Reporting

Proof of Concept 3D Ownership Documentation based on BIM models
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Chapter 1. Introduction

In the context of the implementation The Basic Subsurface Registration (BRO) with data such as cables and pipelines, underground infrastructure, tunnels, etc., is frequently used to perform Proof of Concepts (POCs). The purpose of using POCs is twofold. In the first place, it can be demonstrated very clearly what the possibilities and added value of the new registration are. Second, it is an opportunity to experiment and learn which challenges and opportunities lie with the (re) use of the information from registered objects. One of the questions that has been around for some time is how to deal with capturing 3D properties (buildings, apartments, etc.). This concerns underground and more complex objects and intertwined properties, in particular based on BIM models. For this question, Future Insight was asked to perform a Proof of Concept.

The question

This proof of concept focuses on the question whether this concept also meets the needs of the notary as an important pivot in this process, especially with transfer, but also with 3D splitting (a wish expressed by notaries themselves). The need from the daily work process of a civil-law notary was the starting point. The aim was to set up an easy-to-use working online demo that can be operated by a notary himself. This is an important precondition for successfully implementing such a solution.

Worldwide research has been done into capturing 3D properties. A standard data model (Land Administration Domain Model, LADM, ISO 19152: 2012) is available for this and an attempt is being made to develop solutions for the registration of 2D, 3D and a combination of 2D and 3D objects. The idea that BIM models can be an important source of this is widely supported and researched. BIM models are becoming more popular and due to the wishes and developments to deliver new constructions in BIM from now on, it is expected that a large number of IFC files will be available in the near future. BIM models are a good basis in theory, because they are very detailed, rich in context, semantics and geometry. Moreover, a BIM environment offers the possibility to record additional information (in addition to 3D geometry) in the model (such as materialization, nuisance contours, soil status / reports and legal information).

The IFC standard is an international, standard and open data model for the exchange of physical information that is defined in 3D BIM models in the domains of Architecture, Engineering and Construction (AEC). For this reason, research has also been conducted to see whether a logical relationship can be established between properties and available objects in the BIM model and specifically in IFC format. The relationship with LADM classes 'ifcSpaces' and possibly 'ifcZones' seems suitable for this, since they are used for modeling spatial units and can be grouped based on the same characteristics. In addition, the geo-reference aspect is investigated (since it must be checked whether there is overlap between adjacent buildings), and index numbers in an IFC file to indicate which rooms belong to which apartment.
Future Insight has extensive experience with the use of BIM in relation to its application in government processes. For example, we carried out the design of a successful PoC for an automated BIM permit check for Estonia (https://youtu.be/cmOYWyJDMWY). Our distinctive strength is that, in addition to using open data standards and scalable web-based technologies, we always take the end user as a starting point. What is the problem of the end user and how can we offer a solution with the right techniques and data? We have also applied the approach, experience and technologies from these projects in the implementation of this PoC.

![Example of the Proof of Concept BIM based permit check in Estonia](image)

**Chapter 2. The approach**

An important precondition for carrying out the proof of concept was to find an enthusiastic end-user, a civil-law notary, who wanted to help think about the approach. In the often legal playing field of notaries, innovative solutions with regard to technology do not have the highest priority. Through our network we already had contact with Lars Boellaard of Westport Notarissen NV and Jean-Paul Bolhaar of Hermans & Schuttevaer Notarissen NV. They have been working on the BIM legal initiative together with BPD for some time. An approach in which legal and administrative information, along with the legal source documents, are combined with the corresponding physical spaces of the objects, extracted from detailed BIM models.

