Policy processes and building blocks for Digital Twins

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Content

List of abbreviations

API	Application Programming Interface
AR/VR/xR	Augmented Reality/Virtual Reality/eXtended Reality
Avg	General Data Protection Regulation
CISO	Chief Information Security Officer
CPT	Capabilities Periodic Table
DT	Digital Twins or Digital Twins
DTC	Digital Twin Consortium
DTC	Digital Twin Capabilities
GMO	Healthy Area Development
HTTP	Hypertext Transfer Protocol
IT	Information technology
nDTFL	National Digital Twin Physical Environment
DTNL	Digital twins in the Netherlands
URI	Uniform Resource Identifier
OUP	Open Urban Platform

1. Introduction

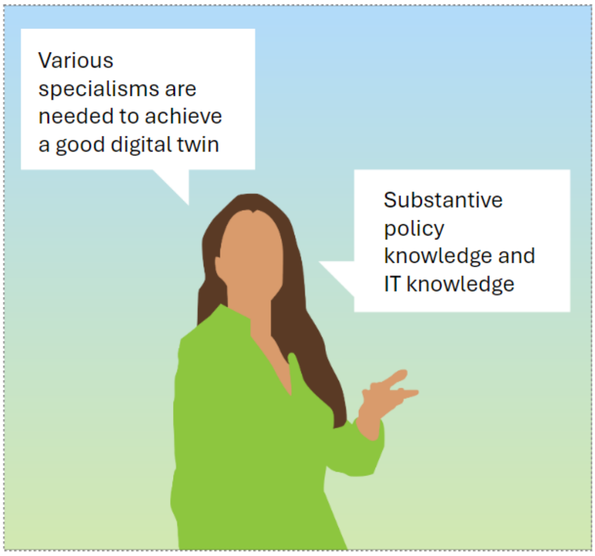
1.1 Reason

The Netherlands faces many social challenges that relate to the physical environment and are inextricably linked to each other. Technologies such as data-driven working and a Digital Twin, in which data from different themes (policy areas) are made integrally transparent and weighed, are seen to improve the policy process around social challenges.

Digital twins offer opportunities to bring together (extrapolate) data and models from the different sectors and to visualize the integration. However, this also means that a Digital Twin will be most successful if it fits perfectly with the (integral) issue for which this means will be used. This requires specialist knowledge from various disciplines:

- the substantive and administrative policy (the policy);
- as well as the technical IT and data specialism (the technique).

To be able to develop and use Digital Twin, policy and technology must be brought together. Policy and technology each have their own jargon. Cooperation between policy and technology is necessary to make Digital Twin possible. This also means that a common language between policy and technology is needed. Policy makers don't talk technically, and technology makers don't talk politically. From a technical point of view, we want to make terms more relevant to policy and from a policy point of view, we want to concretise policy themes that are more understandable to technology. In this study, we give a first impetus to take the common language a step further in the cooperation between policy and technology for making and using Digital Twin.



We will not be able to separate this study from the perspective of the federation of Digital Twins. The federation of Digital Twins emphasizes the importance of a coherent network of different Digital Twins, who can communicate and collaborate with each other (exchange of data, calculation models and visualizations). This federated approach is crucial to manage complex, large-scale systems in the physical environment, such as cities, infrastructures, and rural and natural environments, in an integrated and efficient way. The perspective of the federation of Digital Twins includes several different aspects:

- Many societal challenges, such as climate change, mobility, and sustainable urban development, are interdisciplinary problems. A federation of Digital Twins can contribute to an integrated approach by bringing together data and models from different domains.
- In a federation of Digital Twins, it is essential that different systems can communicate seamlessly with each other (interoperability). This makes it possible to exchange data and insights between different domains, such as energy, transport, water management, and urban planning.

- By sharing data and models between Digital Twins, decision-makers at all levels can make faster and more informed decisions. This leads to more efficient use of resources, better planning, and increased responsiveness to emergencies.

In a federation, all Digital Twins involved must adhere to common policy frameworks. This ensures that the exchange of data and models complies with legal and ethical standards, such as privacy, data security, and property rights. It also requires alignment with societal challenges, such as sustainability, inclusiveness and ethics.

Effective exchange between Digital Twins requires technical standards and protocols for semantics, exchange (APIs), metadata and architectures to ensure compatibility and interoperability between systems.

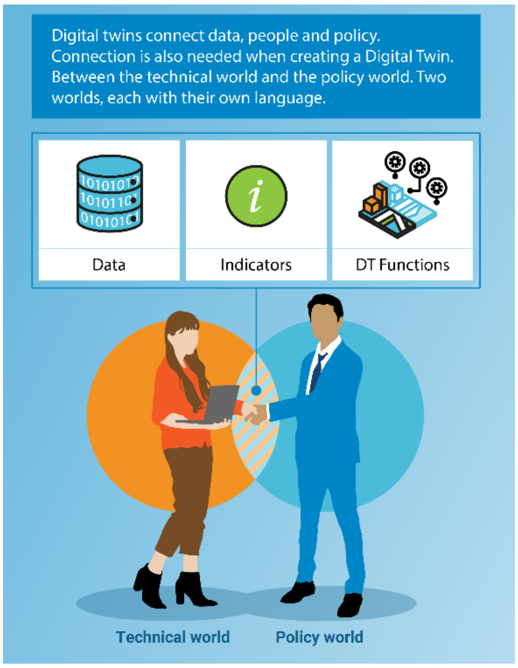
In essence, the federation of Digital Twins sees the exchange and cooperation between different Digital Twins as a necessary condition for (partially) solving complex societal problems and supporting efficiency and decision-making.

1.2 Assignment formulation of the study

The aim of the Province of Utrecht is to be able to conduct the conversation on the basis of cases, semantics, classifications and agreements in order to arrive at 'digital policy products. For this, different angles will come together, the substantive and administrative policy as well as the technical IT. By working together optimally, the right data and information can be brought together in a Digital Twin, which provides a broader understanding and good insights into the entire policy process, it can lead to more inclusive decision-making and a greater chance of finding creative and sustainable solutions for society.

But different perspectives also bring with them challenges of different interpretations and communication problems; People can interpret the same information differently based on their background, experience and beliefs. Words and concepts can have different meanings for different groups, which can cause misunderstandings. It is therefore important to take different perspectives seriously and to strive for a constructive dialogue and cooperation in which everyone can bring their expertise in tackling complex problems.

It is desirable to initiate a methodology with agreements to determine the use in practice of policy indicators for a Digital Twin so that harmonization is possible in the international system of OGC standards, and not everyone does his own trick but that it becomes interchangeable. It is also desirable to initiate a methodology to display indicators for a Digital Twin in a system for Digital Twinning in such a way that a policy officer can understand it and policy officers from all domains know how that is done. The current description 'data products' is in circulation. This is written more from a technical point of view and not from a policy perspective. When communicating about the practice of policy indicators for a Digital Twin, the vocabulary of policy should be more closely aligned.



To achieve this goal, the province of Utrecht asked Geonovum to initiate the dialogue between policy officers and IT staff from different governments and to build a bridge between the technical and the policy point of view.

We also explicitly look at the role of the Digital Twin in the entire policy process. We do this by presenting a starting point for a methodology in which the policy and the policy officer are central to the interaction with the technology to create a Digital Twin for the integration of the many aspects that come with a policy task, such as water management, heat stress, living, parking, recreation. Functional building blocks and policy indicators play a central role in this. They are a linking pin between the policy world and the IT and data world of Digital Twin. For both, working with functional building blocks and indicators for policy is becoming familiar territory and that gives connection and a common language.

1.3 Previous research into building blocks for area-based development

This assignment is a follow-up to an earlier assignment on building blocks for the Digital Twin area-oriented development of the province of Utrecht. To support new and existing policies with Digital Twin, the functional building blocks or 'capabilities' were identified in a previous assignment [1]. Capabilities are the ability to perform certain actions or achieve certain results in the Digital Twin [2]. We also refer to them as 'functional building blocks. These capabilities are visualized in a so-called Capabilites Periodic Table (CPT) from the Digital Twin Consortium (DTC). For this previous advice on the building blocks for the DT, three models of Digital Twin building blocks were first briefly introduced, respectively the building blocks of the DT province of Utrecht, the building blocks of the nDTFL[1] and the building blocks of the Digital Twin Consortium. Then a first match was made of the nDTFL and DTC building blocks. This forms a test of the nDTFL building blocks (does the nDTFL functionality meet the DTC functionality or lack basic functions?). Then a match (quick scan) was found between the building blocks DT province Utrecht and the building blocks nDTFL.

1.3.1 About the International Digital Twin Consortium and Capabilites

The international Digital Twin Consortium (https://www.digitaltwinconsortium.org/) has developed a generic building block board, which we consider here [2]. The Digital Twin Capabilities Periodic Table (CPT) is an architecture- and technology-agnostic requirements definition framework. It is aimed at organizations that want to design, develop, implement and operate Digital Twin based on use case capability requirements versus the functions of technological solutions.

> Depicting a design scenario for a new more sustainable piece of road surface or depicting the installation of a noise barrier around a housing project requires various technical tools for the scale level, level of detail, display of depth and height and the like. Technical capacities shall be matched with policy needs.

The CPT framework facilitates collaboration for teams, who need to create requirements and specifications for Digital Twin in large-scale, complex environments. The CPT framework focuses on

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[1] The National Digital Twin Physical Environment (nDTFL) is an initiative in the Netherlands that focuses on developing a digital representation of the physical living environment of the country [5], [6]. The Digital Twin contains detailed and up-to-date data, calculation models and visualisations on infrastructure, buildings, water management, mobility, biodiversity and nature, and various other aspects and elements of the physical living environment. The aim of the nDTFL is to support government, businesses and other stakeholders in making better and more informed decisions through real-time data and advanced simulations. The initiative promotes collaboration between different parties and ensures that data and calculation models from various sources are standardised and integrated, so that they can be used effectively in the Digital Twins of the Netherlands [5], [6].

[2] DTC is one of the few initiatives with a capabilities framework for Digital Twins. In addition, the framework is open and accessible (compared to some industry frameworks).

the capability requirements of individual use cases. The CPT follows a periodic system approach with possibilities grouped or "clustered" around common characteristics. It is easy to interpret both in the boardroom when explaining the business case to get funding for a Digital Twin project, and in the workplace when collecting requirements for a Digital Twin application. It provides visual guidance for collaboration, brainstorming and making capacity requirements explicit. All the resources needed to understand and deploy the CPT are provided here.

In the present assignment, work continues with the CPT to arrive at building blocks that are also understandable and applicable for the users of the Digital Twin and for the policy officers. The CPT model has been simplified into a limited number of policy building blocks, which have been made understandable for policy officers to better discuss the use of Digital Twin in the policy process.

1.4 Approach and process

1.4.1 Approach

In several interviews and workshops, the task was explained on the basis of Figure 1 below. Work has been done through a workshop approach in which the participants in the workshops have put forward the substantive topics to achieve mutual understanding between policy and IT and the data world on how to use Digital Twins for policy issues. For this task, the following approach was followed in four steps (Figure 2).

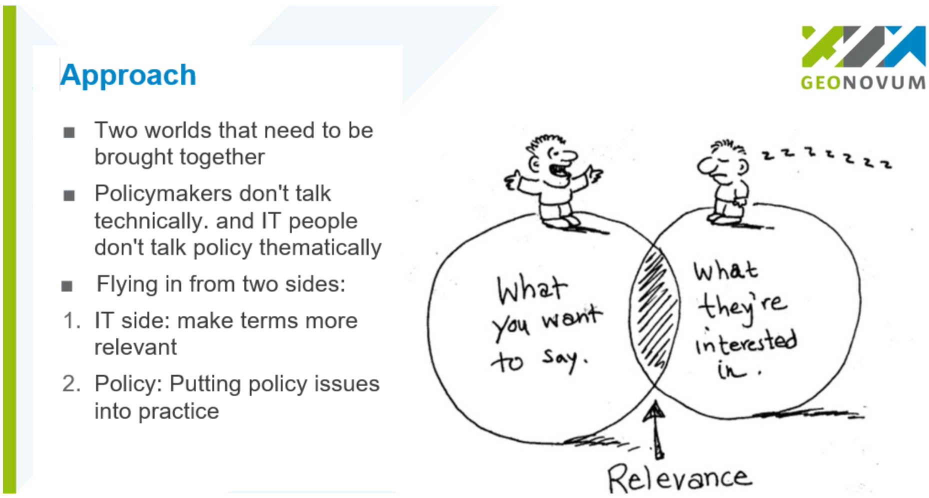


Figure 1. – Addressing this challenge

In a first step, attention was paid to the functional properties of Digital Twin in the form of building blocks or ‘capabilities’. The functional properties of Digital Twin have been simplified so that they better match the perception of policy.
In the second step, we looked at how these simplified functional properties can be linked to the policy process and to architectural principles (general construction of the Digital Twin where the same functional properties are (h)recognised. The Plan-Do-Check-Act cycle was used as an example of the policy cycle to match the functional properties.

In the third step, a further analysis was carried out to link the use of indicators to the policy cycle.

