Validation Challenges for Legal Digital Twins in Dutch Climate Governance

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Abstract
The application of Digital Twin (DT) technology is rapidly increasing, and Dutch planning practitioners are facing several challenges. The translation of legal texts into 3D effect simulations is not without validation issues. General rulings of legal texts require local interpretation. And the 'fairness' of representations of new urban designs and policy effect measurements are part of the struggle. This paper explores six DT cases and presents the findings and some areas for bridging the gap between traditional law and the DT. Based on these cases, a synthesis consisting of nine validation challenges is formulated and future research directions are presented.

Keywords
Validation, Legislation, Business Rules, Digital Twins, Spatial planning

1. Introduction

Dutch governments are using Digital Twin (DT) Solutions at an increasing rate to support spatial planning discussions among stakeholders, operational asset management, and permit processing for citizens. DT technology has become one of the major development programmes on the Digital Agenda of both regional and city innovation platforms [1, 2]. The increasing level of application of DT solutions introduces many questions regarding how the DT of a given city is designed, developed, and implemented and how it functions in the democratic-legislative arena. One important step is to ensure that stakeholders using a DT solution can trust its validity and fairness [3]. But when is a DT solution valid and what is fair? Given the discussion about the transparency of technology in general, this poses a new problem space and new research questions, that we want to explore to help build a validation framework for government agencies using DT technology to improve validity and fairness [4]. The multi-aspect properties of DTs in spatial planning pose a complexity that is not so easy to validate for those stakeholders, including the government agencies themselves. This validation gap provides a fertile ground for speculation, alternate facts and other threats to the democratic discourse. The mapping process involved in achieving climate goals between the regulatory framework, object-related data, and effect measurement requires many steps. The spatial DT solutions in the Netherlands are currently used mostly in the design phase where strategies and

EGOV-CeDEM-ePart 2022, September 06–08, 2022, Linköping University, Sweden (Hybrid)
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policies are moulded into contours with specific design intentions, such as climate goals. The spatial planning mappings are used in the consolidated permission phase and at the monitoring phase to ensure enforcement of law and regulations after the designs are implemented.

The research question is framed as: 'Which validation challenges do governmental organizations in the Netherlands encounter while aiming for a fair translation of policies, laws and regulations into Digital Twin solutions for climate governance?' We match those validation challenges against the existing set of FAIR principles, being 1) Findability, 2) Accessibility, 3) Interoperability, and 4) Reusability [5] to see what issues are surfacing that require more research and more Safeguarding.

2. Background and Related Work

2.1. Digital Twinning, Spatial Planning, and Objects

In the context of spatial planning, Schrotter & Hürzeler [6] provide the following description: The term DT creates proximity to the construction and real estate industry and thus builds a bridge to the new developments in the field of Building Information Modelling (BIM) and digital transformation in the construction industry. Although the term there is used for a single building only, the following step can be made to infrastructure and the urban space itself. The goal is a digital representation of the city to simulate issues such as urban planning to combat climate change.

For our purpose, we use the definition of a DT that is being used for spatial planning where a digital copy of a specific existing physical environment is made that represents the legal boundary, characteristics, and regulatory conditions of that area in one integral and consistent representation. This is a juridical extension of the definition used by Schrotter [6].

In the Netherlands, the legal environmental spatial planning platform Ruimtelijkeplannen [7] already represents the legal source document for spatial planning. The additional layer of regulatory conditions that provide information about allowances such as approximation or nearness and contradicting attribute values [8] is currently being designed and built [9]. This design process involves the exact standardization and definition of environmental criteria such as the 'level of noise and stench', 'dimensions of breeding areas', 'number of aerial dust particles', etc., and the representation of those criteria into a DT solution. The contradicting attribute values such as agriculture function versus CO2 levels require the link with the consolidated legal texts that have been decided on by councils in democratic debate. These attributes are defined in spatial objects within the DT solution. Object-oriented IT design is a common approach, which also enables the use of business rules to support users to work with contradicting aspects in a DT solution. When done right, these business rules are managed as a separate concern from other aspects of the information system [10, 11, 12].

The legal tradition of environmental administration was based on extensive PDF files with long deliberations. The influence of GIS knowledge on the legal profession was also noticeable at an early stage since 'map-people' created the legal term 'search area', which at the time did not exist as a concept in the legal profession [8]. There is also an existing research stream on the validation of models in DTs [13]. The research we seek to add to the body of knowledge are the challenges regarding the 'translation into' and 'application of' law-related business rules in the context of a DT solution. We claim this should be part of the DT maturity model when related to urban planning in addition to what Youg-Woon refers to as ”Dimension 4, “CPS intelligence,” distinguishes different levels of intelligence through, for example, rule-based algorithms, machine learning, and artificial intelligence” [14].