In addition, collaboration has been sought with Delft University of Technology with researchers from the GIS technology department who are actively involved in this subject (Prof. Dr. ir. Peter van Oosterom and ir. Eftychia Kalogianni). They are active in various international research projects around the 3D Cadastre / 3D Land Administration and have actively helped to establish the connections with the latest developments and relevant standards that are being worked on in international studies. They are also part of the core team of the ISO 19152 LADM revision.
After an initial meeting with the gentlemen notaries, the ideas turned out to be a good fit. Both civil-law notaries see the construction task facing the Dutch government to reduce the housing shortage. At least 845,000 homes must be built by 2030, according to figures from Statistics Netherlands and the NEPROM report ‘Home in the future’. Practice shows that more and more and more complex conditions have to be processed in the deeds (complex high-rise buildings, overlapping properties with overlapping rights and/or restrictions, underground constructions, etc.). This is an enormously complex and error-prone process, whereby the current, often analogous, process based on 2D floor plans does not work properly. Reality is 3D. The current process produces a quantity of file folders of 15 meters, which should also be possible in the opinion of the notaries.

This traditional way of working does not meet the needs of clients (project developers), buyers in new construction projects and is (too) time-consuming. Moreover, the aforementioned civil-law notaries foresee that innovation is necessary in order to achieve a reduction of legal failure costs that are experienced in the process from acquisition through a project development to the sale of individual homes and the delivery thereof through a shortening of the chain.

That is why they together with Bouwfonds Property Development (BPD) started BIM legal, where BIM is used in the sales process. However, the vision goes further, so much so that transfer deeds can be generated on the basis of extra data that is linked to a BIM model. This does not only concern the recording of ownership (exclusive use), but also, for example, shared use, joint installations such as heat pumps, easements, and so on. But also think of the recording of agreements that owners now no longer have in 15 meters of documentation folders, but can be consulted online. Many of these agreements can be easily and digitally linked to a BIM model, after which they can also be found much more simply and unambiguously later. In short, not only the building, but also the area is also modeled. In the current world of digitization and (freely) accessible information, private individuals/consumers demand that their purchases are made transparent in a transparent manner. In addition to the legal information, this also includes the other properties of a building or area (such as materialization, with a view to “The Netherlands being circular in 2050”).

However, this is only the first step to subsequently record this information in purchase agreements and deeds of transfer. The possibility to subsequently record these 3D (ownership) relationships in the land register means that from the drawing board, via the purchase agreement and the deed of delivery up to and including the end of the existence of the building in question, the same 3D environment is used. It is this registration with the land registry that makes much more possible. For the sake of brevity, reference is made to an article by the aforementioned civil-law notaries Boellaard and Bolhaar in the Tijdschrift voor Bouwrecht (TBR 2019/43).
For the proof of concept, however, we have now limited ourselves to recording exclusive and shared use, with a focus on aligning as much as possible with the current work process. To this end, we conducted various interviews with employees who specifically prepare these deeds. The 2D construction drawings are an important source here. On this basis, files are defined, after which an active search is made in the drawing for possible usage rights and restrictions that need to be recorded. Together with these users, a sketch was also made of the functionality and user interface of the proof of concept, taking this work process as a starting point.

The technical set-up

Prior to setting up the proof of concept, a number of technical preconditions were established.

1. The solution must work on the basis of open data standards, which enable interoperability and communication between the various components of the system architecture of the PoC.IFC is used for the BIM data, this international standard (ISO 16739: 2017) is generally accepted and is widely accepted and used. CityGML is used for the 3D Digital Twin (ISO TC211) components. This open international OGC standard that models all characteristics of the built environment is also generally accepted and widely used. This solution also supports ISO 19152: 2012 LADM implementation.
2. The solution is web-based and must have a simple user interface. This makes the solution more scalable and easier to use.
3. Data storage and transfer is based on online databases, open APIs and web services. The solution is basically scalable and flexible both vertically and horizontally. This makes it possible to use it on a very large scale (think of the whole of the Netherlands) and very broadly (basis for many different web applications). By using open standards, the solution ensures that it can easily communicate with other databases and systems and absorb data from them.

Reporting Proof of Concept 3D Ownership Record
We use these preconditions from Future Insight for all our projects and activities, but were also very relevant for this PoC. A rough outline of the technical infrastructure is shown below. It is good to know that exactly the same parts are also used for the BIM permit check service that we are currently developing for the Estonian Environment Desk.

