3D Cadastral Lifecycle: An Information Delivery Manual ISO 29481 for 3D Data Extraction from the Building Permit Application Process

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SUMMARY

The lifecycle of a 3D cadastral spatial unit and its associated rights, restrictions and responsibilities is made up of many different parts and substages (Van Oosterom 2013). One part could be the extraction of 3D data from building permit application process. This paper looks at how this process could be coordinated with a number of other processes and the 3D data used for a variety of purposes including testing conformance to building regulations, rates assessment, inclusion in a national topographic map and asset management. An associated use case narrows the scope and illustrates how software which uses the Design and Engineering Methodology for Organisations (DEMO) (Dietz 2006) as reference can be used to facilitate this process.

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1. BACKGROUND

The world of GIS has long called for the need for location data, innovation and collaboration (Rabjabifard 2012) to help our society develop sustainably and to help it rise to the many challenges that face it. These three elements form the basis for effective evidence-based decision making. In Europe, the central tenets of the INSPIRE directive sought to underpin these developments[1]. More recently the Smart Cities movement has rebranded the dialogue (Roche 2014) but fundamentally left it unchanged. One aspect of the Smart Cities movement is the desire of governments around the world to use detailed and up-to-date information to operate with increased efficiency and cost effectiveness at a city if not national level (Oldfield et al, 2017).

In the world of Building Information Modelling (BIM), a similar dialogue of location - although this time in the form of 3D digital models integrating information from Architecture, Engineering, Construction and Facilities Management (AEC/FM) (Liu et al, 2017) - innovation and collaboration has been taking place. Innovation has been on many fronts such as linked data, increased granularity and the inclusion of surrounding information or geo referencing (Liu et al, 2017). Collaboration in heterogenous environments has been assisted by the development of standardized exchange formats such as the open Industry Foundation Classes CEN ISO 16739 (IFC) and by the development of open process standards such as the Information Delivery Manual CEN ISO 29481 Parts 1 & 2 (IDM).

1.1 Information Delivery Manual CEN ISO 29481

When comparing BIM and GIS, emphasis is often placed on levels of detail, differences in data models and dimensionality of the data and on the interactive maps of GIS or the detailed 3D models of BIM (Rafiee et al, 2014 & Van Oosterom et al, 2005), rather than the processes which support the creation and use of these models. The Information Delivery Manual was developed to assist administrative processes and information flows.

The Information Delivery Manual CEN ISO 29481 (IDM) has two parts and is an international ISO and European CEN-standard. At an international level ISO 29481-1 is subtitled 'Building information models -- Information delivery manual -- Part 1: Methodology and format' On a Dutch national level the first part is called the Informatie Levering Specificatie (ILS) (translated: information delivery specification) and is intended as a guideline on how to follow the international IDM.

[1] http://inspire.ec.europa.eu/inspire-principles/9

The ‘Basis ILS’[2] is another type of Dutch Information Delivery Specification but has no relationship with IDM CEN ISO 29481. The Basis ILS is a practical modelling guide. The Basis ILS (Basic IDM), which is also maintained by the Dutch BIM Gateway and widely adopted in industry, defines general and actionable guidelines on how information should be exported to IFC to make models as unambiguous and useful for reuse as possible. The Basis USO[3] extends the Basis ILS by taking a similar approach to openings in elements such as walls and floors to coordinate for provisions for ducts and pipes, an effort in which many disciplines intersect.

The second part of IDM is the Information Delivery Manual ISO 29481-2 subtitled the ‘Information Delivery Manual Part 2, Interaction Framework’. In the Netherlands, the comparable standard is entitled VISI or ‘Voorwaarden scheppen voor Invoeren van Standaardisatie ICT (in de bouw)’. This could be loosely translated as ‘Let’s lay some ground rules before introducing information technology (in the construction sector)’.

The IDM Part 2 facilitates communication and cooperation between people from different organisations or different departments within an organisation. IDM part 2 is an open BIM-standard. It is based on Design and Engineering Methodology (DEMO), a scientific theory postulated and developed by prof. dr. ir. J.L.G. Dietz (Pluijmert et al 2016). This methodology is based on φ theory, or Performance in Social Interaction theory which postulates an operation, a transaction, a composition and a distinction axiom, integrates these in an organisation theorem and then presents The Crisp Model (Dietz 2006). The overall goal of φ theory is to extract the essence of an organisation from its actual appearance. In doing so universal socio-economic patterns of coordination that hold true for all enterprises are revealed (Dietz 2006). These are the patterns of coordination which promote business like and professional cooperation. Basing the IDM Part 2 on these coordination patterns is a guarantee that VISI is relevant both now and in the future (Pluijmert et al 2016).

