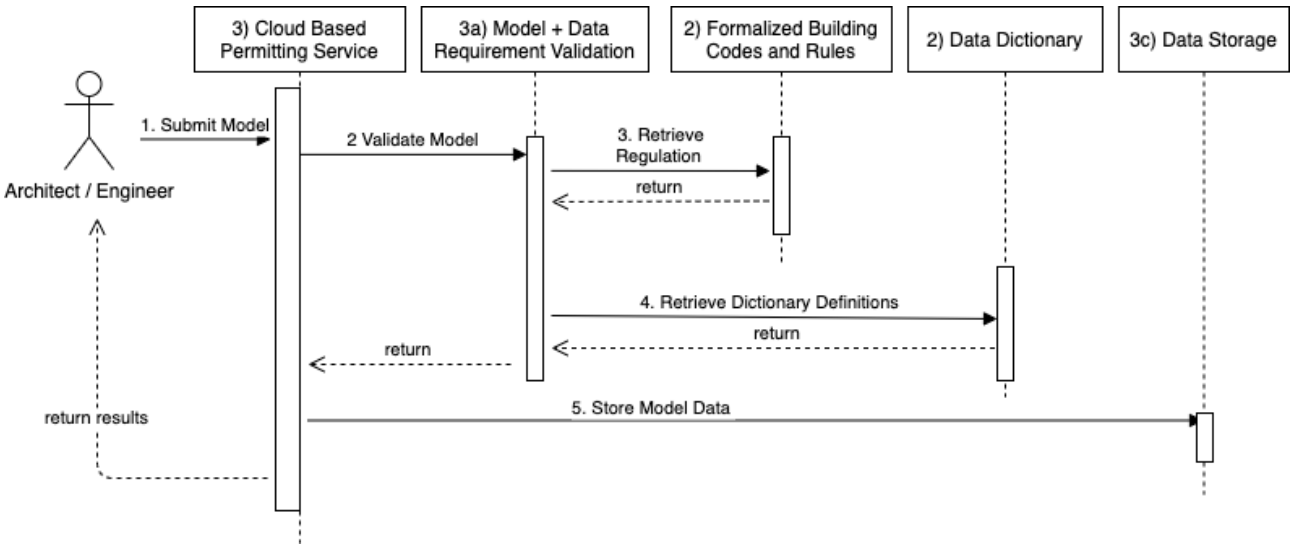


Figure 18. Sequence Diagram: Model and Data Requirements Validation.