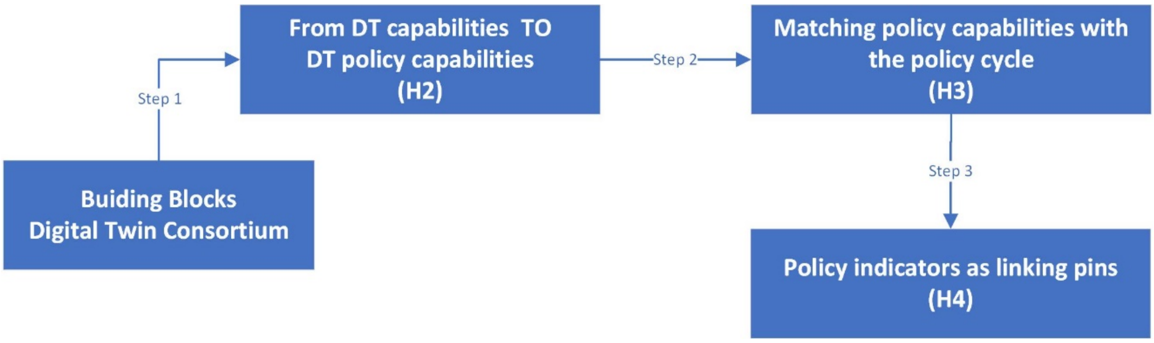


Figure 2. – Methodology for this task

A number of workshops have been organised in the implementation. The way in which this workshop has been designed and carried out and is briefly described below.

To give substance to the approach, an interactive working method was followed. By organizing three workshops and conducting interviews, information was collected to test whether working with building blocks also in interaction with policymakers leads to mutual insights about the form in which a Digital Twin can be implemented. Geonovum applied and tested a model for policy building blocks.

1.4.2 Implementation of workshop 1; Start and interviews

The approach was explained and accepted in workshop 1 of 10 November 2023. They were also introduced to each other. The appointment was made to indicate which data can be used for the necessary interviews. The interviews were planned and carried out with a thematic focus (see table below). The questionnaire is set out in Annex 1. Of the previously indicated 7 participating organisations, 5 remain: provinces of Utrecht, North Holland, and Flevoland, municipality of Eindhoven, Grenzeloos Data Landschap (Rotterdam). Participants in the workshops are listed in Annex 2.

Organisation	EMA	Date of interview
Province of North Holland	Smart logistics	13-12-2023
Municipality of Eindhoven	Residential building monitor	14-12-2023
Borderless Data Landscape (Rotterdam)	Digital collaboration in the subsurface	11-1-2024
Province of Flevoland	Forest strategy	6-2-2024
Province of Utrecht	Cartesius and GMO	14-2-2024

During the interviews, it was generally found that it is very relevant that policymakers and technical people (data and IT) sit around the table and generally discuss with each other how a DT can support the policy. This confirms the task that these people have to talk to each other. During the interviews, the context in which the Digital Twin were created was outlined. The (im)possibilities of the process were also discussed.

1.4.3 Implementation of workshop 2; Functional Features of Digital Twin

In the second workshop an attempt was made to determine the functional properties of Digital Twin for policy. Based on the Capabilities Periodic Table (CPT) of the Digital Twin Consortium, it was examined whether policy can be linked to the functional characteristics of Digital Twins.
It soon became apparent that the Capabilities Periodic Table was too extensive and complex a model to be used for policy applications of Digital Twin. This leads to confusion of speech and contextualisation is necessary to prevent the 'overwhelm' of policy-makers. In the 2nd workshop,

therefore, work was done on bringing the Digital Twin Capabilities Periodic Table for policy applications of Digital Twin into context. This resulted in 16 policy capabilities in the workshop. These 16 policy capabilities or policy building blocks are provided with a description for policy and for technology (data and IT).

During the 2nd workshop, the participants were included in the process described above. How we came to the periodic table, and which functionalities were chosen and why. The 16 functionalities and the corresponding descriptions/definitions have also been verified. Section 2.1 presents the results of the workshop.

It was intended to give 2 more homework tasks:

1. Each participant is asked to indicate the extent to which a certain functionality is used in their Digital Twins.
2. Each participant is asked to indicate per Digital Twin to what extent a certain functionality is used for which policy step.

1.4.4 Implementation of workshop 3; discussion

In the workshop 3 the findings from the first 2 workshops were presented and the discussion took place about the findings. Emphasis was placed on the role of indicators as a possible linking pin between policy and technology in the development and use of Digital Twin. In a lively discussion, various aspects and ideas were exchanged.

2. DT building blocks for policy

This chapter describes how the building blocks of the Digital Twin Capabilities Periodic Table (CPT) can also be more understandable and applicable for the users of a Digital Twin and policy officers. The CPT model has therefore been simplified and converted into a limited number of policy building blocks, which have been put into context for people without a technical background to better discuss the use of Digital Twin in the policy process.

2.1 Bringing Digital Twin Building Blocks into Context for Policy

In the first workshop, an interactive session with policy officers looked at the functional properties of Digital Twin according to the CPT. The functions of the CPT were not always in line with the understanding and perception of the policy world. Subsequently, a simplification has been made of the number of functional properties, which are more in line with policy and are plotted on the CPT (see Figure 3 below).

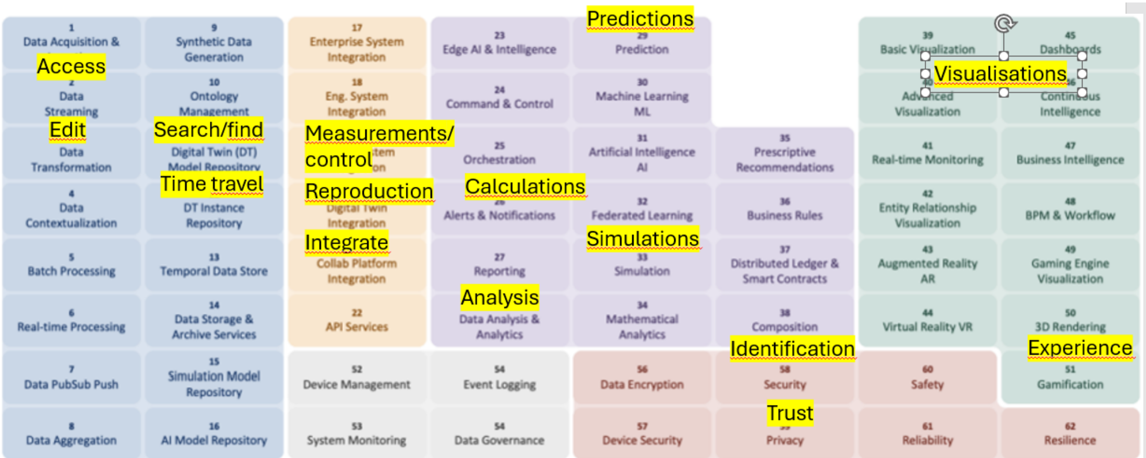


Figure 3. – Policy building blocks plotted at the CPT

A few use cases, which were discussed in the interview round, were also made into heat spots, which indicate which functionalities in the Digital Twins were covered from the use cases (interview themes). The interviews were used to test whether working with the 16 policy capabilities works and whether they return to the use cases (the interview themes). The green clouds in Figure 4 show the heat spots where the policy capabilities have been recognised.

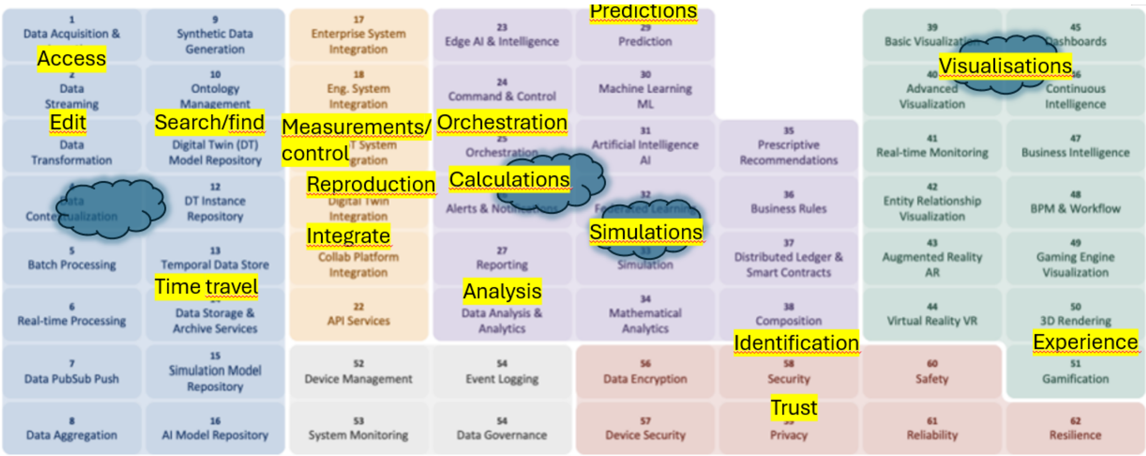


Figure 4. – Use cases plotted on the CPT Building Blocks

This analysis has led to a reduction in the number of 64 capabilities to 16 policy capabilities, which make it easier to enter a conversation with policy makers about the necessary functional properties of Digital Twins. In Figure 5 below, the policy building blocks are grouped and visualised (with an icon) on the CPT.

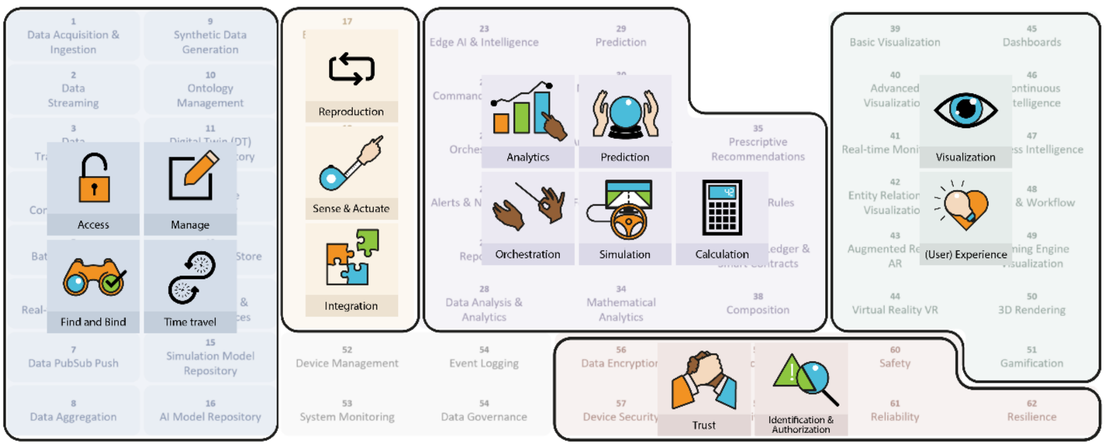


Figure 5. – Visualisation of the policy building blocks on the CPT

2.2 Function map and definitions of policy capabilities

The workshop analysis eventually led to a function map with policy capabilities for Digital Twin. Figure 6 below shows these 16 policy capabilities. We have deliberately drawn up Figure 5 and Figure 6 in the form of a talking plate so that they can be used in the conversation between policy officers and people with a technical background.

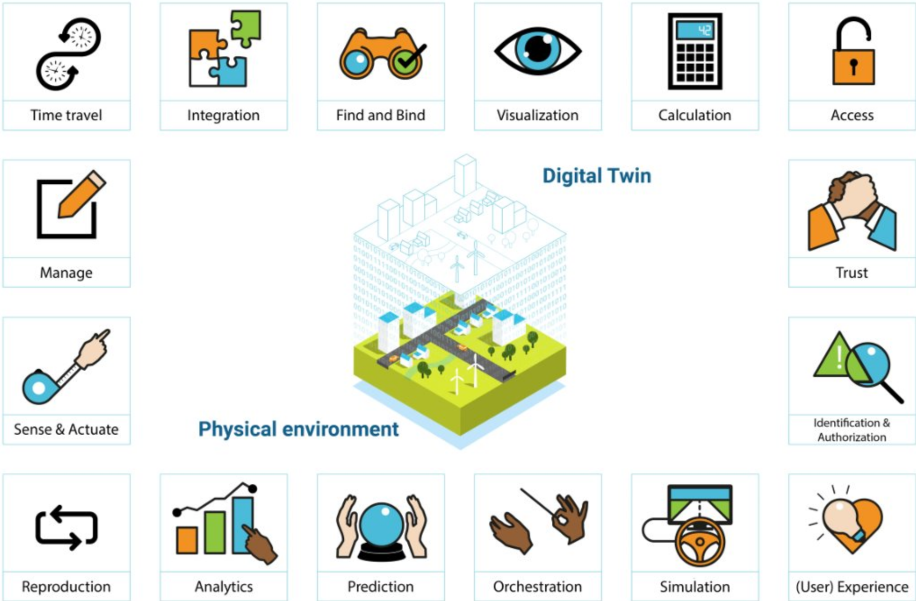


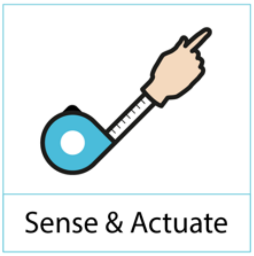
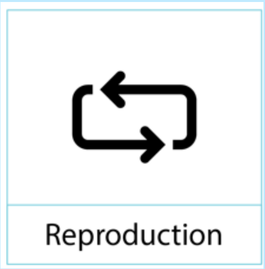
Figure 6. – Policy Capabilities Functional Map for Digital Twin

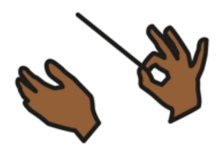
For each policy capability, a description has been made for both the policy officer (non-technical description) and the IT/data specialist (technical description). The descriptions of the policy capabilities are set out in the table below. The developed icons are also included in the table below.