1.2 Enterprise Ontology: DEMO

Figure 1 below illustrates Dietz’s transaction pattern between different actors with text written in blue – request, promise, state, accept. These are production acts and fulfil the operation axiom. The fact that the actors are human and can occupy different roles is represented by the hats. The figures on the left represent the initiator and those on the right the executor who fulfils the request (Dietz 2006).

The text in red outlines coordination acts, the second part of the operation axiom, where in contrast to production acts where goods and/or services are produced subjects enter into and comply with commitments towards each other aimed at production. There are three phases in the transaction which are also described by the text in red; the order phase (proposition), the execution phase (produce product) and the result (result) phase (Dietz 2006).

[2] http://bimloket.nl/BIMbasisILS
[3] http://bimloket.nl/BasisUSO

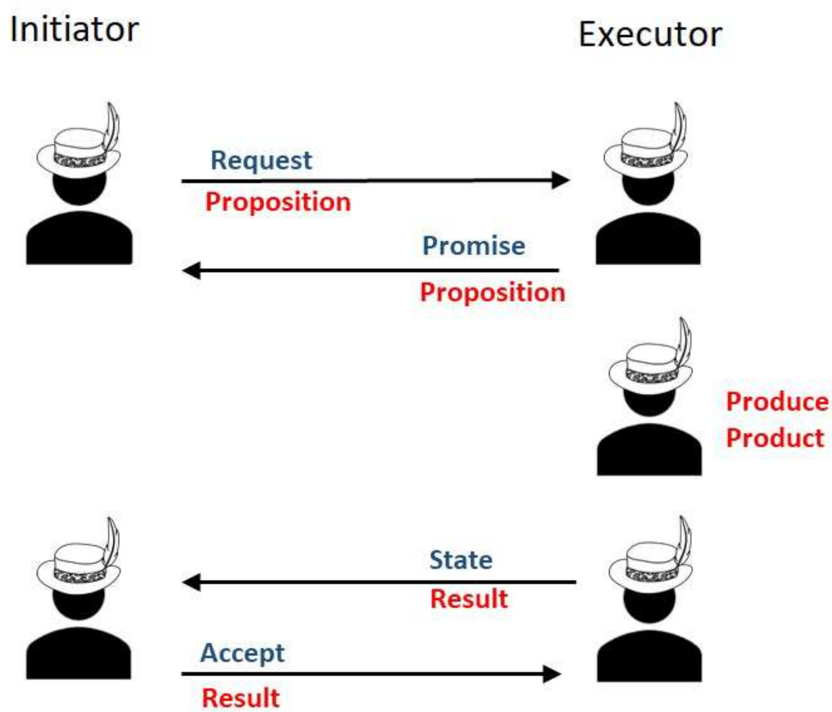

Figure 1. The transaction pattern (*based on a diagram from Pluijmert 2017***)**

DEMO is used to build a cooperative model which defines roles, responsibilities and transactions. Wherever there is cooperation between two roles there is a transaction. If one role wants the other to do something for him then this is detailed in a transaction. Every transaction or communication is clearly defined and details what needs to be communicated in return. The transactions are made digitally within a software environment, which also allows files to be transferred, stored and made accessible to all of those involved in the project. The DEMO model is made up of a network of these roles and transactions that is called a framework within the context of the IDM (or VISI 'raamwerk' in the Dutch context) (Pluijmert 2017).

1.3 3D Cadastral lifecycle

Much of the spatial data currently in use in the Netherlands is 2D or at best 2.5D data – 2.5D pairing a 2D footprint with a uniform height, therefore not enabling complex spatial relationships such as underpassings. This includes the Land Registry Map (Kadastrale Kaart) and the National Topographic Map (Basisregistratie Grootschalige Topografie – BGT) Having these maps in 3D would provide many advantages, including improving spatial analyses for example in a disaster situation or calculating population (Biljecki 2015) to reducing the potential for conflict in relation to property ownership (Stoter 2004). The conceptual Land Administration Model (LADM) ISO 19152 provides a flexible blueprint for the design of a 3D Cadastre. The idea of the complete lifecycle of a legal space and any constructions built within it being in 3D has also been proposed (Van Oosterom 2013).