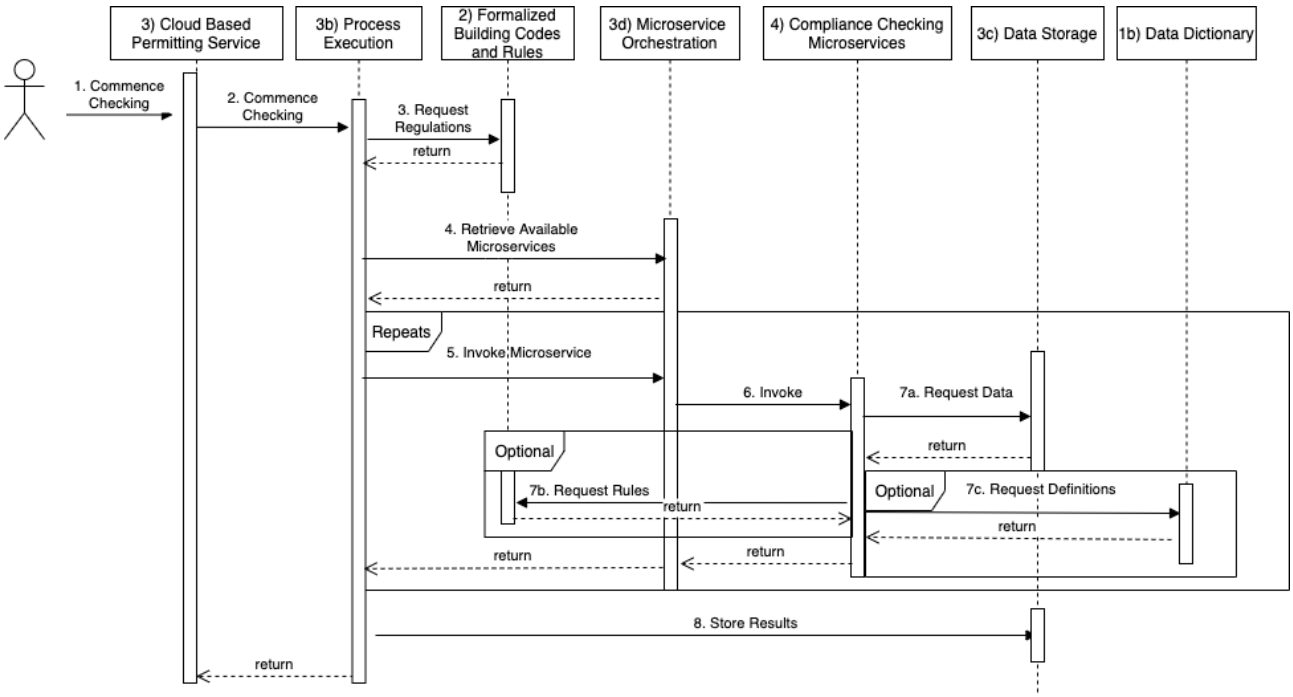


Figure 19. Sequence Diagram: Executing Building Permitting.

6.4 Standards for Storing, Processing, Analysis and Retrieval of Data

This section will describe the standards and demo-specific guidelines that ACCORD will adopt for the storing, processing, analysis, and retrieval of data. This is documented in Table 16.

Table 16. ACCORD Adopted Standards.

Title	**Relevance**	**Reference**
All country demonstrations adopt		
IDS	BuildingSMART Information Delivery Specification (IDS) for defining the model-based exchange requirements	https://technical.buildingsmart.org/projects/information-delivery-specification-ids/
IFC	Industry Foundation Classes (IFC)	ISO 16739-1:2018
German demonstration adopts		
R&D project results on BIM-based building permitting	Selected results of German R&D projects dedicated to BIM-based building permitting (in German): • BIM-based building permit (“BIM-basierter Bauantrag - Konzept für die nahtlose Integration von Building Information Modeling (BIM) in das behördliche Bauantragsverfahren”) • Digitalization of the Model Building Code (“Digitalisierung der Musterbauordnung (MBO2BIM) - Aufbereitung der MBO für BIM-basierte Prüfwerkzeuge”) • Gaia-X project “iECO - Intelligent Empowerment of Construction Industry”: use case “Digitized inspection of the proof of stability - inspection goes BIM” (“Digitalisierte Prüfung des Standsicherheitsnachweises – Prüfung goes BIM”)	https://bim-bauantrag.blogs.ruhr-uni-bochum.de/projektergebnisse/ https://mbo2bim.de/ergebnisse https://ieco-gaiax.de/use-cases-variante-2/
“BIM for Federal Buildings”	Master plan and Implementation Strategy “BIM for Federal Buildings” specifying BIM organisational structures, - processes, - roles, -application cases, - information technology etc. (in German).	https://www.bmi.bund.de/SharedDocs/downloads/DE/veroeffentlichungen/2021/10/masterplan-bim.pdf?__blob=publicationFile&v=3 https://www.bimdeutschland.de/fileadmin/user_upload/Umsetzungsstrategie_BIM_Bundesbauten.pdf
“BIM Portal”	The “BIM Portal” is a parallel initiative supporting the introduction of BIM for Federal buildings in Germany organizing the tasks of diverse actors by offering the following	https://www.bimdeutschland.de/leistungen/bim-portal https://via.bund.de/bim/infrastruktur/landing