Chapter 3. The result
The main functionality of the application in this PoC is to be able to upload IFC models yourself and then enrich them with additional information. In this case, it concerns usage rights for spaces within the model (ifcSpace). Below is a representation of the final web application. Striking is the similarity with the first sketch that was made together with the user. The working proof of concept can be accessed via: [https://bim.nederlandin3d.nl/](https://bim.nederlandin3d.nl/). The login details are provided to the client separately by e-mail.
The working process in the application consists of the following steps.

**Projects**
First, the user simply creates the project himself. After opening the project, it will appear in the window above. Within such a project the following items can then be added:

- BIM (IFC) Models, these can be uploaded to the BIM database
- Files, these can be created. There are two variants of this:
  - General file (for rooms with general use such as installation rooms)
  - Regular file (for rooms with exclusive or partial use)

**Files**
In a regular file, the following information can be stored:

- Files (for example, a division deed)
- Rooms for exclusive use (living room, bedroom, toilet, kitchen)
- Spaces for shared use (hall, entrance, etc.)

A general file is comparable, only one type of space can be selected here (general use).

**Viewers**
Both the BIM models and the extra data (files) are made transparent in two viewers. A BIM viewer and a GIS viewer, these can be selected at the bottom of the screen. The BIM viewer is used to link the usage rights within the BIM model and the 3D GIS viewer can be used to view the project in its environment.
1. **BIM Viewer**

In the BIM viewer (part of) the BIM models is shown in both 3D and 2D view. The 2D view (floor plans) supports the 3D view and is available as 'picture-in-picture'.

At the top right of the BIM viewer are several buttons that contain the following functionalities:
- Filter by type of IFC objects
- Select floors:
  - 2D viewer: exactly 1 floor
  - 3D viewer: 0 or more floors
- Default views: Top, Side, Front
- Transparency: all ifcTypes except ifcSpace become transparent

The right of use for spaces for specific files can be added by selecting this file on the left side of the window and then clicking on the pencil next to 'exclusive' or 'general' use. Then the relevant ones can be selected simply by clicking on them in the 2D or 3D viewer.

In both viewers, the following colors for files are used for the ifcSpaces:
- blue / purple: general area
- green: area for exclusive use
- yellow: area for shared use

The colors of the associated areas of the active (opened) file are colored darker.

In the 3D viewer it is possible to make a small part of the GIS context visible. These LOD1 buildings come from the 3D BAG layer from the Netherlands in 3D.
2. 3D GIS Viewer

A more complete GIS context can be found through the GIS viewer. In this viewer the BIM models in the environment are shown. Only the outside of the model is automatically shown, so that the online performance is still good.

![3D GIS viewer](image)

**GeoLocation**

Unfortunately, IFC models currently usually do not contain the correct geo-location, but if it is present, the model will end up in the correct location by default. If the location is not there, the model can easily be manually placed in the right place.

**Functionality**

Various buttons with relevant functionalities are also available in this viewer at the top right of the screen:

- Move the camera back to the starting position
- Make terrain transparent (for underground information)
- Edit (geo) location
- Switch base layers
- Select map e.g. cadastral map / zoning plans
- Switch 3D building
- Show / hide terrain
- Show / hide shadows
- Hide 3D objects (for example when it is at the location of the design)
- Zoom in on the BIM design
Open data (standards)
Because structural use has been made of open data standards and components, such as WMS, 3D Tiles and glTF, the current example data can easily be expanded with additional (3D) map layers.