Ideally, as listed in Van Oosterom (2013) the complete lifecycle of a legal space and any constructions built within it would be in 3D. This would begin with a zoning plan developed and registered in 3D. Both the public law restrictions pertaining to this zoning plan and the Land Registry public law restrictions would be brought to life in 3D. After purchasing the land or space, spatial units or objects to occupy the legal space would be designed in 3D and then submitted for approval. Whether the newly designed spatial units or objects conformed to the public law restrictions surrounding the legal space would be checked and the resulting permit provided in 3D. Mortgages would be obtained and registered in 3D. Spatial units would be surveyed and measured post-construction in 3D and the deeds submitted in 3D. This data would be validated and checked, and then if it were found to be acceptable, registered in 3D. These spatial units could be stored in 3D and then used for analysis and the spatial units be disseminated, visualized and used in 3D.

1.4 Full BIM lifecyle

Concurrent to research in the world of GIS to have data submitted and stored in 3D are movements within the world of BIM to achieve this. In a presentation given by the Dutch BIM/GIS standards organisation in 2017 (Duivenvoorden), this issue is related to the Dutch Archiving Law which currently proscribes that data be submitted in the open Portable Document Format (PDF) standard. The submission of 3D BIM in IFC format would allow data to be digitally archived, remain available and accessible in the long term and be stored in a machine readable data model. Where PDF merely documents the graphical appearance of a work in printer friendly environment, IFC allows to publish the underlying semantics. The data obtained through the building permit application process by means of the digital permit application gateway (Omgevingsloket online) could be stored in the Information House Buildings (Informatiehuis Bouw) dossier. The Information House Buildings is a part of the Dutch national Digital System to be set up under the Environs Act. It would also form a part of the Electronic Building Dossier (Elektronisch Gebouw Dossier (EGD)) to be set up under the Quality Construction Act (Wet Kwaliteitsborging voor het bouwen (WKB)) for the purposes of asset or facilities management. It could then be stored digitally in conformance with the Dutch Archiving Law (Archiefwet) In general it would be made available to a wide variety of authorized and cooperating parties, both business and government. In the Netherlands building permits are generally applied for with 2D drawings. In the municipality of Amsterdam, for example, applications are uploaded in the majority of cases to a website – a digital permit application gateway (Omgevingsloket online) - in the form of 2D PDF documents or photographic images in jpg format. The application is checked with software to see if it adheres to building regulations, given a digital stamp and returned by email. (Marzabal Galano 2018). If this process could be further automated, then whether a design conforms to its building regulations could be tested automatically (Marzabal Galano 2014), such as implemented in the Singapore CORENET effort (Eastman et al., 2009).

In an interview, (Marzabal Galano 2018) it was stated that the main challenges facing the automation of the building application process were that the IFC models on which the permits were granted could be changed after permission had been granted, that a solution to giving an automated legal stamp would need to be found, and maintaining the readability of files for the future.

The submission of 3D data at a municipal level would enable many other applications. The municipality of Rotterdam, for example, would like to be able to asset managed buildings and include them in wider city models. In particular, they would like to be able to georeference a building, know its shape, size, details of its interior, its functions and inhabitants. They would like to be able to visualize it, know what materials were used in its construction and be able to use it to tell a story. Lastly, they would like to be to be able to check it for technical issues regarding health and safety; does it comply to evolving building regulations, how was it built, what utilities it possesses and what systems it has in place (Goos 2017)?

2. METHODOLOGY

The generation and re-use of 3D data from both design (BIM) and survey (GIS) sources could be facilitated by writing an Information Delivery Specification, based on an IDM-methodology. This manual or specification would structure the use of information being exchanged back and forth between those involved in the process of data acquisition, management and use. The research goal of this paper is to further explore such a multi actor workflow and to supplement it with a use case. This use case narrows the scope down to two interactions; an initial request for a building permit and the enforcement of the building permit based on a 3D design if its conditions are not met. The use case is illustrated with software designed with reference to IDM Part 2.

An example of a use case where an IDM would be instrumental in aligning the building permit application process and the many governmental bodies which would benefit from the data is illustrated in Figure 2 above. In this case data from building permit applications is assessed and processed by the municipality and the Land Registry. The process is simplified and does not rule out the addition of further actors, roles or registrations. This is one scenario set within a Dutch context. What is required to set up a 3D Land Registry will vary case by case from country to country and is driven by user needs, market forces, the legal framework and what technology is available (Van Oosterom 2013). What is feasible depends on BIM implementation levels in industry and incentives to comply with the aim to share and reuse data.

The use case in Figure 2 below encompasses design data obtained from the building permit application process which is processed by the municipality. It is tested to see if it conforms to the national building codes[4], area information and geometry is extracted from it and data from it is used for use in the valuation for tax purposes or rates assessment[5]. This data is then passed on to the Land Registry and the Topographic Map of the Netherlands.