	modules: (1) Attributes - management, maintenance and provision of uniform attributes and attribute groups for public tenders, (2) Employer's Information Requirements (EIR) - definition and generation of EIRs using standardized templates, (3) Object Templates – provision of EIR-compliant semantic object templates for integration into BIM authoring tools, (4) Checking Tools - EIR-compliant compliance checking tools for BIM quality assurance by public building owners.	
LOIN	Information management using BIM: Definition of information requirements and the Level of Information Need (LOIN) (in German).	DIN EN ISO 19650
	Levels of Information Need (LOIN): Specifications to structure, designation, creation, and exchange (in German).	DIN EN 1741
OAA Reference Implemen-tation	Online Access Act Reference Implementation "Digital Building Permit": All actors during building permit application and processing access a web-based dataspace that stores the building application documents. Local building authorities provide such an individual "construction portal digital building permit" ("Vorgangsraum digitale Baugehmigung") (in German).	https://www.digitale-baugenehmigung.de/de/news-tdetail/10-bundeslaender-25-online-dienste-150-bauaemter.html https://www.digitale-baugenehmigung.de/de/baugenehmigung.html https://www.digitale-baugenehmigung.de/de/vorgangsraum.html
E-govern-ment standards	E-government (public administration) IT interoperability and security standards of the Federal Republique of Germany ("XÖV Standard") (in German).	https://www.it-planungsrat.de/produkte-standards/standards
	XPlanung focuses on the provision of planning data by ensuring the exchange of a planning work description (metadata and procedural statuses) and of spatial planning contents (geometry and factual data) of plans that are currently being and already approved plans (in German).	https://xleitstelle.de/downloads/XPlanung_Leitfaden_1.pdf

	XBau provides information and data exchange between parties involved in construction approval procedures, see “Specification for Building Construction” (“Spezifikation XBau-Hochbau”). XBau connects specialized (building permit) procedures with the “EfA services” for digital building permit (see below) (in German).	https://xleitstelle.de/downloads/xbau/releases/xbau_v_2_3/spezifikation_xbau_2-3.pdf https://www.digitale-baugenehmigung.de/de/fachverfahrensanbindung.html https://www.fitko.de/fit-store/fit-store-detailansicht/detail/bauantrag
	OSCI is used by transport procedures for secure, confidential, and legally binding communication over insecure and secure networks. XTA specifies the exchange of messages between subject- and transport procedures and supports the automated, subject-independent further processing of messages (in German).	https://www.xoev.de/osci-xta-3355 https://www.xoev.de/osci-xta/xta/einsatzszenarien-23026
“EfA services”	Implementing the Online Access Act and based on the idea of “one-for-all”, German Federal States can share or reuse a developed online service provided by another state. These “EfA services” are published on the FIT-Store marketplace (in German).	https://www.fitko.de/produktmanagement/fit-store https://www.fitko.de/fit-store
FIT-Connect	FIT-Connect is an IT infrastructure facilitating the digital application for administrative services within the Federal Republic of Germany. It was designed for the federal follow-up use of central online services (“EfA services”). Each private actor/ building permit applicant is obliged to apply for a FIT-Connect account for submitting the building permit application to the construction portal of the relevant federal state using the XBau standard (in German).	https://www.fitko.de/produktmanagement/fit-connect https://docs.fitko.de/fit-connect/docs
ELBA	Digital interface developed by the Federal Association of Design Review Engineers (“Bundesvereinigung der Prüfingenieure für Bautechnik e.V. - BVPI”) allowing for the digital exchange of construction documents subject to inspection between construction supervision authorities, Design Review Engineers, and proof providers by using a digital checking file (in German).	https://bvpi.de/bvpi/de/aktuelles/elba.php

LCA	Environmental management - Life cycle assessment - Requirements and guidelines (in German).	DIN EN ISO 14044:2021-02
Environ-mental performance	Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method (in German).	DIN EN 15978:2012-10
DGNB Certification System	Certification system developed by the German Society for Sustainable construction (DGNB e.V.) supporting sustainable solutions for buildings, quarters and interiors/ renowed “Global Benchmark for Sustainability” (in German).	https://www.dgnb.de/de/zertifizierung/das-wichtigste-zur-dgnb-zertifizierung/ueber-das-dgnb-system
QNB seal	Sustainable Building Quality Seal - QNB (“Qualitätssiegel Nachhaltiges Gebäude”) (in German)	https://www.bmwsb.bund.de/Webs/BMWSB/DE/themen/bauen/bauwesen/nachhaltiges-bauen/nachhaltiges-bauen-artikel.html;jsessionid=47312E57206259594EDC8BD838734445.1_cid287 https://www.bmwsb.bund.de/SharedDocs/downloads/Webs/BMWSB/DE/publikationen/bauen/qng-neubau-von-wohngebaeuden.pdf?__blob=publicationFile&v=3
Gaia-X Standard	Gaia-X Trust Framework	https://gaia-x.gitlab.io/policy-rules-committee/trust-framework/technical_prelude/
	Gaia-X Architecture Document	https://docs.gaia-x.eu/technical-committee/architecture-document/22.10/overview/
	Gaia-X Policy Rules and Labelling Document	https://docs.gaia-x.eu/policy-rules-committee/policy-rules-labelling/latest/policy_rules_labeling_document/
	Gaia-X Federation Services (GXFS) Specifications	https://www.gxfs.eu/specifications/
Spain demonstration adopts		
No further requirements		
UK demonstration adopts		