Policy building block	Non-technical description	Technical description
	The concept of time travel in a Digital Twin offers the opportunity to study a situation in time. That involves going back in time to give a reflection of how something was in the past. Digital Twin also make it possible to look forward in time. This allows you to perform historical analyses, explore what-like scenarios, imagine or predict future situations.	By using a combination of (a lot of) historical data (on a subject), (almost) real-time information and algorithms (calculation modules), a Digital Twin can travel in time: The Digital Twin can use the time aspect in historical data to set the time back to a certain moment in order to reflect how something was in the past. Travelling in the future is also possible, by using calculation modules that can extract and predict (based on predetermined calculation rules). The present is represented by, among other things, almost real-time sensor information, assisted by up-to-date administrative data.
	A Digital Twin makes it possible to define different policy perspectives and thus get a holistic view of	From a technical point of view, a Digital Twin is a data/data/information integration

 Integration	policy area or policy project. This combination helps to gain deeper insight, make better decisions and generate value in various domains. This is an important tool to integrate all layers into one situational image.	exercise: By bringing together different data (data layers) and combining them, new insights and data products are created. Combining (traditional) data is no trivial exercise models can differ greatly. Data Transformation functions (to transform data) are therefore an important part of the Integration function. Integration must be sensitive to policy processes (and not the other way around) – reality processes are represented in the Digital Twin.
 Find and Bind	In a Digital Twin, different types of data are brought together and make the most accurate picture possible of the policy choices. Digital Twins need to speak the language and images that policymakers recognise – including normalising and standardising the indicators used. A Digital Twin also provides contextual information that helps users understand what the data represents, where they come from, how they were collected, and how to interpret them. This is especially important because Digital Twin often contain complex and diverse data sources. It is essential for the successful use of Digital Twin in various domains.	A Digital Twin is a data integration exercise (see also Integration), which assumes that one knows where (the URI) that data is and that we are accessible. People usually don't know that. If one knows, then data is like home: Someday someone will put it elsewhere – and you'll have to look for it again. Same with data. Therefore, searching for data, data (can also be other things: computational models, concepts, ...) so important for a Digital Twin. The result of the search is described in Metadata: describe the dates – just like a label on a bottle of wine or a description of a book in the library (also where you can find the book).
 Visualization	The power of visualization in a Digital Twin lies in its ability to turn data into understandable, interactive, and actionable images that provide insight, detect problems, improve communication, and contribute to better decision-making and performance. Visualization can be done in many ways: 2D (flat top view), 3D (to better visualize and analyze complex spatial data in a way that traditional 2D maps cannot) glasses can also be used in which images are projected that overlap with reality. Images can be static (current image of a situation) or very dynamic (interactive map where you can turn buttons to change indicators and see the associated policy effects	1 picture says more than 1000 words. The Digital Twin of the physical environment comes into its own when it can be visualized in 2D and 3D, with a Level-of-Detail that meets the requirements. The images can be static or dynamic, very realistic (in terms of colors and effects) or just not (false colors). The use of AR/VR/xR can also offer more insight and interaction with reality, without us being able to see it.

	immediately in the picture), contain a lot of details and are realistic or not. The choice of visualizations depends on the nature of the data and the purpose of the Digital Twins. By combining different visualization techniques, users can get a more complete picture of a system, understand processes, and make better decisions.	
 Calculation	Digital Twin can use calculation models (e.g. heat stress, flooding, noise zones). These calculation models can analyze data using techniques and algorithms. In this way patterns and trends become visible. These calculation analyses can be used to gain insight into behaviour and make predictions about future situations. The results of Calculation Models translate into indicators. Indicators are the link between Digital Twins and Policy. Computing is therefore an essential part of both policy and of a Digital Twin.	One formula says more than 1000 prints (Edsger Dijkstra). The imitation of reality is computationally intensive – any process that appears to be going through in reality without too much effort must be described digitally. Many processes happen in parallel with each other and also affect each other. It is just as 'unrestful' in the Digital Twins as it is in reality. This 'unrest' is important to take into account when it comes to policy with indicators – indicators influence each other. See also the sliders plate of Figure 14. Calculation modules are registered in the algorithm register, so that everyone can read exactly what the module does.
 Access	To visualize the physical living environment, data is layered together in a graphical environment. The data of the layers come from divergent registers and often suggest policy choices or legal standards and the sliders are the different policy ambitions in relation to the standards for, for example, noise or public green. The layers can be controlled with sliders, so that interests can be balanced and in a fair way in proportion to each other.	All forms of data can be brought together. The data is minimally copied and can be accessed via the web (HTTP, APIs).
 Manage	Digital Twin is interactive and dynamic (measured data from the environment – including measurements made by the citizen, also known as Citizen Science, so that the citizen is involved in initiatives). The user will be able to go beyond simply observing data and models. The user will be able to modify the data.	A Digital Twin is not only static, but will adjust data and data sources - whether or not in the 3D environment: the location of objects can be moved, their attributes adjusted. The metadata of elements can also be adjusted (and logged).

	Some Digital Twins are able to process (measurement) data in real time, monitor (to see whether policy also has the desired effect in the policy cycle), and optionally respond to changes. This requires calculation rules (algorithms) that can quickly analyze data and act based on results. Measurements are kept so that in it they can be used to make a statement about a series from the past so that, if possible, trend in indicators can be seen)	To create an image of reality in a Digital Twin, aspects of reality must be measured; Think of temperature, pressure, status at some point in time. That state at the time is sent to the Digital Twin, so that the image can be shown (in a 3D environment). The measurements are kept up to date, so that a statement can also be made about the situation in the past (see reproducing). Conversely, the status of an object can also be controlled via actuators (e.g. remotely opening the water tap). Controlling the status is also stored for later use.
	Any policy decision (at the time) made on the basis of a Digital Twin must be reproducible at a later date. So, the state that the Digital Twin has at a certain moment must be able to recall, including the value of the indicators on which the decision was made. The reproducibility of the circumstances in which a policy decision is made, through a Digital Twin, is very important: 1. In a rule of law, decisions are taken on the basis of a legal framework and linked indicators and 2. The Digital Twin is really seen as a policy tool and that it can be trusted and helps in efficiency.	Any policy decision (at a time) made on the (partial) basis of a Digital Twin must be reproducible at a later date. So, the state of the Digital Twin at any given time must be able to be recalled, including the value of the indicators on which the decision was made. This phenomenon is also called 'Contestability by Design' (a decision can be challenged at any time, the Digital Twin is then put back in time).
	Analyzing is the process of examining and interpreting the data in the Digital Twins. This includes applying different analysis techniques, models and algorithms to gain insights into the behavior, performance, and trends within the Digital Twin. The purpose of the analysis is to see whether control has the desired effect and where necessary can be adjusted for more or less effects.	The Digital Twin provides insight into an aspect of the Digital Twin, by bringing together one or more forms of information. The result of the insight can be displayed graphically, textually or otherwise. This function is like a Business Intelligence system, but also to an operations center of a security region where information is brought together for analysis and display.
	Digital twins make it possible to anticipate future events, trends or behaviors based on the current and historical data of the simulated object or system. Using advanced analytics, models and algorithms, a Digital Twin can simulate potential outcomes and scenarios, allowing users to proactively respond to potential changes or challenges.	The ability to make a statement about the future state of the representation of reality, based on historical data (through statistics and models). The parameters of the models can be adjusted in such a way that different future situations are predicted. The future state can be visualized in the same interface where the current and previous state were displayed. See also time travel.

 Orchestration	Orchestration ensures that the various components or services within the Digital Twin work together to perform a particular task or workflow.	Tasks performed in the Digital Twin can be connected to each other, if not according to a condition. The output of one process becomes input for the next (parallelized or not). This sequence is not static, but rather dynamic, based on the status of objects or events (see also measuring and analyzing).
 Simulation	A Digital Twin makes it possible to bring together different types of data and combine them into a holistic view of a system, process or entity. This combination helps to gain deeper insight, make better decisions and generate value in various domains. This is an important tool for data-driven work. Simulation can also be used to make use of AI for 'opportunity finding'. The probability cards and what-may-where cards indicate areas with potential for solutions to conflicting interests in that area!	Simulation is based on a chosen starting situation and a model (which can calculate the changes on that starting situation) showing what happens when one or more parameters are changed. Various techniques are applied, such as time travel through data and model results, step-by-step simulation of data series, simulation, event-driven analysis and what-if analysis.
 (User) Experience	A great strength of a Digital Twin is the experience aspect. These experiences go beyond simply observing data and models; They enable people to virtually experiment, learn and understand how something looks or functions. This is achieved by users interacting with a virtual copy. The interaction can take place in different ways. User-friendliness and intuitive interface that makes it easy for users to navigate and perform the necessary actions are also important.	A Digital Twin offers a certain form of experience - a user experience that is inviting and perceived as "efficient". Experience also includes a form of gamification, in which 'user rewards' play a role.
 Identification & Authorization	Identification is a foundation of modern software systems that ensure efficient and secure functioning within digital infrastructures. They are supporting components that can provide access control and access rights, preventing unsecured access. Identification also makes it possible to personalize systems for individual users or groups, so that the user interface or customized	A Digital Twin offers the possibility for an anonymous experience, but this is very limited. In order to experience all the functions of a Digital Twin, the user must present himself or herself through his or her digital credentials. All user activities are logged for later analysis (who requested which state or analysis or controlled actuators). All user activities take place at least following GDPR guidelines and the ethical

	content can be offered and that preferences and settings can be stored.	framework. All access control according to security regulations.
 Trust	A Digital Twin stands (or falls) with the accurate representation (according to agreements and rules) of reality. All data and information that feed the Digital Twins have been tested against agreed quality requirements. Errors cannot be avoided, and user expectations are set accordingly. Trust is also gained through formal agreements and frameworks. For example, the user must make himself known in the system (Identity & Access Management), confidential data is exchanged (data spaces), is logged in and APIs are managed (via gateway functionality).	Confidence in Digital Twins is crucial. A number of (technical) key aspects contribute to trust in ICT systems: Security (protocols), data protection, transparency in data processing, reliability and availability of data and system, comply with standards and laws and regulations. But in addition, a user-friendly and intuitive interface that makes it easy for users also plays a role in trusting the Digital Twin.

3. The policy process and DT policy building blocks

In this chapter, the policy building blocks are matched in some practical exercises or finger exercises with some known policy cycles or policy processes. Examples include the Plan-Do-Check-Act cycle and the spatial planning cycle of the Environment Act and View of the Netherlands.

3.1 The Plan-Do-Check-Act cycle

The PDCA cycle, also known as the Deming circle, is an iterative management model, used for continuous improvement of processes and products. PDCA stands for Plan-Do-Check-Act (see Figure 7).

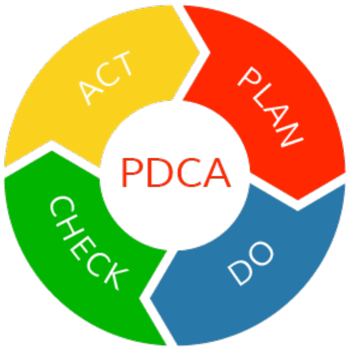


Figure 7. – PDCA cycle

PLAN or Plans
Three activities are central to this phase of plans:
- Problem identification: Identify a problem or opportunity for improvement.
- Analysis: Analyze the current situation and collect data.
- Objective and planning: Set goals and develop a plan to achieve them, including the necessary resources and steps. This involves defining the policy tasks, policy ambitions and policy objectives.

DO or Execute
After planning, the implementation follows:
- Implementation: Run the plan on a small scale to test the effects.
- Implementation and control: Perform the planned activities and record the results.

Policy instruments are used to achieve the stated ambitions. These are measures, laws, subsidies, rules, campaigns, etc., that are used to control the behavior of people, companies and organizations.

CHECK OR CHECK
The CHECK phase evaluates and analyses:
- Evaluation: Compare the results with the expected goals.
- Analysis: Analyze the differences and identify causes of any deviations.

Indicators are used to determine whether the ambitions are achieved. Indicators are measurable quantities that indicate the state of play or the progress of the policy. By monitoring these indicators, it can be assessed whether the policy is effective and needs to be adjusted where necessary.

ACT or adjustment

Finally, the adjustment phase ensures:

- Corrective measures: Take corrective action based on the evaluation and adjust improve performance.
- Standardisation: If the plan was successful, implement the changes on a larger scale and standardize the improved processes.

This cycle is continuously repeated to promote continuous improvement and to systematically optimize processes and products. The policy is periodically evaluated based on the indicators and other relevant information.

Match PDCA cycle with the policy building blocks

We also practiced matching the 16 policy capabilities with the PDCA policy cycle. Two finger exercises looked at whether patterns can be discovered between the policy capabilities of Digital Twin and the policy process. Two finger exercises have been performed for this. Figure 8 shows that certain policy building blocks can be applied to a greater or lesser extent in the policy cycle.