Figure 2 illustrates several ways in which 3D representations obtained from building permits could be used. One or several IDMs could be written or designed aimed at maximizing the use of IFC files submitted during the building permit process. For example, in ‘standard’ IFC files which define physical spaces the ownership units are usually not explicit. Instead virtual

[4] Bouwbesluit
[5] WOZ

spaces or objects in IFC files which were made up of a combination of virtual and physical spaces would need to be defined in order to adequately represent legal spaces. 3D parcels could then readily be extracted (Oldfield et al 2017).

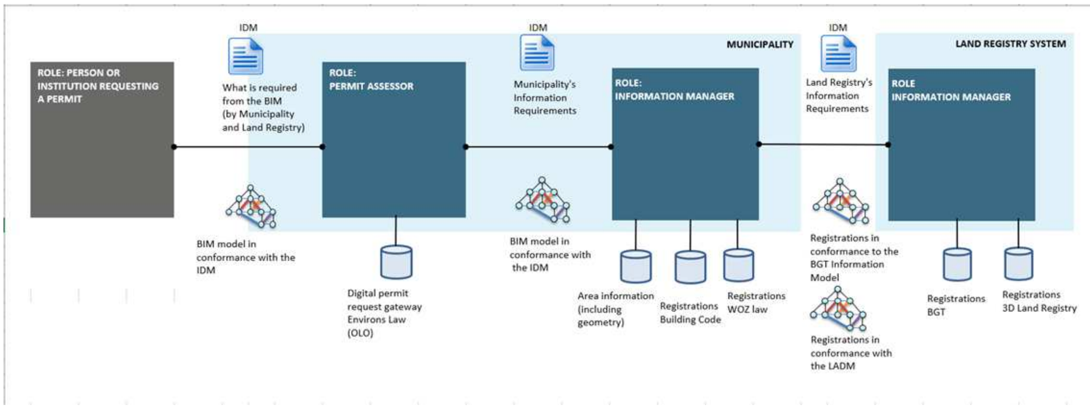

Figure 2. One part of a complete 3D lifecycle

One benefit of reusing the IFC data obtained from building permits is that it would help prevent inconsistencies in the data and facilitate its use. Interoperability would also be underpinned by the use of open standards ensuring that the data would remain operable and understandable for a long time. Furthermore, IFC files are a detailed source which include the interiors of buildings and which can effectively be visualized. The fact that it is a data source which is already being produced makes its acquisition cost effective.

Currently, only one construction drawing or model is taken into consideration by Dutch law. This is the drawing or model on which the building permit is granted and which recieves a stamp to show that it has been approved. (Marzabal Galano 2018). In the workflow suggested in Figure 2, this model would be the ‘As designed’ model. Under the new Environs Act which has been passed but which has yet to be implemented, two models will be taken into legal consideration and kept in government archives. The second model, an ‘As Built’ model, would include information about what materials have been used and alterations which can have been made to a construction without requesting a new permit. In order to meet the challenge of an As Built model remaining within the boundaries of a permit granted on an ‘As Designed’ model, and thus retaining its legal status, the two models would need to be compared. This could be a task for building inspectors. If the As Built model infringes its permit, the building would lose its legal status.

A further step which could be considered is the submission and storage of an As Sold model. An As Sold model would be of particular interest to a Land Registry as a building may be subdivided and sold in a different way to which it was intended to be when a permit was granted on an As Built design. Such a model would also need to have a legal status complete with stamp to show that it adhered to Land Registry regulations in the same way that an As Designed and As Built model would have a legal status and stamp to confirm that it adhered to building regulations.

The workflow illustrated in Figure 2 extends the work of a previous paper (Oldfield et al) which detailed a workflow in the Business Modelling Process Notation (BPMN) which makes up a part of IDM Part 1. This workflow described how 3D topological GIS surface objects which conform to the geometry requirements of the Land Administration Domain Model (LADM ISO) could be obtained by digital means by first defining a Model View Definition to produce generalized objects which could then easily be converted and then be filed in the current Dutch Land Registry database for use in a future overview map. These objects, which as described above could be made up of a combination of virtual and physical spaces, would more adequately represent that 2D parcels imply 3D columns (Stoter et al, 2004).

This design data approach is different from the approach which takes existing IFC data and then attempts to extract objects from it by filtering and, if necessary, repairing the data (Donkers 2013) but tailors to the guidelines proposed by Stoter et al (2017) to prepare IFC data for conversion. It was stated that 'integration (between IFC and CityGML) was not possible due to inconsistent coding of IFC elements that made transformation to CityGML complicated' and that a 'clear set of specification needs to be set for the preparation of IFC files'. Part of Stoter et al's solution was to attempt to further extend and enforce the Basis ILS in the Netherlands.