UNICLASS	Classification Schema	https://www.thenbs.com/our-tools/uniclass
Finnish demonstration adopts		
BIM Guideline COBIM	Common BIM Requirements 2012 will be used in the modelling of the Finnish demo BIM based on OpenBIM philosophy	https://wiki.buildingsmart.fi/en/04_Guidelines_and_Standards/COBIM_Requirements
BIM guidelines for building permitting	YTV section 14 (in Finnish): the use of BIM models for building permitting. Other specified data requirements (RAVA 3Pro – project outcomes)	https://drive.buildingsmart.fi/s/mWExxJytMWFTPdM http://www.rava3pro.fi/
Codes	Code lists and classifications compiled from the data area of the built environment	https://koodistot.suomi.fi/
Classification	Classification system in the level of spaces, building parts, systems, and materials. TALO 2000 Construction 2000	https://tiedostot.rakennustieto.fi/Nimikkeistot/Construction_2000_Classification_netti.pdf
Data models	Describe the data metadata, concept definitions and the code sets used in them	https://tietomallit.suomi.fi/
Estonian demonstration adopts		
BIM requirements	Estonian national common BIM requirements (ÜBN)	https://eehitus.ee/juhendid/bim/

6.5 External Advisory Board Input

The revised ACCORD framework was presented to the advisory board members on 20th of June 2023 and their feedback was collected through four questions on a Miro board. Imagery of the feedback is shown in Figure 20.