3. Research Method

The research presented here is explorative in the sense that we seek to set contours for the problem space and at the same time assist the government agencies involved to explore the fairness and validity of the DT, which to our knowledge has not been done before. To provide a structured overview of the challenges of legal (regulatory) DTs we have chosen to investigate six cases where province and city management seek to build a legally consistent DT for different reasons. The number six is chosen because this set proved to be rich enough to raise challenges that require further research. The approach is that of action research, the researchers are involved in supporting cities and provincial councils, and consulting on standardisation validation internally on a professional basis. The identification of validation challenges was carried out in an unstructured way during design discussions with the responsible design teams, the cases were centrally discussed during these sessions. In addition: eleven webinars and online team meetings were organised in 2020 and 2021 by Dutch umbrella organisations VNG [15] and IPO [16] discussing the development of DTs among software suppliers and civil servants of many Dutch cities and provinces. Another two sessions in 2020 were dedicated to the semantic harmonisation of the terminology used in legally binding spatial plans. Specific research was carried out in the context of the Healthy Urban Living programme [17] and the Feed eParticipation EU project [18]. In addition, 22 interviews (eleven semi-structured and eleven open interviews) were held specifically with the professionals engaged in the building of the digital infrastructure for the National environmental act (DSO) [19]. Based on the data collection, a multitude of challenges were identified. The strength of this action research using multiple explorative cases is also its weakness. The validation challenges were gathered over time under different circumstances in discussion with government peers, subject-matter experts, domain experts and legal experts. Formalisation of the method using structured interview protocols would often have disturbed the richness of the discussion. For the analysis of the data, three filters were put in place to achieve a level of objectivity: 1) The challenges listed were mentioned at least three times on separate occasions, 2) The challenges listed were mentioned by at least three different respondents, and 3) The challenges had to applicable to at least three domains, for example, the built environment, emission, and mobility as depicted in a DT.

3.1. Case 1: Amersfoort Railway Station Area Planning

The province of Utrecht and the City of Amersfoort together worked on the mapping of the characteristics of a specific area around the railway station into a DT to support the decision-making process of the redesign of that area. The main goal of the DT was the ability to visualize in 3D the different design aspects and discuss these in co-design with the stakeholders of the railway station neighbourhood. In particular, the need to manage the (relatively new for the Dutch) rain flooding problem and the heat stress problem caused by too much concrete and too little green. Different planning scenarios and estimated cause-and-effect relations were mapped into the DT. The legal environment concerns city planning rules. The strategic policy level involves many and sometimes contradicting climate-related policy issues, such as solar energy fields, less car-based mobility and clean sewer systems and avoiding air pollution.

3.2. Case 2: Towards a nationwide DT, 'applicable rules' in the Dutch Environmental act service platform

The Environmental act digital platform 2022 is a major programme to advance the Dutch spatial planning process toward more integration, fewer pre-set rules and better (digital) government service for the citizen. It combines 22 sets of regulations concerning environmental planning into one integrated workflow. The 'applicable rules' are business rule translations of juridical texts and they are called applicable because they should enable the citizen to click on any object in the Netherlands and retrieve all governing rules related to that object. These applicable rules should answer the permit request of a stakeholder to act employing webforms. This is enacted by the design of 'smart' forms following a dynamic decision tree as a permission check beforehand. The set of business rules is feeding the requested requirements for entering a specific permit per theme or activity type.

3.3. Case 3: Utrecht Merwede Kanaalgebied

This DT has been designed in the context of the Environment Act (as of the first of July 2022), The DT is used to visualize national datasets, such as the real estate or building data, road infrastructure data and 'green' areas and subsurface data. In addition, the city of Utrecht applies the DT for participation with stakeholders. This DT is based on Unity's game engine. The advantage of this DT approach is that one can, unlike with more traditional GIS platforms, enlist the development power of the gaming industry to develop the 3D city model of the city of Utrecht. The development of this DT is a collaboration between the cities of Amsterdam and Utrecht. The aim is that all Dutch municipalities should be able to use modules built based on this open platform.