A use case will be presented based on Figure 2 and the Business Process Model workflow from Oldfield et al 2017. There are many interfaces where the IDM Part 2 could be applied to be found in these diagrams. They include the interface between the permit assessor and the model owner; the interface between the permit assessor and the municipality's information manager and the interface between the municipalities information manager and the land registry and topographical map's information manager (Kadaster). The use case simplifies this supply chain into the interface between the model owner (project initiator) and the land registry (authorities).

This simplified use case is drawn as a transaction diagram based on DEMO methodology and detailed in the open BIM-standard IDM Part 2. IDM Part 2-compatible software[6] will be used to edit the framework stemming from the transaction diagram and then a test project set up in the same software. This test project will illustrate the environment used by the members of a project, which looks similar to an email client. Projects can vary from a large infrastructure project, for example building a bridge to the use case in this paper, granting or denying a building permit. The free VISI viewer provided by commercial software[7] has been used to visualize the transactions.

[6] www.bakkerspees.nl
[7] www.alfamail.nl

3. USE CASE

This use case uses the IDM Part 1 and Part 2 and its supporting software to facilitate the process of requesting and enforcing a building permit. This approach is already common in the BIM and Infrastructure world in the Netherlands and is used extensively, for example, by the Municipality of Amsterdam and Rijkswaterstaat ('the national agency that provides dry feet, clean and sufficient water and a quick and safe flow of traffic')[8].

3.1 Mapping the transactions

Figure 3 illustrates the transaction between the model owner (project initiator) and the land registry (authorities). This transaction has been extracted from the first phase of the process model 'Cadastral Registration by means of a 3D BIM' (Oldfield et al) with the subtitle orientation-advising-design-granting a permit- execution. In phase 1 the 'project initiator' - who could be the architect or model designer, builder or property owner - requests details from the municipality. This results in a file detailing rights restrictions and responsibilities associated with the spatial unit, zoning plans, survey plans for existing measurements and any 3D material if the project is a renovation being sent. They use this information to design a 3D model which conforms to the regulations for example with regards to soil pollution, easements, whether it is positioned within legal boundaries or zoned correctly. This As Designed 3D model is submitted as in IFC and tested. If it passes this test, then a permit is granted; if not it is rejected. This is transaction 1 (Figure 3).

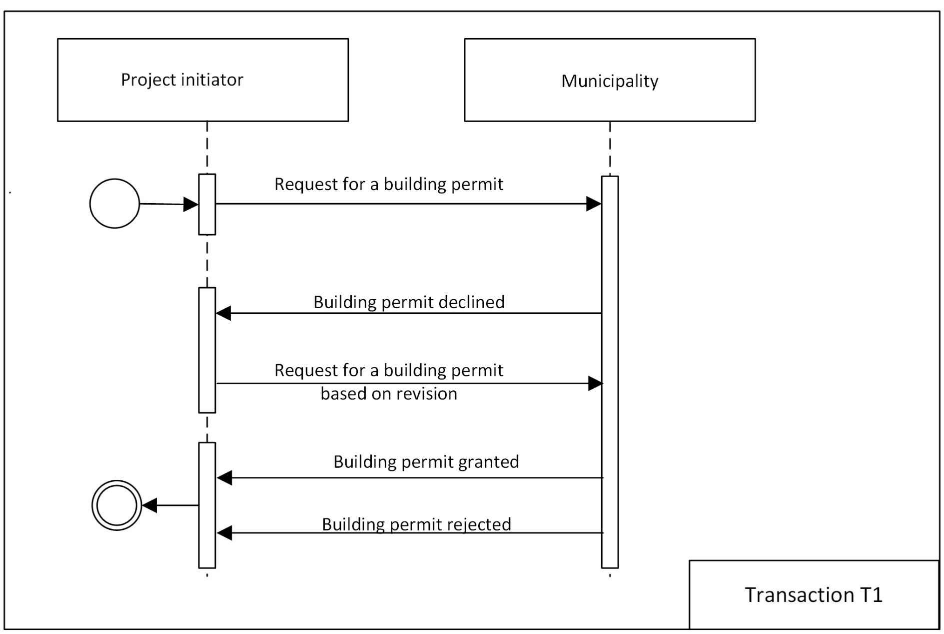

Figure 3. IDM Part 2 Transaction Map Cadastral Permit Request

[8] www.rijkswaterstaat.nl

The transaction in Figure 4 has been extracted from the second phase of the process model 'Cadastral Registration by means of a 3D BIM' from Oldfield et al with the subtitle realization-inspection of AsBuilt/AsSold - enforcement. When the building has been completed an As Built model is submitted to the authorities. If this is satisfactory then a permit is granted and transaction 1 is carried out for a second time. If the As Built model does not conform to its permit, then the building owner is legally required to adapt the building and an enforcement transaction comes into play. This is transaction T2 illustrated in Figure 4.