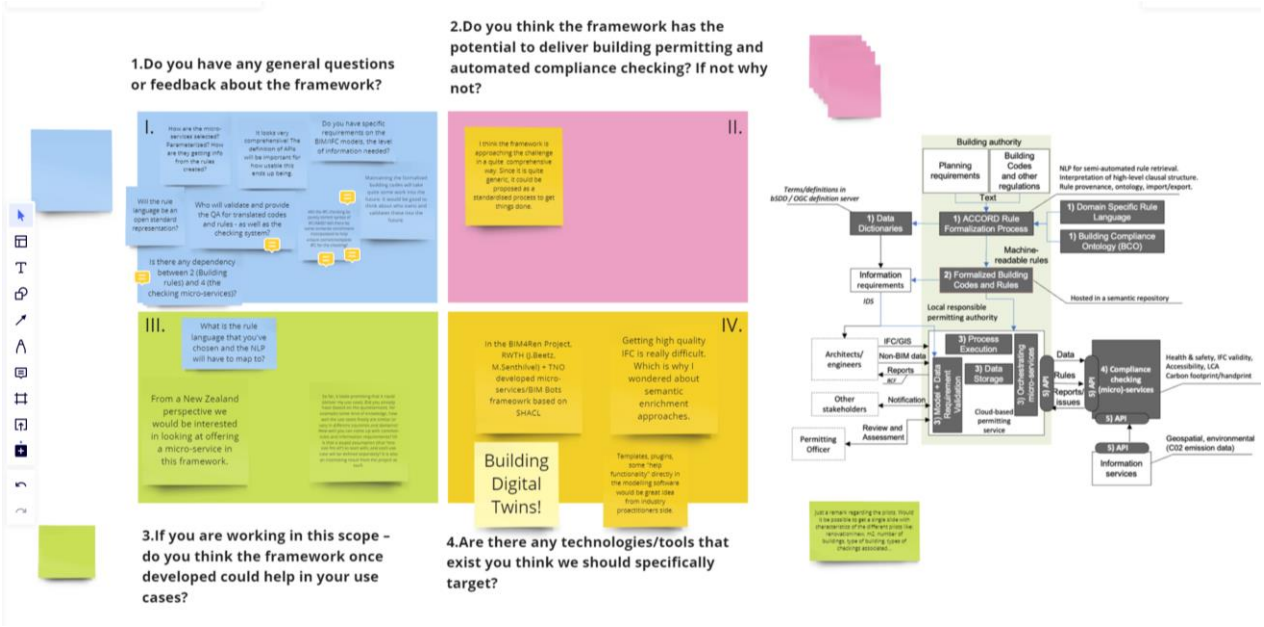


Figure 20. Imagery of Advisory Board Feedback.

The questions raised by the advisory board members, along with ACCORD are summarised below in more detail:

Do you have any general questions or feedback about the framework?

1) *External Advisory Board*: How are the micro-services selected? Parameterized? How are they getting info from the rules created?
ACCORD: We envision two use cases; (a) a microservice executes an individual element of a rule i.e., width==10 - or (b) it could parse and execute an entire rule in its entirety. The selection of which service to use is done by the planning/execution component and data is transferred using APIs we will define.

2) *External Advisory Board*: It looks very comprehensive! The definition of APIs will be important for how usable this ends up being.
ACCORD: We agree, and this will be carefully considered in the later phases of the project.

3) *External Advisory Board*: Do you have specific requirements on the BIM/IFC models, the level of information needed?
ACCORD: Our plan is that we hope to be able to generate IDS from the data requirements we will collect from the digitisation process. We will then check against these using IDS standards.

4) *External Advisory Board*: Will the rule language be an open standard representation?
ACCORD: Yes

5) *External Advisory Board*: Who will validate and provide the QA for translated codes and rules - as well as the checking system?
ACCORD: The are experts in each demo who are knowledgeable about how the regulations should be understood. The manual approach for digitisation is planned to be a collaborative work between them and the technical team. We then plan to validate the NLP outputs against these manual results.

6) *External Advisory Board*: Will the IFC checking be purely correct syntax of IFC/MVD? Will there be some semantic enrichment incorporated to help ensure correct/complete IFC for the checking?
ACCORD: Our plan is that we hope to be able to generate IDS from the data requirements we will collect from the digitisation process. We will then check against these using IDS standards.

7) *External Advisory Board*: Maintaining the formalised building codes will take quite some work into the future. It would be good to think about who owns and validates these into the future.
ACCORD: Yes, this is an important point and will be considered in a future work package.

8) *External Advisory Board*: Is there any dependency between 2 (Building rules) and 4 (the checking micro-services)?
ACCORD: We envision two use cases; (a) a microservice executes an individual element of a rule i.e., width==10 - or (b) it could parse an execute an entire rule in its entirety.

Do you think the framework has the potential to deliver building permitting and automated compliance checking? If not, why not?

1) *External Advisory Board*: I think the framework is approaching the challenge in a quite comprehensive way. Since it is quite generic, it could be proposed as a standardised process to get things done.
ACCORD: Yes, we agree, we aim to plan for this at the conclusion of the project.

If you are working in this scope – do you think the framework once developed could help in your use cases?

1) *External Advisory Board*: So far, it looks promising that it could (deliver my use case). Did you already have (based on the questionnaire, for example) some kind of knowledge, how well the use cases finally are similar or vary in different countries and domains? How well you can come up with common rules and information requirements? Or is that a stupid assumption (that “one size fits all”) to start with, and each use case will be defined separately? It is also an interesting result from the project as such.
ACCORD: So, we have identified common functionality across demonstration use cases such as model validation/verification, we will also be analysing in detail the regulations of each demonstration cases and will attempt to extract common functionality in this way.

2) *External Advisory Board*: From a New Zealand perspective we would be interested in looking at offering a micro-service in this framework.
ACCORD: Yes, this would be an excellent collaboration

3) *External Advisory Board*: What is the rule language that you've chosen, and the NLP will have to map to?
ACCORD: We have developed a rule language which is a simplified version of the DRL rule language.