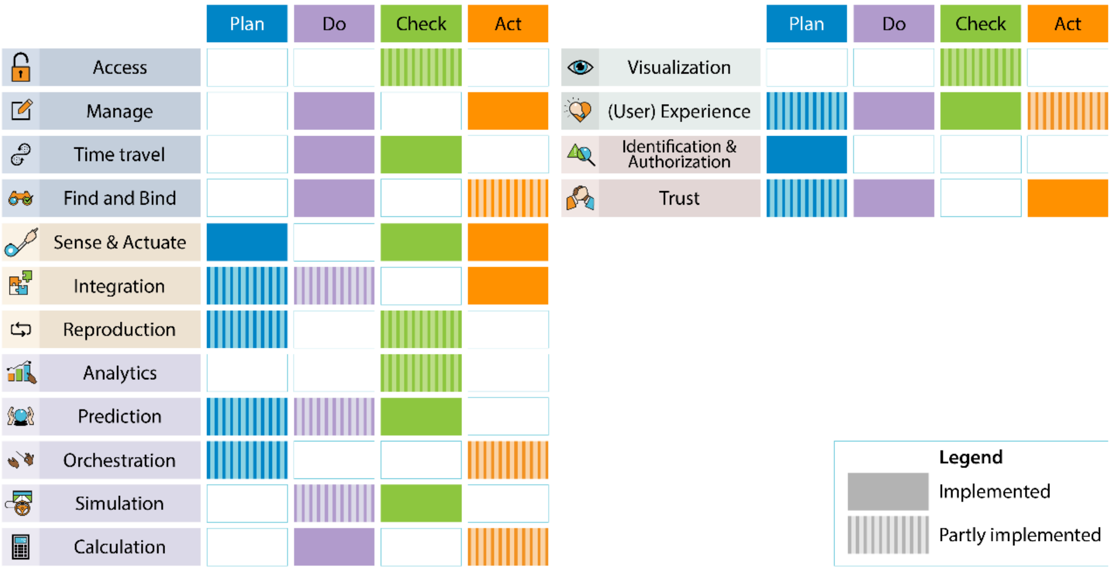


Figure 8. – Finger exercise matching policy capabilities with the PDCA cycle

Take, for example, the policy building block 'time travel'. Time travel in a Digital Twin offers the opportunity to study a situation in time.

That involves going back in time to give a reflection of how something was in the past, but also the ability to look forward in time. Time travel includes the possibilities to carry out historical analyses, explore what-as scenarios, imagine or predict future situations. Time travel is not directly applied in the PLAN phase. Time travel plays a role in the DO phase to mainly test the effects. Time travel is also important in the CHECK phase to analyse the results with the expected goals and to identify the differences and causes of any deviations.

At the stage of Act or Execution, time travel does not seem to matter. For example, each phase of the PLAN-DO-CHECK-ACT cycle requires certain policy building blocks more or less (or not at all). This in turn leads to different Digital Twins, which can support different functions and offer certain policy building blocks. This also means that usually the entire policy cycle is followed by different

Digital Twins, which support different functions in the policy process or that the Digital Twins will change character during the cycle.

3.2 Environmental Law Policy Cycle and View of the Netherlands

During the workshops, the neutral PDCA cycle was used as a finger exercise. The same exercise was also carried out with the policy cycle of the Environment Act and View of the Netherlands (see Figure 9).

Policy development

This includes the process of formulating policy objectives, principles and tools based on analysis of relevant information and stakeholder involvement. It results in the adoption of strategic choices and guidelines for environmental policy.
This is recorded in an environmental vision (each BG its own O-vision), which describes the desired quality of the physical living environment.

Programme: The program describes the specific goals and ambitions that one wants to achieve and contains an overview of the measures and actions that are taken to realize, monitor and evaluate the set goals and ambitions.

Policy pass-through

In doing so, the developed policy is translated into concrete regulations, plans and implementation instruments. This may include drawing up environmental plans that promote the desired spatial development and protection.

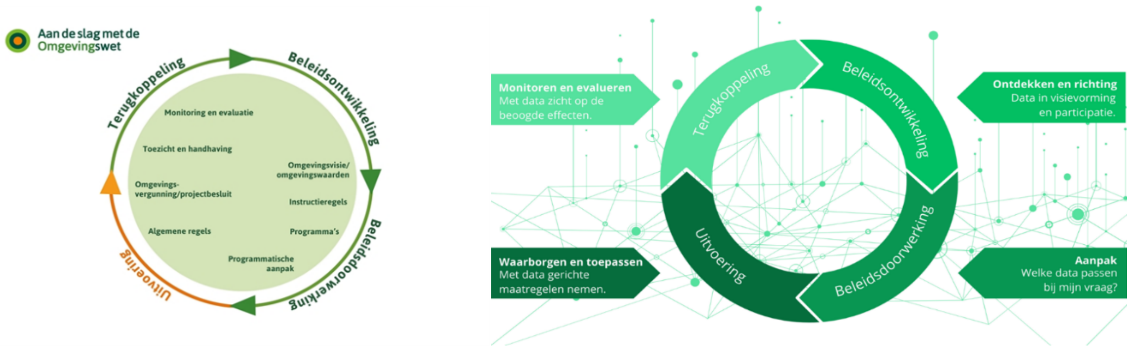


Figure 9. – Environmental Law Policy Cycle [3] and View of the Netherlands [4]

Implementation

In this phase, the established policy is implemented through operational measures, projects, permit granting and enforcement. This includes, among other things, applying permitting procedures, monitoring activities and ensuring regulatory compliance.

The programme shall include a monitoring and evaluation system to measure the progress and effectiveness of the measures taken. Based on this monitoring and evaluation, any adjustments can be made.

The policy is then implemented by public authorities, municipalities, provinces or other relevant parties. This includes enforcement to ensure that rules are complied with, and targets are met.

Feedback

"This concerns the process of evaluation and monitoring of the impacts and results of the policies implemented. Based on insights and feedback from stakeholders, adjustments and improvements are made to policy and implementation practice to strengthen efficiency and effectiveness. The policy is periodically evaluated based on the indicators and other relevant information. On the basis of these evaluations, policies can be adjusted to increase their effectiveness or to address new challenges."

Match policy cycle View of the Netherlands with the policy building blocks
In a second exercise, the 16 were matched with the policy cycle of Zicht op Nederland [4], the government's policy vision in which Digital Twin for the physical living environment was also mentioned as an instrument for social tasks. Figures 10 and 11 below show the results of a finger exercise with policy capablities in the different phases of policy development.

Figure 10. – Finger exercise 1; matching policy capabilities with the View on the Netherlands policy cycle

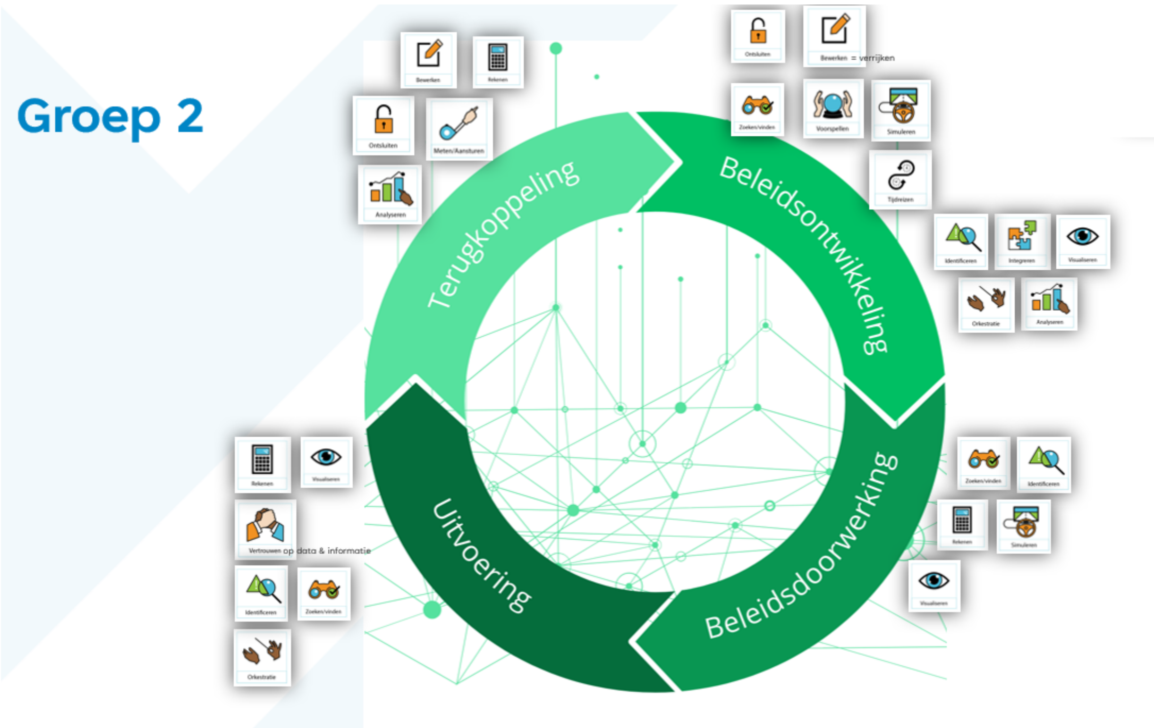


Figure 11. – Finger exercise 2; matching policy capabilities with the View on the Netherlands policy cycle

This exercise was carried out in a workshop in which both policy officers and geodata specialists were present to test whether the icons and the policy capabilities can be applied as a means of communication to be able to conduct the conversation with each other. The conclusion is that this is quite possible, but it also became clear that it is important to provide good definitions of the capabilities to ensure that the concepts with associated icons are applied in the right context so that they always fit the 62 capabilities of the Digital Twin Capabilities Periodic Table.

3.3 DT policy capabilities and the policy cycle; A match?

That a Digital Twin is a valuable tool in making, implementing and monitoring policy is not in question. The Digital Twin can perform various support functions in policy processes:

- Vision formation; by analysing and understanding the functioning of the (coherent) systems and processes - in the present, past and future.
- Simulation and prediction. Simulations help to determine possible effects of proposed policy measures in the physical environment. After policy implementation, Digital Twin can be used for impact analyses and predictions. By comparing the actual results with the predicted results in the Digital Twin, policy makers can assess the effectiveness of policy measures and make any adjustments.
- Participation and communication. Digital Twin can also be used as a means of communication to stakeholders and citizens. By visualising data and scenarios, complex policy issues can be made more accessible. This can increase stakeholder participation and involvement in policy development.
- Monitoring and evaluation. The Digital Twins are used for monitoring and evaluation of policy measures. Policymakers can collect and analyze real-time data to assess the performance of the environment and adjust if necessary.

In fact, the strength of a DT lies in the fact that it can be used as a supporting instrument throughout the entire policy cycle. The 16 different policy building blocks can be used during different phases of the policy process, strongly depending on the type of policy issue that is being addressed. In a few finger exercises, an attempt was made to match the policy building blocks with the policy process. The workshops showed that the Digital Twins help to organize integrated area-based management of the environment, because the entire policy cycle is mapped out and the Digital Twins can provide a situational picture of the effects of policy in all phases. This is more difficult to get into the picture based on documents and research reports. In this way, the Digital Twin is a good tool for consultation between policy advisors. This is important in an era where political decisions are judged more quickly.

The Digital Twin is context-dependent and will change its character slightly over the policy cycle as the data collected in the Digital Twin will change during its use in the policy cycle. In the different phases of the policy cycle, therefore, not one but several Digital Twin are used. Therefore, we started looking for an additional mechanism to bring policy and technology closer together when working on Digital Twin. The next chapter therefore illustrates that the use of indicators brings policy back closer to technology as the next step in the cooperation between policy and technology.

4. Indicators as linking pin

Indicators form the linking pin of policy to the Digital Twin to enable data and model-driven work within the policy process. Indicators link policy standards to the effects of policy measures, guide the implementation of the policy measures and the monitoring and evaluation of the policies implemented. Different types of indicators play a role in the different policy phases of the policy cycle.

4.1 The role of indicators in the policy cycle

Indicators form the linking pin of a policy step to the Digital Twin to enable data and model-driven work within the policy process. To make this possible, policy objectives are first formulated using indicators. These are often high-over indicators. The indicators are further detailed and provided with policy standards or ambitions. As soon as the indicators are sufficiently measurable, we can collect data from reality about those indicators (measurements) and, over time, also calculate for the future (predictions). With the help of policy measures, we can influence and somewhat steer reality, so that the set policy standards are achieved within a policy area. A policy measure also includes the intended impact on the defined indicators. Monitoring and evaluation will help to establish the state of play of the indicators for the policy standards and measures set, using the data collected, and to analyse the real impact of the measures implemented. Various types of policy analysis and research (also a tool for the policy process) can be carried out with the Digital Twin (or other instruments). Of course, the substantive policy themes also influence each other. A policy analysis can help to find links between policy themes and how much mutual influence there is between policy themes. The pass-through will also be reflected in the indicators used. Policy research and analysis can be used to make an analysis of the indicators and their relationship to determine the most important links so that they can be included in the Digital Twin.

Figure 12 below illustrates the role of indicators as a linking pin between a policy step and technology. During the 'handshake' that takes place between policy and technology, the conversation takes place about data, indicators and functions (building blocks) of the Digital Twins. That this can be put into practice, policy and technology can understand and understand each other better. For the policy, the policy themes are converted into indicators and data to make the indicators measurable, and the policy building blocks provide the relevant interpretation for the technology to shape the Digital Twins.