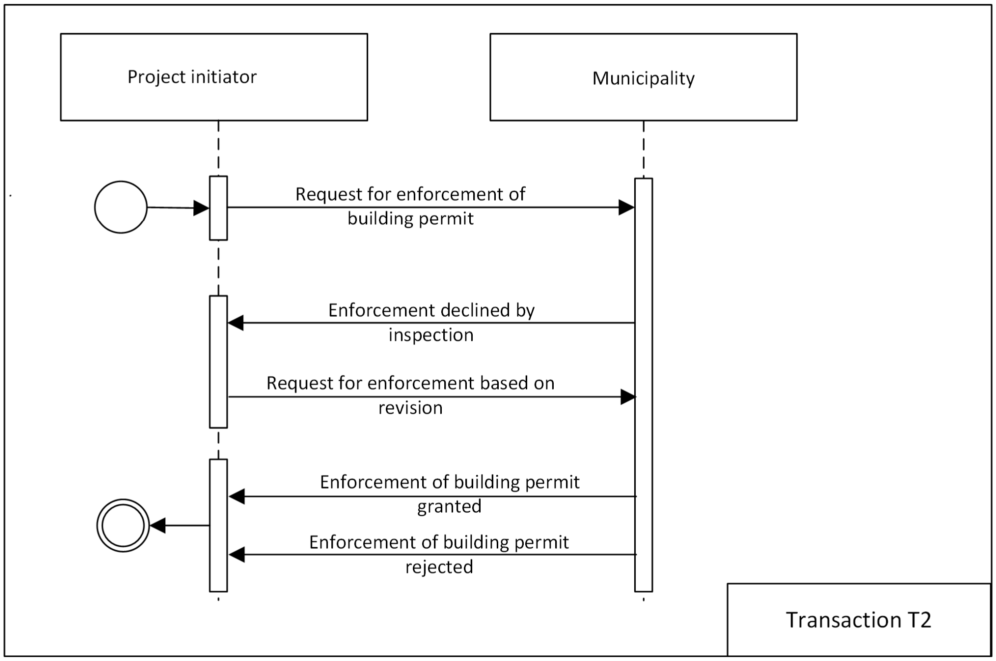

Figure 4. IDM Part 2 Transaction Map Cadastral Enforcement Request

A building may be subdivided and sold in a different way to which it was intended to be. This means that the As Sold spatial units may be different from the As Designed and As Built. Once again, the two types of transactions are brought into play to either grant a permit or enforce the lack of adherence to one.

3.2 Automating the process using xml-based software

While the permit process has traditionally been done manually with paper-based application forms, it can be automated.

Figure 5 below shows a snippet of the XML file. Figure 6 below shows the matching section in the XSD which facilitates the automated validation of the content of messages sent. The underlying DEMO-theory's transaction patterns are used in modelling the transactions. Text in the xml of Figure 5 illustrates the result of the transaction, that a permit for a building has been granted (or rejected).

```xml
<TransactionType id="T01_Building_Permit">
  <description>T01: Building Permit</description>
  …
  <result>
    Building permit is granted or rejected. Accurate 3D-BIM models have been
    registered by the cadastre and a building permit has been granted, the
    realisation of the building may proceed as well as inspections.
  </result>
  <initiator>
    <RoleTypeRef idref="Role_A01_ProjectInitiator"/>
  </initiator>
  <executor>
    <RoleTypeRef idref="Role_CA02_Authorities"/>
  </executor>
</TransactionType>
```