Are there any technologies/tools that exist you think we should specifically target?

4) *External Advisory Board*: In the BIM4Ren Project, RWTH (J. Beetz, M. Senthilvel) + TNO developed micro-services/BIM Bots framework based on SHACL
ACCORD: Yes, we have reviewed this work as part of landscape review.

5) *External Advisory Board*: Getting high quality IFC is difficult. Which is why I wondered about semantic enrichment approaches.
ACCORD: We agree. Our plan is to enrich the models as part of the work in the demonstration activities to validate the ACCORD framework. As an output of the project, we will also provide recommendations on the contents of models to enable digital building permitting.

6) *External Advisory Board*: Templates, plugins, some "help functionality" directly in the modelling software would be great idea from industry practitioner's side.
ACCORD: This is an excellent suggestion, but it is not within the scope of ACCORD to develop this. However, we will produce industry recommendations as part of our work, and this will be incorporated here.

6.6 Conclusion

This section has described the revised ACCORD framework that has been developed considering the user requirements elicited in Sections 3-5. This revised framework and definitive list of user requirements will play an important role in later tasks of the ACCORD project:

- It will inform the development of the Building Compliance Ontology in Task 2.2.
- It will inform the development of the Manual, Hybrid and NLP based formalization methodology, and the supporting rule formalization tool in Tasks 2.3-2.5.
- Finally, it will provide a starting point for the elicitation of technical requirements (Task 4.1) and the design of the ACCORD cloud platform (Task 4.2).

7 Discussion and Conclusions

This deliverable has documented the revised ACCORD framework and its user requirements. The process of developing these user requirements and the revised ACCORD framework has been through the integration of high-level requirements (elicited in D1.1), the original ACCORD vision presented in the proposal and demo-specific requirements. These user requirements and the refined ACCORD framework will be used as the basis for eliciting the technical (functional and non-functional) requirements of the ACCORD framework components, which takes place in WP4 (T4.1).

The demo-specific user requirements were collected in all country demonstrations using three approaches. First, the current as-is building permit processes were analysed. The current as-is building permit processes were described as part of ACCORD's D1.1. Then, a digitization scenario/storyline was described. These stories described how the building permit process stakeholders will most probably use the ACCORD methods and tools in their practical work in the future. Finally, visionary to-be building permit processes were modelled.

The methodological approach allowed to elicit the demo-specific user requirements which are part of specifying the ACCORD demonstration deployment. As a result, the demo-specific user requirements elicitation was based on both the current as-is building permit processes and visionary to-be building permit processes. This approach will support the elicitation of technical requirements for future tools and services in T4.1.

It must be noted that the selection of the methodology for user requirements elicitation was done deliberately to enable it to support the future tool development. As only the "as-is" processes were modelled in detail (in D1.1), "to-be" processes were modelled at a high level to support an understanding of the future vision of each pilot, however these will be further extended in later tasks.

The country-specific demonstrations (WP5) are supported by other ACCORD work packages, especially WP3, and WP4 and vice versa. Figure 21 illustrates the connections between these work packages in terms of inputs and outputs. The figure also describes the methods used.

The to-be building permit processes derived as part of this WP (T1.3) will be used as an input to WP 3 where these initial to-be process descriptions will be enriched with more detailed information on data flows and data content requirements for the demo-specific deployments.

The to-be process descriptions were supported by the input from WP5, specifically the use case definitions. Other input from WP5, checking rule definitions, will support the technical requirements elicitation (in WP4).