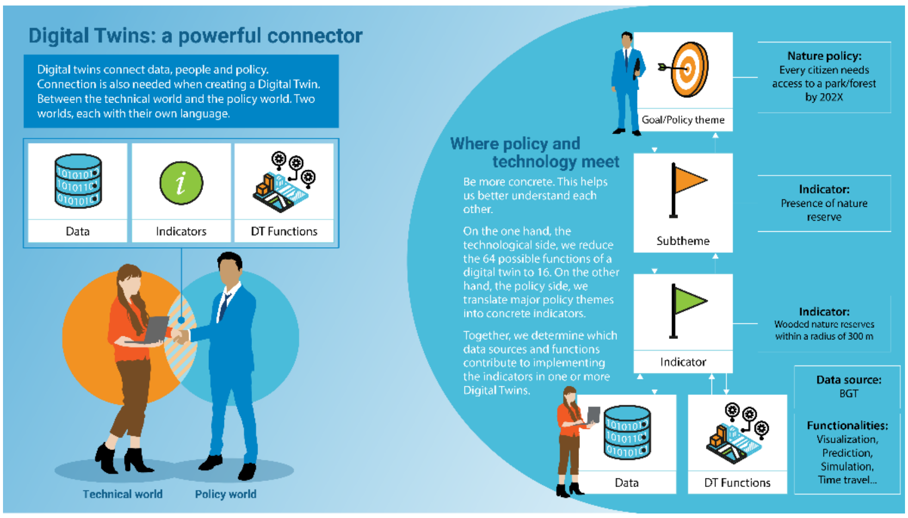


Figure 12. – Indicators as a linking pin between policy and technology

Best practice GMO province Utrecht

The third workshop also illustrated how indicators can be applied in the different policy phases. For this, the Digital Twin of the Healthy Area Development of the province of Utrecht has been taken as an example (see Annex 3). Indicators at various levels also play an important role in the GMO Digital Twins of the province of Utrecht. The indicators are described in detail from the policy themes and their sub-themes (see also the [Handbook on GMO Digital Twin Province Utrecht]). In the examples below, the indicators for the air theme have been taken as an example (Figures 13 to 20).

Thema	Lucht			Energie	Water	Bodem	Geluid
Subthema	Luchtkwaliteit NO_2	PM_{10}	PM_{10}				
Indicator	Aantal woningen in NO_2 contouren	Aantal woningen in PM_{10} contouren	Aantal woningen in $PM_{2,5}$ contouren				

Figure 13. – Indicators for the air theme of the GMO Digital Twin province of Utrecht

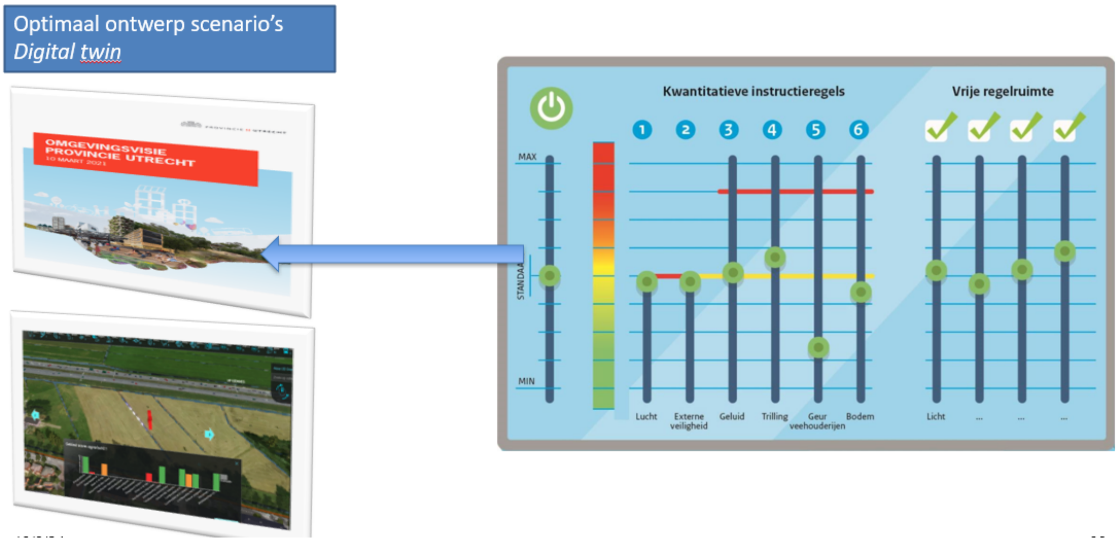


Figure 14. – Quantitative Instruction Rules and the GMO Digital Twin Province of Utrecht

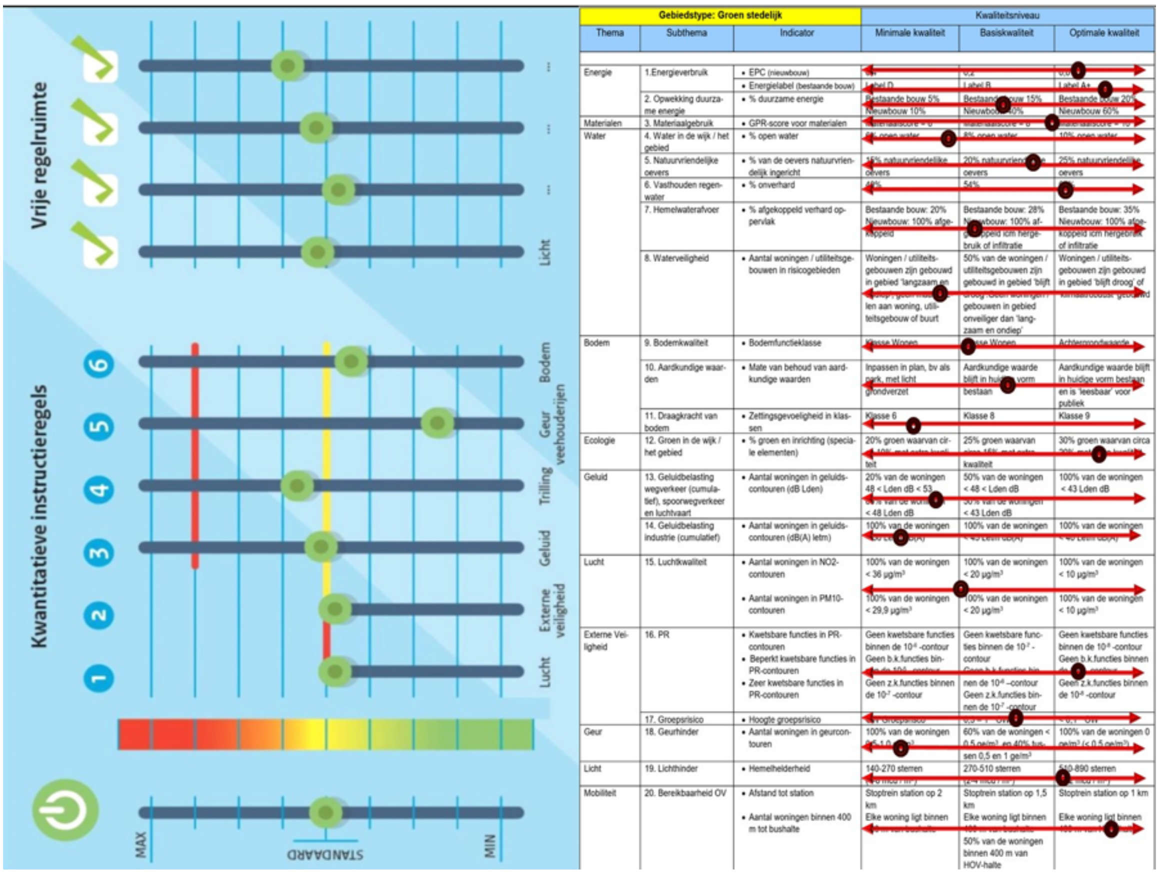


Figure 15. – Indicators of the GMO Digital Twin province of Utrecht

Figure 16. –The GMO Digital Twin province of Utrecht

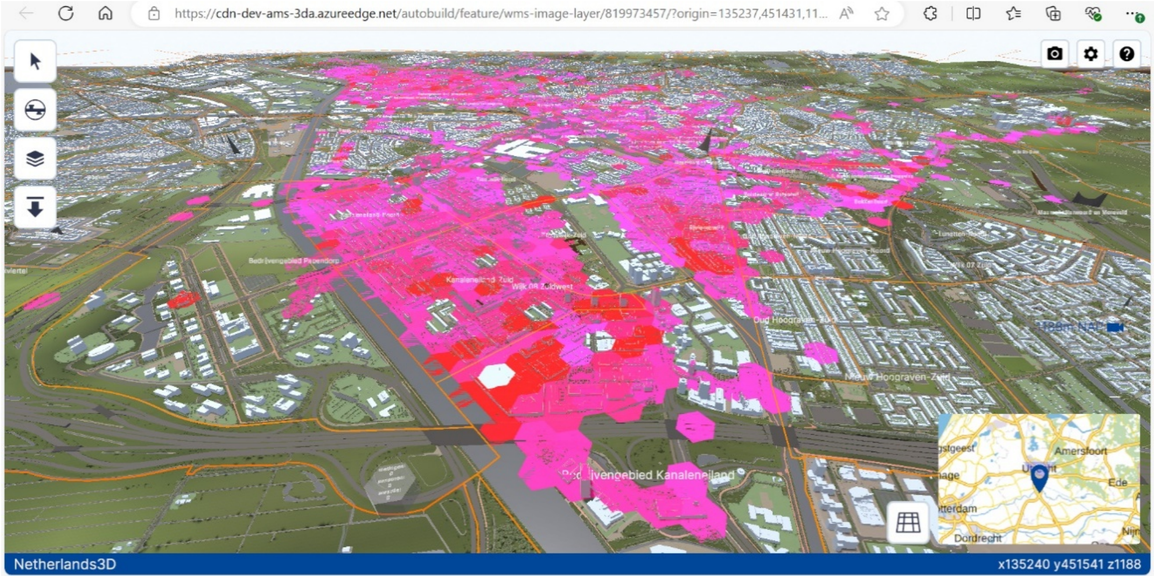


Figure 17. – Heat stress measurement of the municipality of Utrecht in the context of 'green neighbourhood, cool neighbourhood and the EU project 'urban releaf' (source: 3d.netherlands.eu)

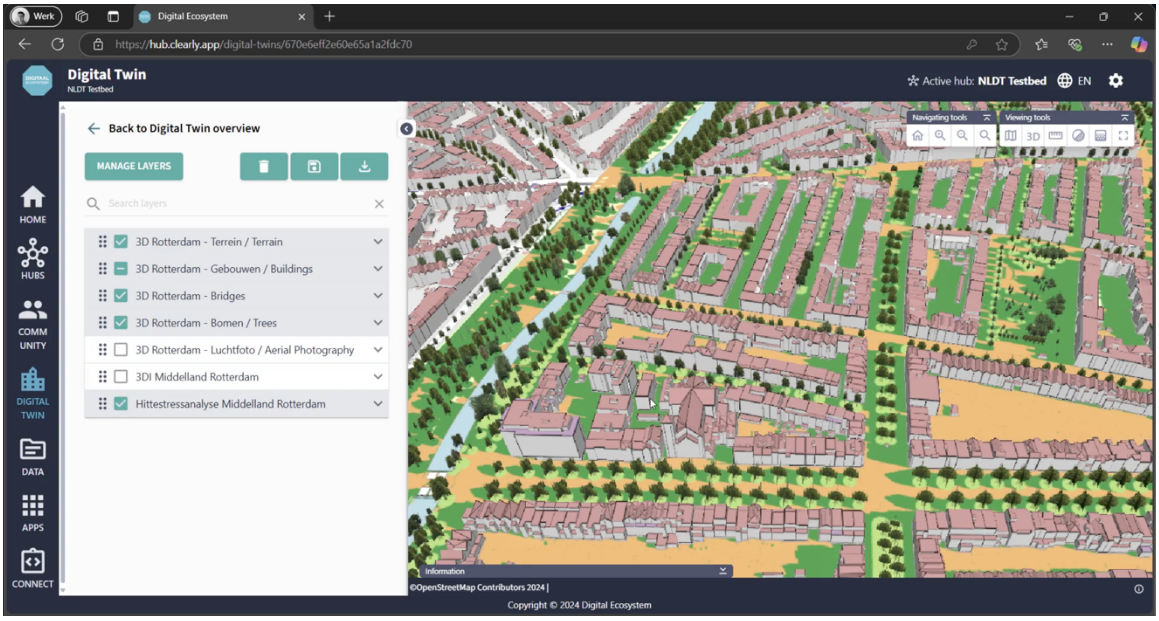


Figure 18. – Heat stress measurement of the municipality of Rotterdam in the context of a Geonovum testbed around Calculation module interoperability (source: Future Insight with OUP, City of Rotterdam, Tygron)