Figure 5. A section of a VISI transaction type in XML, defining the description, result and precisely limiting the DEMO initiator and executor to specific roles

```xml
<xsd:complexType name="T01_Building_PermitType">
    <xsd:complexContent>
        <xsd:extension base="visi:elementType">
            <xsd:sequence>
                <xsd:element name="description" type="xsd:string"/>
                ...
                <xsd:element name="result" type="xsd:string" minOccurs="0"/>
                <xsd:element name="initiator">
                    <xsd:complexType>
                        <xsd:choice>
                            <xsd:element ref="visi:PersonInRole"/>
                            <xsd:element ref="visi:PersonInRoleRef"/>
                        </xsd:choice>
                    </xsd:complexType>
                </xsd:element>
                <xsd:element name="executor">
                    <xsd:complexType>
                        <xsd:choice>
                            <xsd:element ref="visi:PersonInRole"/>
                            <xsd:element ref="visi:PersonInRoleRef"/>
                        </xsd:choice>
                    </xsd:complexType>
                </xsd:element>
            </xsd:sequence>
        </xsd:extension>
    </xsd:complexContent>
</xsd:complexType>
```

Figure 6 The matching definition in XSD that can be used to validate the XML

3.3 What the user sees: the software interface

As has been illustrated in Figure 3 and Figure 4, when the DEMO methodology is applied a process can be interpreted as a series of transactions. IDM part 2 is based on this DEMO-methodology and provides systematics and guidelines for creating an interaction framework for digital implementation. Digital implementation means that transactions and its related IDM-components are converted into an XML-framework and can be validated using an accompanying XSD file to make it machine readable. The user, however, needs to know nothing of this. A further capability is that large files, for example IFC files, can also be transferred between users and are retained centrally for all users.

Figure 7 illustrates how the user experiences the standard. In the use case illustrated, John Architect has contacted Eloise Land-Registry who works at the Municipality for a building permit for a building to be sited at 1 Rose Street in Gardentown. This message is situated in Eloise's to be replied folder indicating that she needs to reply to John Architect's request with details concerning the spatial unit. A due date for reply has been selected which is a few days before the legal due date.

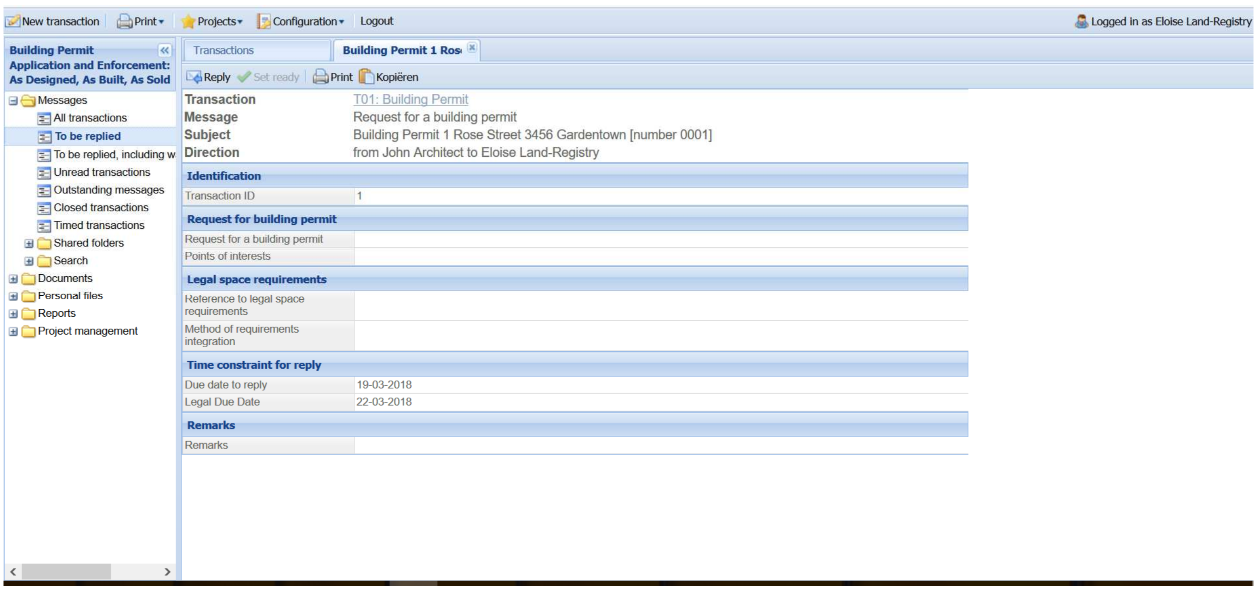

Figure 7.What the user sees: a IDM-part 2 compatible software interface

Each user, be they Petra Property-Developer who faces enforcement when a property is not awarded its As Sold permit or Mary Land-Registry who is behind the enforcement, has a log in name and access to the VISI software. The software has been made to look like an email client for intuitive use but, in comparison, has more functionality.