The following datasets are currently available in this poc:
- terrain: AHN
- 3D buildings: BAG
- overlays: spatial plans, cadastral map, boundaries of map, map
- base layers: open street air national geo register, BRT

Chapter 4. Lessons learned
- Despite the fact that notaries in general are not known for digital and technological progress, there is certainly room and need for innovation and concrete opportunities for these kinds of developments are seen. The need for innovation is experienced due to the increase in the complexity of the buildings to be realized. Furthermore, inner-city developments teach that connections between adjacent properties, established in a traditional (written) way, are increasingly difficult or hardly to fathom. Moreover, the notarial profession is experiencing that the desire to achieve a circular economy with associated buildings increases the demand to record more detailed property relationships. With good concrete examples such as these and clear steps, much progress can be made in the short term, while the current method of recording is no longer (sufficiently) in line with the developments and needs mentioned.
- There is a need for better and user-friendly tools to properly and unambiguously record the increasingly complex information of overlapping property rights and restrictions. Often the tools are still too technical and complex. The consulted notaries and employees of notary offices were enthusiastic about the results that can be easily achieved with this PoC. With a further development of the tool, they provide an accessible and efficient way of recording properties and associated rights. The intended method will furthermore result in an acceleration of the method, because it is possible to record the properties and associated rights by the lawyers involved in the 3D environment. This leaves the current practice, in which another party is required to convert the intended legal relationships into (currently) 2D drawings.
- The recording of rights of use for underground information such as a source for a heat pump is becoming increasingly topical in this regard. By including this in the BIM model, this can be properly registered. Below is a representation of the recording of shared use of the source of a heat pump.
The quality and content of supplied IFC models is generally still very diverse. Depending on the makers of the BIM / IFC models and the purpose of the models, there are several flaws and differences to discover; such as the absence of the necessary elements / classes, such as: ifcSpaces, ifcZones and a geo-location stored in a just way. Supplying such a heat source, for example, does not normally go well either. We added it ourselves for this proof of concept. That is why it is so important to develop guidelines for modeling BIM / IFC files used for cadastral registration.

The understanding of the added value of the use and support of open standards leaves something to be desired. In both the BIM and GIS domain, the market is dominated by large market parties that do not support them well and promote their own internal formats. This makes it still difficult to get good IFC models.

The available Basic ILS for IFC is a good start to create more uniformity in supplied BIM models. However, it is still too general for applications such as this and, for example, an automatic permit check. One of the useful additions to this can, for example, be grouping the ifcSpaces of one residential unit in an ifcZone. We also see the same structure developing in the permit project in Estonia.
Chapter 5. Challenges
Organizing the lifecycle
In principle, all technical components and data standards are available for the implementation of such a system. At the same time, many additional agreements and further specification of standards are needed to connect the various parties in the life cycle of a building. It is important to enthuse the parties in the life cycle with these kinds of inspiring examples and to let them experience the opportunities and possibilities of cooperation in the chain. By involving the chain partners in these concrete experiments, it is possible to work step by step on the further development of knowledge, agreements, solutions and associated standards. Such a circular approach requires close cooperation and coordination between stakeholders, a relevant legislative framework and standards that enable this communication, both at the data and system level.

Different BIM versions
For different phases in the design, different types of BIM models are made. Think of a Preliminary Design, a Final Design, but also, for example, an ‘as built’ version of a BIM design. In particular, agreements will have to be made about the exact content, accuracy and, for example, delivery date of these different versions in order to avoid misunderstandings.

Submitting user rights to a national 3D property database
In this proof of concept, we only concerned ourselves with the needs of the civil-law notary and the concrete recording of user rights based on BIM. We have not looked any further into a possible follow-up step in which these rights of use are merged at a national level into a national 3D ‘ownership’ database. As indicated earlier, for example, the CityGML standard (version 3) as well as the ISO 19152: 2012 LADM supports. The second edition of LADM, which is currently under development, has a broader scope, including valuation information, spatial plans, marine spaces and various technical implementation solutions that enable data exchange and communication with other standards. There are already various initiatives for this internationally, in which this is being further elaborated, such as research into the (re) use of BIM files at 3D Cadastral Databases in Australia (Melbourne³) and Malaysia⁴ in pilot projects. In both cases, the tested cadastral databases were based on LADM. At prototype level, a recent study in the Netherlands proof of concept⁵ proposed of a complete data processing chain for registering new apartment rights in 3D (with minimal modification of the current procedures). The idea is to enrich IFC files with information about ownership units. All these developments are carried out in pilot projects, but using real-life examples. However, it has never actually been put into practice anywhere on a national scale. It is interesting to note here that Estonia is explicitly looking at whether the central BIM facility that is being set up for the permit check can also be used to accelerate the 3D cadastral developments in the country.