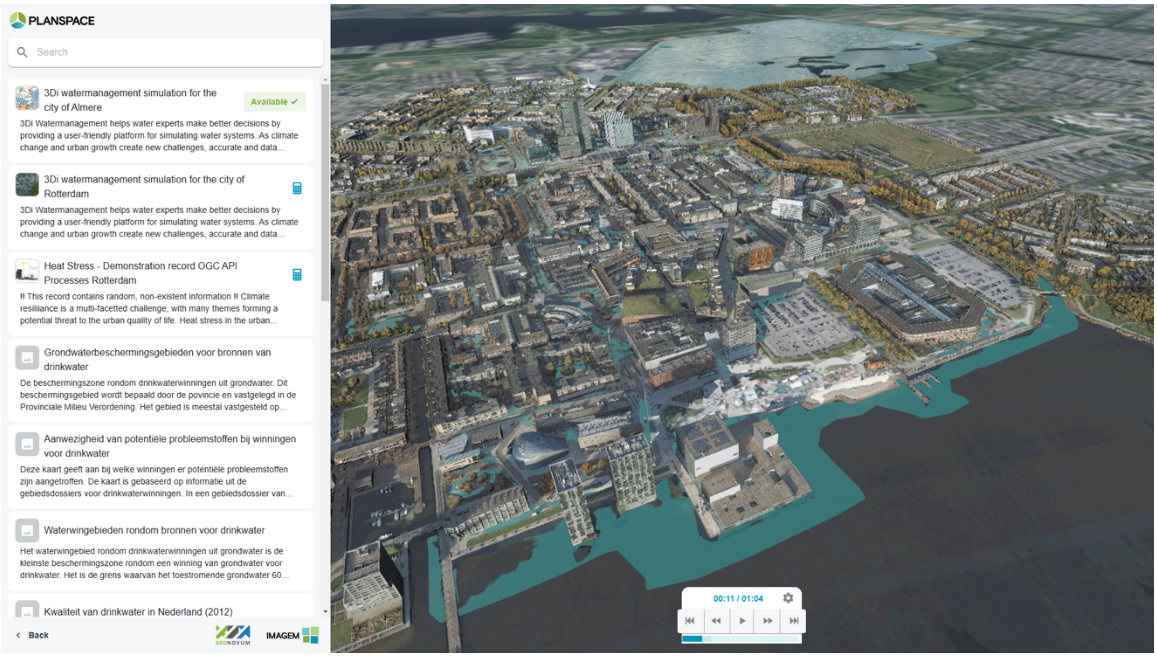


Figure 19. – Water flows are displayed in real time in the IMAGEM Planspace application (source: Almere, Imagem and Nelen & Schuurmans)

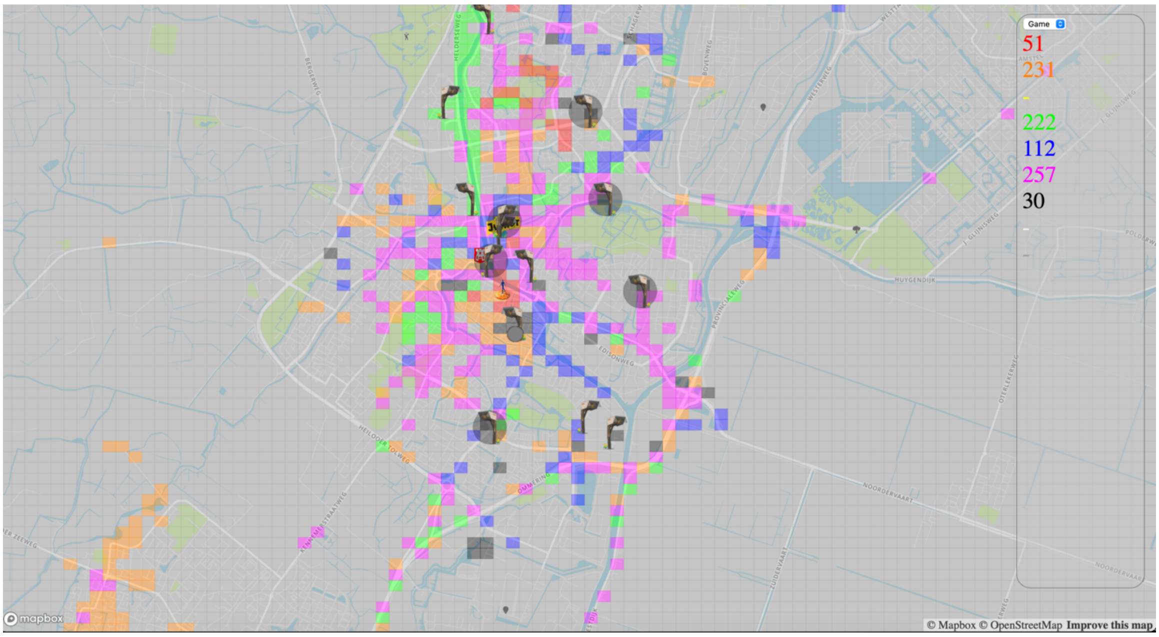


Figure 20. – Junior Smart City Challenge of the municipality of Alkmaar, a game in which the juniors in Alkmaar conquered the digital map of the city centre. A Citizen Science project. (Source: Alkmaar and its inhabitants)

Figure 21. – Temperature measurements data anonymised displayed in GMO Digital Twin province Utrecht (approved by CISO) (source: 3d.netherlands.eu)

Figure 22. – Example of the GMO Digital Twin province of Utrecht

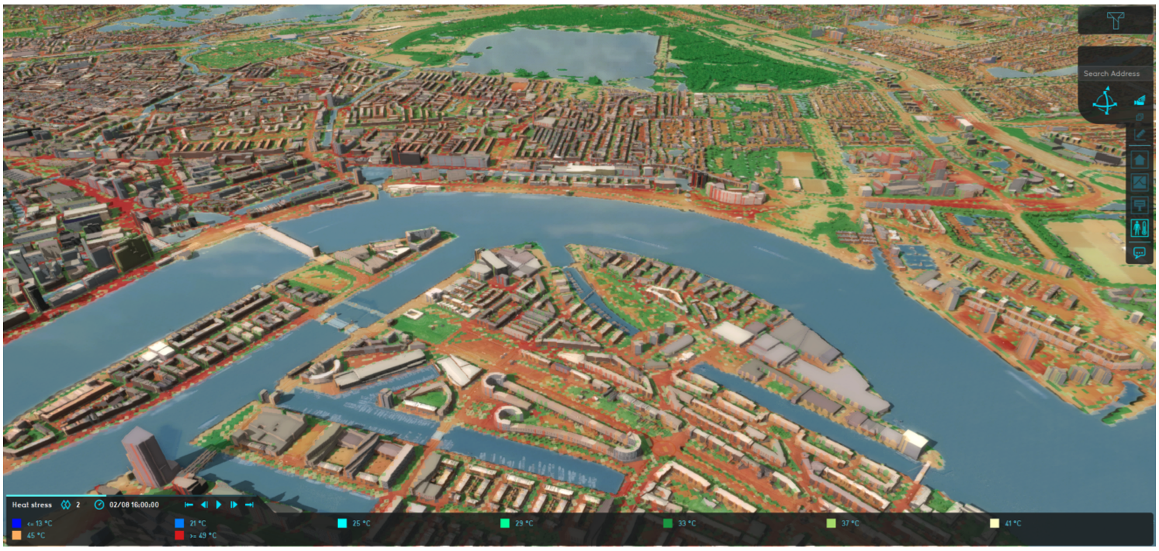


Figure 23. – Example of heat stress calculation in Rotterdam (Source: Municipality of Rotterdam, Rotterdam 3D and Tygron)

Gebiedstype: Centrum stedelijk

Scores

Bescherming gezondheid

Thema	Subthema	Indicator	Kwaliteitsniveau: Minimale kwaliteit Score 6		Basiskwaliteit Score 8		Optimale kwaliteit Score 10	
			standaard	1e lijn	standaard	1e lijn	standaard	1e lijn
Geluid	1. Geluidbelasting industrie, wegverkeer, spoorwegverkeer, luchtvaart, windturbines	• Aantal woningen in geluidscontouren (dB Lden)	100% < 58	100% < 63	100% < 53	100% < 58	100% < 48	100% < 53
		• Mate waarin het oppervlak van een gebied geluidbelast is (dB Lden)	100% < 58		100% < 53		100% < 48	
Lucht	2. Luchtkwaliteit NO_2, PM_{10}, $PM_{2,5}$	• Aantal woningen in NO_2-contouren	100% < 22 μg/m³		100% < 18 μg/m³		100% < 10 μg/m³	
		• Aantal woningen in PM_{10}-contouren	100% < 20 μg/m³		100% < 16 μg/m³		100% < 10 μg/m³	
		• Aantal woningen in $PM_{2,5}$-contouren	100% < 11 μg/m³		100% < 9 μg/m³		100% < 5 μg/m³	
Geur	3. Geurhinder	• Aantal woningen in geurcontouren	100% tussen 0,25 en 0,5 ou_E/m^3		60% < 0,25 ou_E/m^3 en 40% tussen 0,25 en 0,5 ou_E/m^3		100% < 0,25 ou_E/m^3	
Externe Veiligheid	4. Plaatsgebonden Risico	• Kwetsbare functies in PR-contouren • Beperkt kwetsbare functies in PR-contouren	Geen kwetsbare functies binnen de 10^{-6} -contour Geen b.k.functies binnen de 10^{-5} –contour		Geen kwetsbare functies binnen de 10^{-7} -contour Geen b.k.functies binnen de 10^{-6} –contour		Geen kwetsbare functies binnen de 10^{-8} -contour Geen b.k.functies binnen de 10^{-8} –contour	

Alerts

Bescherming gezondheid

Thema	Subthema	Alert
Staling	A. Electromagnetische straling	bij woningen binnen 0,4 μT-contour langs hoogspanningslijnen
Geluid	B. Stiltegebieden	bij plangebied in 'stille kern' en/of 'stiltegebied' en/of 'bufferzone stiltegebied'
Klimaat-adaptatie	C. Waterveiligheid	bij plangebied in 'overstroombaar gebied' en/of 'vrijwaringszone regionale waterkering' en/of 'waterbergingsgebied'

Gebiedstype: Buitencentrum

Figure 24. – Indicators for the health protection of the GMO Digital Twin province of Utrecht

In the figures below, a first translation has been made of the indicators for the theme of air into the planning phases. Relevant functions are selected for each policy step; It's all about the indicator. A 3D visualization of the physical environment is not a Digital Twin, it only becomes a Digital Twin if the environment is related to one or more indicators.

Theme Air, sub theme: Air quality

■ KPI: Number of houses in NO2 contours

Plan (analysis of the problem):

From the DT side: defining the contours, current NO2 values in the contours as a coverage, putting coverage on the map with colors, overlaying with other indicators in the same policy area via search)

Theme Air, sub theme: Air quality

■ KPI: Number of houses in NO2 contours

Do (Test possible Solutions)

Acalculation module calculates the NO2 values, given the number of houses and their location - result if a coverage (over time?) is analyzed and shown on a map.

The calculation module can calculate multiple scenarios - all scenarios can be laid on top of each other for comparison.

Theme Air, sub theme: Air quality

■ KPI: Number of houses in NO2 contours

[Check (Verify effectiveness)]

Of the different scenarios, 1 is retained.

All data, data, parameters of this choice must be kept up to date, so that the choice can be reviewed later.

Take a snapshot, so that in 20 years the choice can be substantiated again

Theme Air, sub theme: Air quality

■ KPI: Number of houses in NO2 contours

Houses are built according to the outcome of the chosen solution.

The No2 values in the policy area are measured as a coverage over time (time series).

4.2 The use case canvas refines with the linking pin method

The indicators for policy are of course determined by the policy, with substantive experts negotiating the variables, which may or may not be indicative of the desired direction. And the functions and data for the Digital Twin are more the field of technology and relevant concepts for the technicians. How and when do they come together? For this purpose, the use case canvas method is available. The use case canvas method is a method to use various workshops together with the policy (policy officers) to count down a policy theme into a number of user stories in which the indicators are central. During the entire phase, both the policy officers and the data specialists are involved. At the beginning of the process, policy officers will be the most active in the joint workshops. They tell you what is needed and how things relate to each other. Later in the process, the user stories are considered and discussed on data and functionalities that are necessary for making them measurable and working with the indicators in the Digital Twin. Data specialists and IT staff will then play an increasingly active role, enabling IT staff to create a prototype Digital Twin (see Figure 21). In practice, it appears that (geo)data specialists are key persons in this process. They understand very easily where, from the policy point of view, the demand for information lies and they know where they can answer that question.

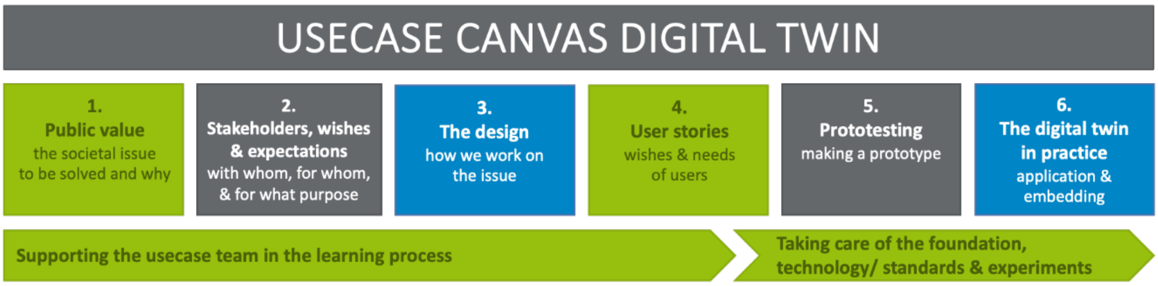


Figure 25. – The use case canvas method

The use case canvas method is built up in different steps in which workshops with the stakeholders, both the substantive policy and the technology are central (see Figure 22).