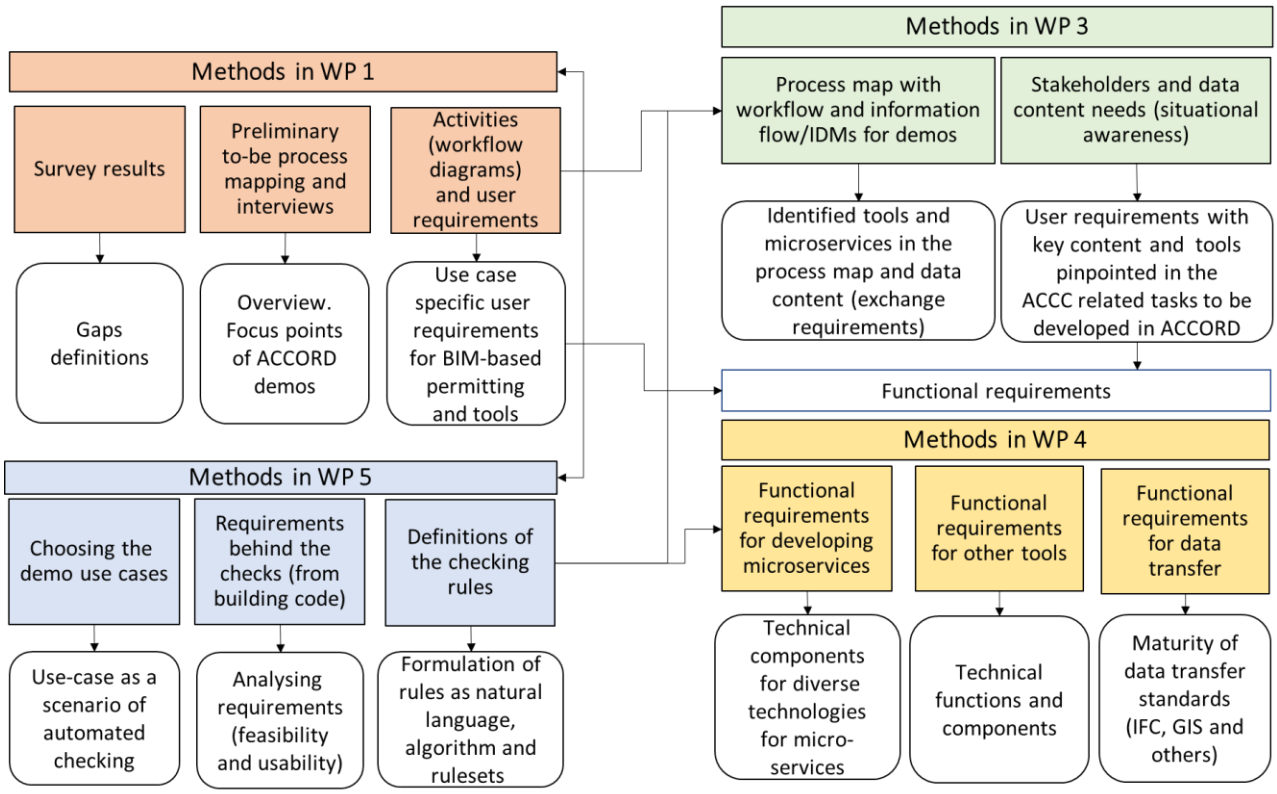


Figure 21. The connections between the WPs regarding the methods used for gathering data, describing processes, and defining user and technical requirements.

During this work, the ACCORD partners were able to understand the digitalisation process of building permit processes more thoroughly. For example, buildingSMART International (bSI) regulatory room has developed a four-step maturity roadmap toward automated building permitting. Taking this roadmap as a starting point, ACCORD could identify additional steps toward automation. The first step in the bSI roadmap is *manual* where data exchange takes place through drawings (pdf). The second step is *BIM initiation* where communication between authorities and building permit applicants takes place in a cloud-based service. The third phase is *hybrid* when the authorities re-use public data and 3D models for visualisation. Finally, the fourth phase is *automated*, when the whole regulatory building permit process is automatically controlled and data flows between private and public databases. In addition to these steps, ACCORD would like to add two steps and rename *BIM initiation* and *hybrid* steps:

- step 1: *manual* data exchange
- step 2: *automated information exchange*, which refers to automating the submission of project information for building permitting using appropriate data models.
- step 3: *automated validation*, referring to automating the validating of information submitted for completeness.
- step 4: *partial automation*, meaning the automatic assessment of some key aspects of the building permitting process.
- step 5: *automation*, referring to the fully automated assessment of the entire building permitting process but requiring final human review for approval.
- step 6: *fully automated* building permitting.

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