Security of central data storage
When important data such as property is stored centrally and digitally, it is important that this is done ‘securely’. Such a central 3D property and BIM database will have to be set up in a well-secured manner. Reference could be made to the originally supplied IFC models, which should ultimately be digitally signed with a higher reliability level of eID. In the project in Estonia, where the eID is already widely used, this is also used and the official IFC models will have to be delivered digitally signed.

Legislation
Laws and regulations are not our expertise, but for a highly legalized environment such as this, laws will undoubtedly have to be amended. The legal changes required to implement 3D Land Administration Systems are under investigation, and from time to time there are aspects related to BIM. There are several studies (at national level) regarding legal mandates / implications for BIM (especially in the UK).

Availability of simple tools
At the moment, BIM is mainly used in very technical environments for a very technical target group. The potential is much greater, but because the technology and deployment are often still very complex, the reach is very limited. In order to reach this larger target group, it is very important to offer simple, simple process-oriented applications using modern web techniques.

Chapter 6. Next steps
Based on the Proof of Concept it has become clear that in terms of need there are concrete opportunities for recording 3D ownership and usage rights based on BIM models. In terms of technology, all necessary parts are now available to fulfill this need. Of course, there are many challenges to ultimately achieve a comprehensive lifecycle and ecosystem, which will probably take years of development. The question is therefore what the next concrete steps should be, in which on the one hand the most important challenges are tackled and on the other hand added value and extra energy are immediately created.

Below are a number of steps with which we would start from our experience.

1. Broadly speaking, the technology is there. Given the size and complexity, a further interpretation of the exact need and interpretation will require a more agile approach. To this end, first carry out more separate PoCs with different user groups to clarify the needs, requirements and further interpretation of the technology. Together these provide input for a possibly larger follow-up plan. Consider, for example:
   - Further fulfillment of the user needs from the notary, whereby further attention is given to the recording of property and the associated rights in the flat surface, stacked property and “layered property” (above and below ground). Also consider further splitting up existing spaces and also involve other types of 3D spatial units; eg related to (underground) utilities, or tunnels;
   - Translation of this type of recorded ownership data on the basis of BIM into a country-wide 3D database (in accordance with ISO 19152 LADM);
   - Experiment with establishing more detailed interior / exterior space separation: do exterior / interior walls belong to the apartment or are they separate legal areas? Where is the boundary of the apartment? On the inside of the wall, on the outside
or in the middle? The same also applies to the facades (all of which are also related to legislation);
- Drawing up more detailed delivery specifications, testing them and coordinating feasibility with BIM designers. Also include the various standard delivery times and specifications. For example, use IFC files as actually submitted to municipalities for building applications (and upgrade for 3D LA if needed). Complete the specifications based on this;
- Investigate the possibilities of a digitally secure file transfer and storage with, for example, eID. For example, also work together with Estonia, where this has already been arranged and include the way in which notaries already exchange data with the land registry in a secure environment;
- In line with the identified needs, investigate which legislation is blocking and should be amended. This can lead to the drafting of legal guidelines to enable efficient reuse of IFC files (as submitted for building permits).

2. A technical facility is required to carry out these PoCs. Set up a flexible and scalable experimental environment for this, which can be expanded step-by-step. A number of starting points for this are:
   - Central open BIM database
   - Central open Digital Twin database (must comply with ISO 19152 LADM), where IFC and GIS data (2D cadastral map, buildings without IFC model) are integrated
   - Use of open standards and APIs such as IFC and CityGML

3. There is a great need for direction and explanation about the possibilities of the 3D digital transition in the Netherlands. Actively facilitate this by providing frameworks and showing examples, such as through the results of the PoCs. This gives parties a better picture of the possibilities and preconditions.