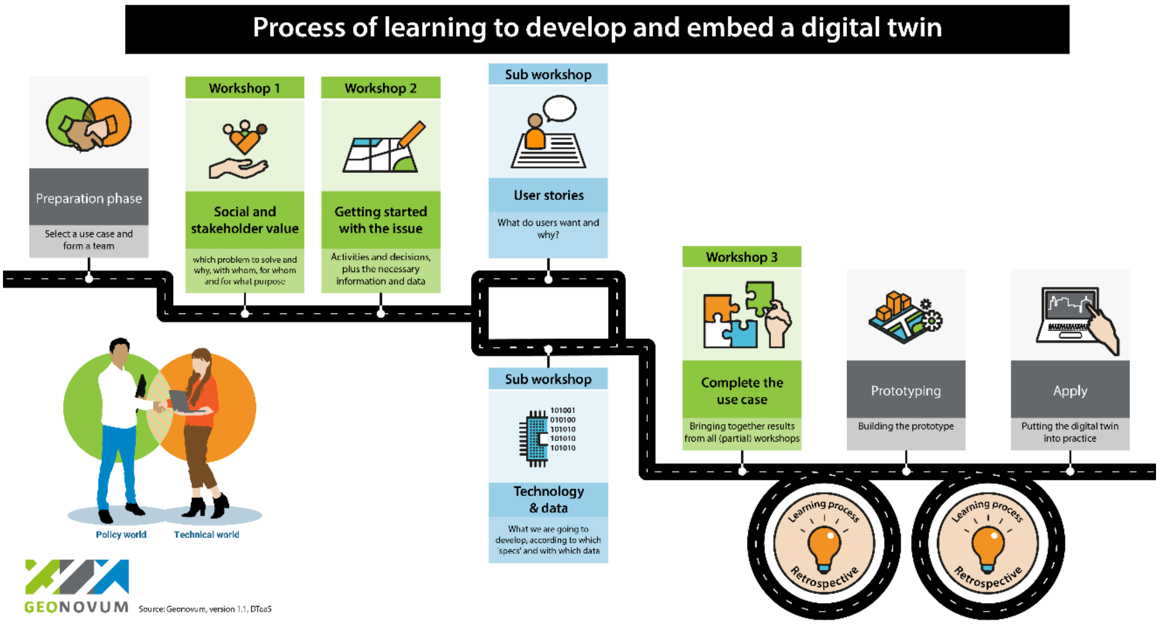


Figure 26. – The process steps for going through the use case canvas method

The use case canvas method is structured in several steps in which questions are always central (see Figure 23).

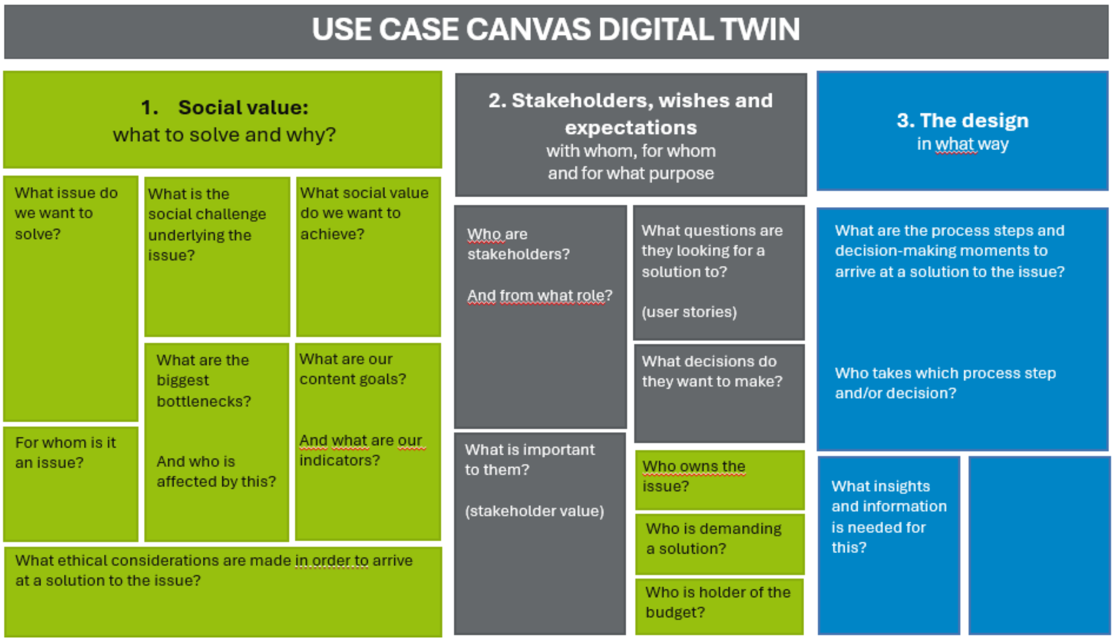


Figure 27. – Questions at the heart of the use case canvas method

Below is an example of a user story that is being executed in the DMI project (Figure 24). This way of drawing up a use case is developed by Geonovum into a new standard that can be used in new tenders for Digital Twin. In the method, policy and technical staff are gradually connected to each other at relevant times – in an agile way (and especially not in a waterfall way). Both employees then engage in conversation and work iteratively together, where they also learn to speak a common language together.

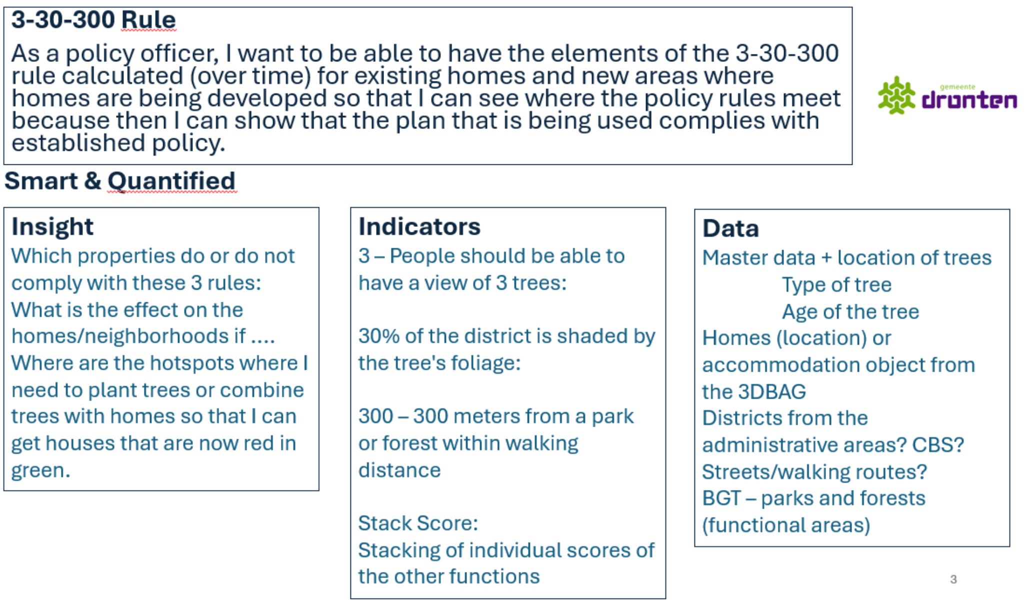


Figure 28. – Example of a user story; from policy demand to indicator and data

4.3 Key recommendations

During the three workshops, some clear findings emerged. The policy world and the technical world can come closer together by trying to understand each other's language and engage in conversation. In doing so, we can use the different methods:

1. The 16 basic functionalities of a DT for policy: the policy building blocks for Digital Twins.
2. Give more attention to the indicators for policy as a linking pin between policy and technology; indicators are the linking to data and functionalities for the Digital Twins.
3. Use the use case canvas on policy and engineering to work together to develop and use context specific Digital Twin in the policy process.

During the workshops, various focus areas and several 'brackets' to be developed in more detail were identified. Below are some focus areas and 'brackets':

Basis of policy

Policy is based on a basis, i.e. policy is laid down in rules and agreements, which often have a (legal) basis. The question is what do you take with you in your Digital Twins and where is the boundary? The question of what we want versus what we need also plays a role in this. Capturing what the foundation remains an important aspect of working together on Digital Twin. The use of algorithm and sensor registers by the Digital Twin is essential for transparency and trust.

Enriching use case scenarios

The collaboration between policy and technology in Digital Twin starts with the use case canvas. The use case canvas is the method to start the conversation between policy and technology. The use case canvas is a method, with various workshops, to initially peel off a policy theme into several user stories together with policy officers. Subsequently, additional data specialists and other IT professionals will discuss per user story which data and functionalities and concrete indicators are needed. With this, the IT staff can work on creating a prototype Digital Twin that will be improved by testing with the policy staff. The findings of this study, working with policy building blocks and indicators, should be part of the use case canvas method. The use case canvas method should be enriched with the iterative/agile design with policy building blocks and indicators (instead of a static tender).

More attention to integrality

More attention for integrality is always reflected in the discussions held. Policy assessment frameworks are usually integral, especially in the case of spatial policy. The GMO of the province of Utrecht is an example of this. How do policy ambitions, indicators and area profiles and the assessment frameworks relate to each other? How the indicators from different policy themes relate to each other in space and time and with the effects of interventions is a permanent focus and a core function of the Digital Twin.

Impact on architecture

There was also talk about the impact on architecture for Digital Twin, a project that was initiated separately from View on NL and DMI (DTNLArchitecture in Development) and earlier from the Location Pact (DTFLArchitecture). It has become clear from the discussions that the participants think it is important that the findings will also have an impact on the DTNL architecture (see Figure 22). This task lies with the architects. The architects of the NLDT use existing agreements as much as possible, from the government (eg ICTU & Logius), the provinces and the municipalities.

A Federation of Digital Twin

The NLDT does not build Digital Twin itself but brings them together[3]. It is an addition, multiplication, union, cross-section, etc. of a field under commonly accepted conditions. A high degree of interoperability is a prerequisite for achieving the national 'field' of Digital Twin: The 'countability' of Digital Twin is an important condition for the NLDT. The following topics should be highlighted for research and depth:

1. More central role of Indicators in architecture. Because Indicators play such a central role in policy, they should also be more central in the architecture – The Data Working Group, the group working on interoperability and interchangeability of Data in the NLDT (see Figure 22) with other components: Visualization and Calculation Models.
2. Archiving (or 'snapshot') of the data, which was used for policy purposes. In other words: 'contestability by design': you must be able to revert the Digital Twin to a situation (simulation or real) where policy was pursued, so that it can be verified that the chosen path was the right one[4].

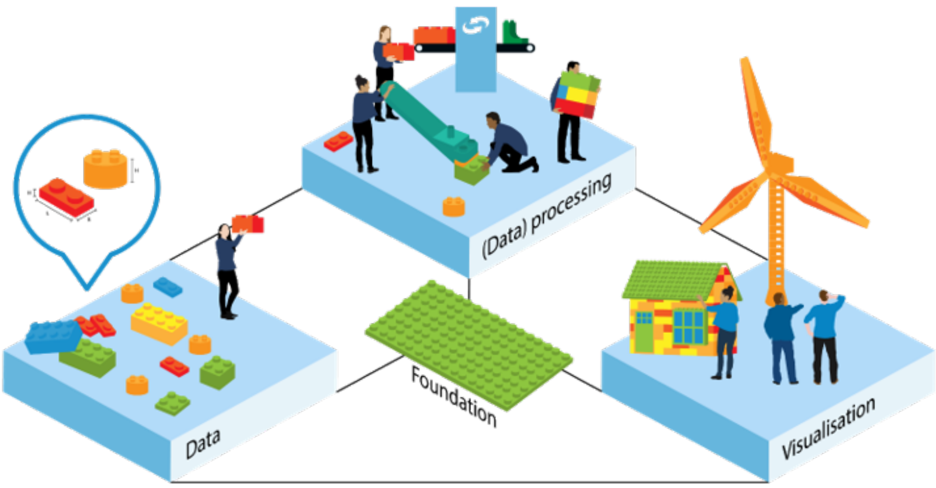


Figure 29. – Architecture of Digital Twin

Influence on surrounding initiatives

There are currently, at the time of writing, a number of initiatives and projects, both in the Netherlands and Europe. For example, the Netherlands has indicated that it wants to be involved in the EDIC of the Digital Twin, as well as there are municipalities that play a leading role in Living in EU projects and organisations. The Netherlands is seen as one of the leaders in the field of deployment of Digital Twin (to a greater or lesser degree of maturity).

In this way, we could use this study in new initiatives by Europe, in order to bring policy and technology closer together.

[3] The NLDT is a programme of the Ministry of the Interior, which is part of the policy agenda View of the Netherlands. The Ministry of the Interior is working together with Geonovum on an architecture and a research agenda for the NLDT, in which missing tools, standards and working methods are developed for the NLDT.

[4] In 2024, Digital Government awarded a grant to expand a standard for transparency in decision-making. It is important that the government provides accountability and transparency to citizens and businesses about its actions. Citizens and businesses need to know what data is being used and how decisions are being made in and with Digital Twin.

However, the approach is not theoretical (there have been enough of them), but focused on real and existing challenges. The direction that we have to take is given here as a 'guardrail':

- Reasoning from real problems and policy challenges, such as housing or energy or NIS2 (and others);
- Demonstrably interoperable policy building blocks according to agreed NLDT principles and architecture as well as those of the EU Citiverse (which are compatible with the NLDT). The 'Citizen Verse' puts the inhabitant first, which is close to what we invest in policy-making;
- Not only participatory (measuring together) but also legally synchronous for the entire policy cycle (using environmental law/DSO, as well as monitoring);
- Above all 3-layer: municipality, province and state (without a hierarchy), i.e. taking green transport or water for a cross-border dimension (other countries do not have that, and that is necessary: just look at the downpour of 2023 at the 3 country point);
- Integration BIM/civil-district-infra as a partial answer to the Levels of Detail question. The layers are connected through APIs.
- Joining (national) register, sensor register, algorithm register and AI directive;
- Archiveable for later burden of proof in court (time stamping) (see also impact on architecture);
- Using genAI to support residents and in line with the SURF/TNO LLM pilot we are currently doing;
- Connecting other municipalities and colleges;
- Connecting suppliers.