3.4. Case 4: The Green Benefits Planner

The Royal Institute of environmental control and disease control (RIVM), The Utrecht University and the province of Utrecht collaborate on a project called 'the Green Benefits Planner' to discuss scenarios with a positive effect on climate policy goals with stakeholders. The project is part of a larger regional initiative called the Healthy Urban Living programme [17]. The DT is part of the scenario builder and depicts the effects of different design decisions such as planting trees, creating water channels or new cycling areas and themes such as heat stress. The goal of the Green Benefits Planner is not to show one thematic map, but to balance many themes. The balancing was implemented in the software called Tygron. To provide policymakers with a simple control panel that shows policy goals, the 'policy room for manoeuvring' and the effect of those choices on the living environment.

3.5. Case 5: Markerwadden Island

The Markerwadden, as a design decision, was a multi-million Euro compensating action for building in a Natura2000 (thus heavily guarded by law) protected area in the Dutch grand sweet-water lake. The Markerwadden is an artificial island for 'green' and biodiversity purposes. This was a result of an extended negotiation period. The next step was to reach an agreement about the exact spatial design of the protected area. The DT was created because of the many conflicting interests. The goal of this juridical DT was to enable stakeholders to consider other stakeholders' interests in the planning process. In this case, the Natura2000 was conflicting with the water directive, so a clear-cut legal solution for several land allocation purposes could not exist.

3.6. Case 6: Green Urban Water Transport

This case originated in the process of designing green electrical transportation over the water towards Dutch city centres. This DT was developed to support the Provincial council debate about the role of the province in the emerging digital landscape. The province and the cities with more and more shipping of (internet) goods to the city centre, were pushing for climate goals, but the market required intervention in cheaper fossil-based transport over land. The DT depicts the terminal area and the dilemmas that require government intervention, such as deploying a blockchain platform for identity management. The DT was built in the game platform Unity, together with suppliers of the infrastructure who provided DT equivalents of their products in a reusable object library.

4. Positive Tone (RQ1)

To examine the impact of the identified validation challenges we map them against the FAIR principles [5]. Overall, in the translation of the guidelines and principles into climate models and software there seem to be many standardization challenges in maintaining consistency in this translation- and mapping process. These challenges are interesting because they often occur at the gap between the world of law and policies and text on the one hand and the (more absolute) world of ICT, AI, and objects on the other hand. To shed more light on the aforementioned gap, we present a synthesis of our findings below.

1. Findability and visualization: versus the level of detail. The challenge is to offer the right level of detail for the right purpose. In some cases, this is a risk due to 'expectation management' where showing too much detail at the wrong time or in front of another target group raises sentiments of the finality of the concept where the message meant was much more open for discussion between scenarios. The public stakeholders also tend to focus on details which were not meant to be part of the scenario target theme by the experts. The level of detail among professionals and in the situation of a court case tends to be much higher than what is politically necessary during scenario debates.
2. Consistency: The reduction of large descriptive texts into binary schemes, i.e., digital 'yes' allowed' versus 'no, not allowed deontic logics. The standardization of policies into

binary Yes or No answers for permission requests is required for efficient service delivery to citizens in a digital front office of the city.

3. Legal semantics and accessibility: the mapping of legal terminology (semantically) is often too diverse to harmonize sufficiently for a binary purpose. The policymakers are eager to preserve room for interpretation and city spatial plans tend to have a very high level of freedom without much standardization, which contrasts with the service delivery aim of that same city. There are also semantic issues concerning juridical terms, especially those with a juridical history. Juridical terminology is precise to exclude non-intended exemptions. The demands on digital service delivery through smart forms and business rules require accessible language for the end-user. Successfully mapping the 'folksonomy' to the legal taxonomy (applicable rule) is a matter of interpretation and it makes it harder to maintain consistency.
4. Interpretation and consistency: In the Netherlands, a culture of case-based law processing exists that is not compatible with the perspective of a consistent nationwide infrastructure; differences in the notion of case handling as a paper-based administrative process versus a standardized spatial data infrastructure that has to work on a country level scale.
5. Legal: authorization of modelling of policy criteria for design planning sessions and monitoring. For example, the water flooding models, heat stress models and mobility models as described earlier represent the problem of validation and the 'democratic mandate' of the supplier of those models. In one region there were three heat stress models in use by different agencies and developed by three different suppliers. This leads to confusion about which is the right or 'officially recognized' model. Government agencies are seeking a new role in certifying the models in use [20].
6. Integrality and interoperability: Specialist sectoral applications do need to become interoperable and exchangeable for the sake of better collaboration and re-use of data. The challenge in a DT is to create inter-sectoral validation.
7. Consistency: Correct (transparent, logical, explainable) translation or mapping of legal texts into object languages and business rules. This includes correct representation of the cause- and effect relations concerning the variables in (informal) design sessions versus those that will stand in more formal (e.g., court or tendering) situations. This includes issues of timing and expectation management, especially in participative trajectories. It also includes 'applicable rules" and forms during the permit stage.
8. Archiveability: Historical consistency for court cases (and ownership of the historical database). The legal consistency and legitimacy entail the existence of legal memory. The higher administrative courts require 'time stamping' or the ability to travel back in time and obtain the 'picture' of the case many years back. The challenge is to generate that integral picture over time as a consistent whole, including contextual information. Although GIS systems and DTs can log many variables and data layers, it is hard to determine what a 'complete' contextual picture should look like, especially given the increasing technological capabilities over time.
9. Interoperability: Supplier modelling interoperability and modular software development. Separating business rules from their representation by DT vendors (separation of concerns). The business rules have to be explainable so that public values can be audited,