Each transaction, for example, is associated with a project (see Figure 7). Users can switch between projects using a dropdown menu. This means that Mary Land-Registry could be administering many projects at the same time. The messages column on the left of Figure 7 clearly directs the user to which messages, as shown in the 1 Rose Street, have not been answered. A documents folder holds the documents associated with the project, for example the IFC file of the spatial unit. These documents are made available to all the users involved.

Use of this automated process means that communications are traceable, and the same communication can be held on different servers. If necessary, those involved can be held accountable for failing to meet deadlines or other agreements.

4. CONCLUSION

3D data, collaboration and innovation are all crucial to the creation and success of a 3D Cadastre. All three of these criteria can be met using the approach outlined in this paper by using international standards for structuring and automating the life cycle process. 3D spatial units can be obtained from enriched IFC files which make property units explicit and submitted as part of digital permit applications; whether through a process of automated extraction, conversion and repair; the use of a prescribed Model View Definition to facilitate this process or a combination of the two approaches.

Collaboration can be achieved using the Information Delivery Manual ISO 29481 Parts 1 and 2. The collaboration within a life cycle can be structured as a chain of interactions. The communication acts which define the collaboration between actors can be specified in an Information Delivery Specification (ILS) based on IDM part 1. In turn, a multi-actor workflow can be specified to coordinate the many processes which would benefit from the data, including testing conformance to building regulations, rates assessment, inclusion in a national topographic map and asset management. The interactions between actors would be specified as transactions and consequently be expanded in more detail in their related messages. The exchange requirements which characterize IDM part 1 are related to a message in a transaction. This has been modelled in this way so that information and its accompanying formats and structure can be delivered for decision making. Once decisions have been made, the desired transaction result, for instance adherence to land registry regulations as part of the building permit application process, can be achieved.

To achieve a digital implementation of the specified information delivery in the ILS, an interaction framework can be modelled following IDM part 2 guidelines. This interaction framework is an XML-file with an accompanying XSD -schema. IDM-part 2 compatible software can be used to import these interaction framework files and to provide the functionality needed to establish digital collaboration according to a predefined communication structure of the multi-actor workflow. At a user level, this complexity can be given a friendly face by using IDM Part 2 based software which in turn satisfies organizational-level requirements for traceability, accountability and archiving.

The innovation requirement is met by the fact that both the automation of 3D data extraction from building permit applications and the use of IDM Part 2 based software in the Geo world are new areas of research.

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Jennifer Oldfield works for the Gobar Consulting Group as an Information Specialist. She first became involved in geographical information in 2008 and worked as translator for Geonovum on two projects, firstly the City GML domain application for the Netherlands and then the Dutch data dictionary for construction – the CB-NL. In 2017 she graduated from a Master's in Geographic Information Management Applications completed at Utrecht University and later that year published an article based on her thesis.

Ronald Bergs is the Managing Director of the Gobar Consulting Group. After a role as a project leader for a real estate project management agency, he began at Gobar in 2003 as a Consultant. Since 2003, he has been assigned by various public clients to support them by complex information management issues and projects. As an expert of open information exchange standards he has been in several boards and committees on an international level. In 1999 he graduated from a Master of Science in Civil Engineering and Management completed at Twente University. In 2002 he received a PD Eng from Eindhoven University of Technology in Architectural Design Management Systems.

Peter van Oosterom obtained an MSc in Technical Computer Science in 1985 from Delft University of Technology, the Netherlands. In 1990 he received a PhD from Leiden University. From 1985 until 1995 he worked at the TNO-FEL laboratory in The Hague. From 1995 until 2000 he was senior information manager at the Dutch Cadastre, where he was involved in the renewal of the Cadastral (Geographic) database. Since 2000, he has been a professor at the Delft University of Technology, and head of the 'GIS Technology' Section, Department OTB, Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands. He is the current chair of the FIG Working Group on '3D Cadastres'.

Thomas F. Krijnen is a doctoral candidate at the Eindhoven University of Technology (NL) since 2014 where he is working on the scalability of large archives of building models. Thomas is the initiator and main developer of IfcOpenShell, one of the leading software libraries for Industry Foundation Classes (IFC) building models. Previously Thomas worked a Senior Software Engineer for Genry Technologies in Los Angeles (USA).

Miquel Marzabal Galano works at the Amsterdam City Council, in the old town borough (Stadsdeel Centrum) at the building permits department. He graduated in 2014 as engineer on Building Management at InHolland university. In his last year he made an analysis on what would be needed to be able to carry out assessments for building permit applications with BIM. His graduation thesis consisted of an attempt to create an automatized check on 10 aspects of the Dutch Building technical requirements decree (Bouwbesluit 2018) using software to check IFC models.

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