Finally

In the last workshop it was concluded that a 'handshake' between policy and technology is necessary to be able to apply Digital Twin properly in the policy process. However, a number of 'profit warnings' are also issued and questions remain about the findings:

1. After all, organisational reality must be taken into account. Organisational reality is not the same everywhere, which means that processes and cooperation between policy and technology will not always take place in the same way. Take this into account;
2. The use of indicators also means that the issues to be solved are made concrete in reality and expressed in figures. This 'concretisation' is not always manageable for policy and for directors;
3. Working with indicators in policy also quickly leads to the classification and coloring of policy situations with red-orange-green characterizations. Consider carefully what it means for policy and considerations in space;
4. Achieving more integrality in policy also requires that indicators of various policy origins and affiliations should be considered in relation to each other. How do indicators interact and interact with each other? And do we not need a framework of impact indicators for this?
5. For the use of the policy building blocks, an additional battle is certainly needed about the meaning, definition and coherence of the policy building blocks. As an example, the building block is called 'time travel', which is associated with 'reproducibility' and the building block 'calculation', which is also important for some other building blocks, such as 'predicting' and 'simulating'.
6. It remains important to take into account the different levels of detail in Digital Twin. The question of how to deal with this also often comes back and deserves more attention. This question is addressed in the DMI project as part of Geonovum's research questions.
7. The intensity with which policy building blocks are applied in Digital Twin also varies. We see variations of Digital Twin in the different policy phases. Focusing on the policy question can be assumed to be guiding. Which design and effect parameters are best suited to this?

Source material used

[1] Geonovum. Advice Digital Twin province Utrecht Geonovum. Version 1.0, 10 March 2023.

[2] Digital Twin Consortium. Digital Twin Capabilities Periodic Table A Digital Twin Consortium User Guide 2022-03-28. URL: https://www.digitaltwinconsortium.org/wp-content/uploads/sites/3/2022/06/Digital-Twin-Capabilities-Periodic-Table-User-Guide.pdf

[3] Environmental Law Policy Cycle. URL; https://iplo.nl/regelgeving/omgevingswet/beleidscyclus/

[4] Vision View of the Netherlands. Data-driven collaboration on the physical living environment. Ministry of the Interior. November 2023. URL: https://www.zichtopnl.nl/

[5] Investment proposal National Digital Twins for the Physical Environment. Version 1.0, 15 July 2021. URL: https://www.geonovum.nl/uploads/documents/DTFL-Investeringsvoorstel-Compleet-v14.pdf

[6] Geonovum. Reference Architecture System Digital Twin Physical Environment. V0.9 11 February 2021. URL: https://www.geonovum.nl/uploads/documents/20220211%20Referentiearchitectuur%20Stelsel%20DTFL%20versie%200.9.pdf

Annex 1 – Interview questionnaire

Digital Twin (DT) Interview Questionnaire

min			
10:00-10:05	**1**	**proposals**	
	a		Pitches
10:05-10:15	**2**	**Context Digital Twin interviewed**	
	a		Which DT is it today?
	b		Do you have any more?
	c		If so, are they different or do they have similarities?
	d		What is your role on the issue?
	e		What is your role in DT?
10:15-10:45	**3**	**Why and what to solve**	
	a		Why was this DT developed?
	b		What problem does it want to solve?
	c		What social task (or legal obligation) is at the root of the problem?
	d	*	Is it applicable to every policy area?
	e		What does the user want to be able and achieve with the DT?
	f	*	How the DT is used in practice
10:45-11:00	**4**	**Who are the stakeholders**	
	a		For whom is it an issue?
	b		Who owns the issue?
	c		Is this also the owner of the DT? Who is the budget holder?
	d		Who are the main stakeholders in the issue?
	e		Who are the (primary and secondary) users of the DT?
	f		Who has the most benefit from the DT?
	g		Who might be negatively affected by the issue/DT?
	h		Who was involved in the design of the DT? How?
11:00-11:10		**COFFEE/THEE PAUZE**	
11:10-11:40	**5**	**design**	
	a	*	At what stage of policy implementation is the DT used?

	b		Which (spatial) area does the DT relate to?
	c		What is the characteristic of the DT? What's it supposed to do? What, for example, is visualized or measured?
	d		How does the DT contribute to trade-offs/decisions?
	e		what assessment criteria were used for the drafting?
	f		How can you make the policy measurable with the DT?
11:35-11:40	**6**	**Ethics**	
	a		Have ethical considerations been made in order to arrive at a DT for the issue?
11:40-11:50	**7**	**success factors**	
	a		What bottlenecks have you encountered?
	b		Success factors.
	c		What technical requirements and limitations did you encounter?
11:50-12:00	**8**	**evaluation**	
	a		How others look at it/What feedback or compliments Do you receive for this?
	b		If you were to do it again, make a DT, how would you do that? tackle? What else would you do/do the same?
	c		What recommendations can you make for comparability, summability and usability

Annex 2 - Participants workshops and interviews

(in random order)

Rob Peters – Province of Utrecht

Martin van Battum – Province of Utrecht

Pjotr Sillekens - province of Utrecht

Jolanka van der Perk - province of Flevoland

Albert de Graaf - - Province of Flevoland

Serhat Genc – Province of Flevoland

Arny Plomp - Province of North Holland

Niels Hoffmann - Province of North Holland

Elles de Vries - Province of North Holland

Brigitte Cavens - van der Sommen - Municipality of Eindhoven

Arno van der Most – Municipality of Eindhoven

Andries Osseman – Borderless data landscape

Klaas van Veelen - Borderless data landscape

Gineke van Putten - Geonovum

Bart De Lathouwer - Geonovum

Silvy Horbach - Geonovum

Annex 3 - Healthy area development province of Utrecht

The Province of Utrecht is looking for opportunities to support the policy cycles more innovatively and integrally from a strong knowledge role. That is why the province started a process a few years ago to develop indicators for the quality of the living environment that reflect the situation in a certain area before (0 situation) and after (variants) the realization of an area design. This translates a physical area into a digital area (Digital Twins). For the considerations within an area development, the ambitions, policy objectives and underlying policy indicators are important. For these indicators to speak, it is necessary that there is a way to visualize and calculate the indicators in a 3D platform. Further detailing of this goal is the provision of a 3D platform to support an improved way of working through specific user stories. For this phase, the following use case has been developed for a (policy) advisor in the implementation of a planning process [1]:

> *"as a (policy) advisor, I want to understand the 0-situation (start-up situation) of a project area on the basis of validated indicators, so that I am better able to fully align the ambition with regard to my domain (climate, housing, mobility, etc.) with other domains, resulting in a healthier and more balanced plan for the project area."*

During the exploration of the regional 3D platform, the process of planning around the housing assignment was selected as the process where the platform can provide the most added value at this moment and in the coming years. In addition, (policy) advisors have been identified as a stakeholder as a logical first step to work with indicators and a regional 3D platform. The planning process with regard to the housing assignment as outlined below in Figure B3.1 looks high, whereby both the advisor on the housing assignment and advisors on other relevant themes such as climate, water, mobility and greenery can get added value from the platform (see [1]). Using the platform to view the 0 situation of a project area will mainly help the consultant at the start of the project to align realistic goals (ambition) with each other in order to create the healthiest possible living environment.

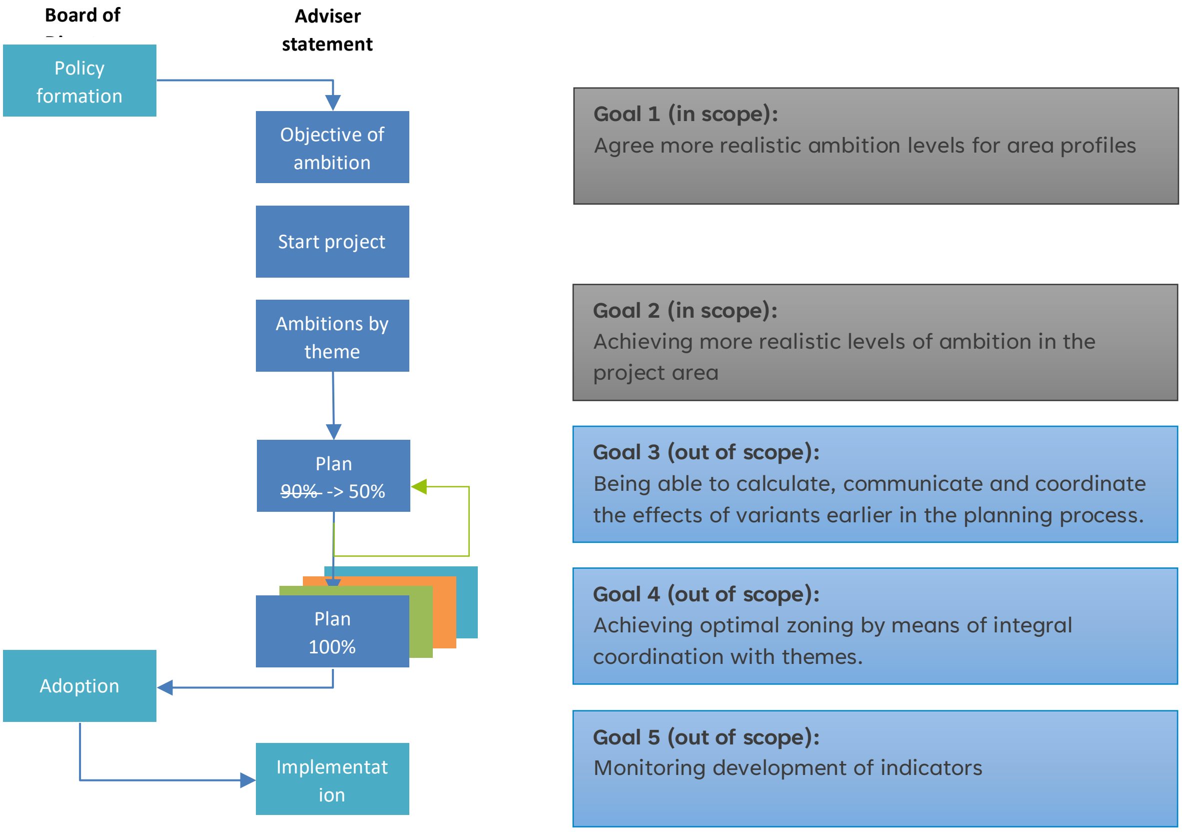


Figure B3.1 – The planning process for the housing declaration (Source: [1])

Presentation of area indicators

A presentation (dashboard) with area indicators tells how the area scores in its current status. The score says something about the quality of the area in relation to the policy ambition as laid down in the area profile. An indicator is scored with a number from one to ten, whereby a different ambition may apply per area profile and it differs. The purpose of this building block is a clear, user-friendly overview in the form of a graph and/or table of how the area scores on the indicators (see Figure B3.2).

Figure B3.2 – Score of area indicators Digital Twin Province of Utrecht

Explanatory map layers
In addition to an integral score of the total project area on an indicator, it is important to see geographically from which data and model basis these scores have been derived. This also makes it clear where in this **area** high and low is scored on the indicator. The explanatory map layers can be switched on and off separately and viewed. In addition to the geographical visual display, a specific location/point in the project area can be selected and information can be requested about the value and score of that specific location in the area. The explanatory data and the **indicator** data must be consistent, this means that both data must be 'frozen' and based on the same (currentity of the) source data, the definitions and the calculation basis.

Translated to the use case:

*"as a (policy) advisor, I want to understand the specific values at specific locations within the project area using validated **indicators**, so that I understand the possible measures to meet the ambitions according to the defined area profile."*

Recognising accountability
During the planning process, indicators may lead to discussions on the establishment of the indicator, the models used and the accuracy and **timeliness of data sources** used. It is therefore important that the methodology used behind an indicator can be seen. At least there should be **described** which **model** (version) has been used and **how** this **model** is **justified** (scientific technical validation), which source data has been used and what the current situation is. The indicator is thus a defined data product with owner. It should be explicitly described how the platform and the indicators can/cannot be applied. Based on **the justification,** the indicator should be fully reproducible. NB: Semantics is important here! You want to have your legend consistent, you want to know what source data was used to build a map layer.

Translated to the use case:

"as a (policy) advisor, I want to understand how the score per indicator is established, in order to be able to justify it to the director."

Relevant sources

[1] Roadmap - Regional 3D platform Province of Utrecht. Powerpoint province Utrecht (4-11-2022)

[2] Luc de Horde, Mark Haaksman, Ilco Slikker, Regional 3D platform. Plan of Action Phase 1. Version 1.1 (8-11-2022)

Related activities

In this research, the Province works closely with the Digital Twin Lab of Utrecht University of Applied Sciences under the leadership of Dr. Koen Smit. Examples of this collaboration, such as Cartesius, are shown here HU Stories: Digital Twin Utrecht University of Applied Sciences Utrecht and have been nominated by a professional jury for the computable award 2024.

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