especially if they have a legal consequence [21, 22]. If this is not done, public values cannot be guaranteed in the public stack due to the lack of transparency.

5. Discussion and Future Research

Our research at this point confirms that the mapping of policies, laws, and regulations into object attributes for DTs should receive more attention in light of the FAIR principles. This was true for single business rules that power webforms for citizens and it is even more important in DTs with more integrated climate themes. The 'validation gap' between the abstract Fair principles of Findability, Accessibility Interoperability, and Reusability and the validation challenges as found in this research should be bridged by a maturity model that fits with the object-oriented policy cycle. The logic is that climate goals programmes in the end seek to address attribute values of objects in the physical environment and governments work in object-oriented policy cycles to achieve them. This cycle is speeding up due to increasing demands on scarce space and conflicts with climate goals. The Dutch Courts of Law are taking an increasingly firm position in this debate. The need to build correct representations of the spatial environment in all its aspects and themes (e.g., sound, water, biodiversity, economic activity, mobility, pollution) is therefore increasing, [23, 24]. For both the overall environmental strategy design and during implementation, government agencies need to be increasingly consistent in the mapping between design plans, project plans, and the existing legal-administrative landscape [25, 26, 27]. Citizens would feel 'cheated' if the DT scenarios were unfeasible in the juridical reality of constraints and boundary values, such as policy goals on climate. There is a complex mapping process in play here that pose potential risks for the valid implementation of the law and regulation. The models that feed a DT depict the actual space for manoeuvring while balancing policy goals for the relevant authorities. Integrality is another reoccurring theme. The DT infrastructure enables measuring variables of one theme, e.g., planting trees aimed at emission reduction against another theme, e.g., the mobility effect of less roads. The data in a DT represents a wider range of themes, data sets, standards, criteria, semantics, and assumptions about cause- and effect relationships to enable scenario design. The visualization of the spatial environment in DT is thereby shifting from static digitalized spatial plans with links to the relevant legal texts in large PDF's towards 'dynamic DTs'. These DTs depict de potential effect of different legal regimes on climate related aspects of the environment in a number of design scenarios [28]. The thematic integrality as described above and the regional level of detail would require DT solutions that go beyond the 3D representations of cities, especially for the legal interoperability.

The proposed variables that should be measured and scored between the policy cycle phases at all DT layers are: 1) Integrality: are policy themes taken into account in all phases? 2) Consistency: are datasets, definitions, values and norms consistent in all phases? and 3) Object status: are object attributes and mutations (of roads, buildings, biodiversity, air quality, etc.) in the environment monitored in all phases?

One of the questions is whether the research question is valid outside of the spatial planning domain and climate issues. Other authors, such as Schrotter [6], face the same problems in Zurich, while also mentioning Singapore, but we did not identify many references to the legal

Fair principles	DT Layers	Design scenario's	Climate programmes	Climate Permission processing	Climate Enforce ment	Effect Monit oring
Findability	Visualization					
Reusability	Modelling values and criteria		←	Measuring integrality	→	
Accessibility	Legal layer					
Reusability	Data quality					
Interoperability /reusability	Interoperabili ty		←	Measuring consistency	→	
Findability	Archive ability			Object status monitoring		
Findability	Semantics					

Figure 1: Initial validation framework for Legal digital twins: measuring the maturity of DT layers on consistency, integrality and object status against the policy cycle phases

side of the DT. The results of this explorative research point to several future tracks of interdisciplinary research directions. To achieve an operational level of transparency, trustworthiness, and legitimacy of planning processes in the cause of climate goals, further research is required about DTs. This supports the translation of ethical guidelines about public stacks into 'fair' DTs. From the policy side, we envision more awareness and empirical support for formalized versions of the policy-making cycle: design, permit- and enforcement processes (based on legal sources) and effect monitoring.

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