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Landscape projections Kennemerland: display, model and use (image courtesy Tinker imageers)

## 3D-models in landscape architecture

### 1. Introduction

Landscape architecture consists of a basic attitude that involves four principles of study and practice. These are: anamnesis (palimpsest), process, three-dimensional space and scale-continuum (relational context). The core of landscape architecture as a design discipline is the construction and articulation of three-dimensional outdoor space. It considers the *understanding*, *representation* and *realisation* of the landscape composition as constituent components of spatial design. Visual representation is essential in the understanding and construction of landscape and facilitates the dialogue between conceived and realised space (Nijhuis, 2010, 2011).

Models are an important form of visual representation. This paper is about the role of physical 3D-models and modelling in landscape architectonic research and design. These landscape models, next to drawings and maps are crucial in the process of *design research* and *research by design* in landscape architecture. In this respect models offer landscape researchers and designers different modes of operation for visual thinking and visual communication. This contribution explores the different functions of (augmented) models for landscape architects, which include exploration, confirmation, synthesis and presentation in terms of use and process. It introduces and describes a typology of models based on their performance (instrumental use), exemplified with several cases. Although the focus here is on the role of models in landscape architecture, the argument developed in this paper is also relevant to the closely related disciplines of architecture and urban design and thus exchangeable.

The paper is structured as follows: In section 2 we introduce a typology of models based on their modes of operation in the design process in terms of visual thinking and visual communication. Section 3 elaborates on the concepts of situatedness, dimensionality and augmentation as decisive factors in the performance of models. Augmentation of models is introduced as a discursive form of representation, next to the conventional non-discursive use of models. Section 4 showcases examples of the different types of augmented models. Finally we wrap up with some concluding remarks.

## 2. Types of models based on performance

Models are a form of visual representation. In general visual representation consists of two important components: *visual thinking* and *visual communication*. Visual thinking implies the generation of ideas through the creation, inspection, and interpretation of visual representation of the previously non-visible (knowledge discovery), while visual communication refers to effective distribution of ideas in visual form. From this perspective (augmented) models consist of 'different layers of productivity' or 'modes of operation' and include exploration, confirmation, synthesis and presentation (Nijhuis 2010, 2012). This implies that models – and the involved action, modelling - in landscape architecture are not only suitable for depiction and understanding of (future) reality, but are also instrumental for manipulation, analysis and expression of ideas, forms and relationships available in two and three-dimensional space.

There are actually three phases in the landscape design process during which models can become crucial: (1) *analysis of the existing situation* in order to provide an accessible information base on which to make (design) decisions, (2) *design generation*, to develop the main ideas and testing

them, and (3) *presentation and public communication*, when those familiar with the project must step back and explain it in a limited time and space to those who know nothing about it, are unskilled in the reading of abstractions like models, and may be only marginally interested or aware of its potential impact on the environment, or their lives (Appleyard, 1977). Regarding the phase of design generation (ad. 2) we can distinguish three modes of operation related to different iterative cycles of the design process: *origination*, *development*, and *testing* (Lawson, 2008; Thiel, 1997; Zeisel, 1981). Actually these cycles are about the conversation of the designer with models (visual thinking). The origination-cycle is about the creative evocation of the latent, half-formed internal representations in the mind of the landscape architect, which by externalisation in a self-simulating/stimulating recursive process achieve their initial tentative tangible form. The development-cycle is a nurturing procedure, involving the creative responses of the designer (and others) to the 'embryonic' model developed to a greater degree of explicitness, coherence, completeness and specificity. The testing-cycle is the 'moment of truth', when the model is evaluated against the criteria and standards given by the design-brief or the expectations of the audience (Lawson, 2008; Thiel,

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Figure 1: Example of a spatial iconic landscape model. Design proposal Museumplein, Rotterdam (the Netherlands) (design and model by West 8 urban design and landscape architecture)



Figure 2: Example of a spatial semi-iconic landscape model. Proposal for improving the Randstad water system (design and model by H+N+S landscape architects)

1997). Because of this interaction models are far from being incidental outputs but rather central outputs to the thinking process (Lawson & Dorst, 2009; Schön, 1983).

Based on their distinct elementary role and performance in the design process we can distinguish different types of models (figures 5, 6 and 7):

- **Analytical models:** modelling is about simplification, selection, combination and organisation of situative and contextual information in order to gain understanding and acquire design knowledge;
- **Evaluative/synthetic models:** modelling is about origination, development and testing of new ideas and information and consist of experimentation, transformation, addition and evaluation;
- **Presentational models:** modelling constitutes of effective and comprehensible communication of ideas and/or situations to a wider audience.

Among the actual resulting models there is a distinction between 'models of' and 'models for'. *Models of* are usually relative rigid and descriptive or predictive, *models for* tend to be more open to exploration and invention (Dunn,

2010; Stellingwerff, 2005). Before we illustrate the typology of models based on performance, it is important to address the concepts of *situatedness*, *dimensionality* and *augmentation* because they position the model as an important form of representation next to drawings, renderings, etc.

### 3. Situatedness, dimensionality and augmentation

Regarding the performance of models, *situatedness* is a decisive property, which determines the importance of models as a form of representation. Situatedness is a term derived from cognitive psychology and is about knowledge that is structured, based on real places or real applications (e.g. occasion setting and context depended) (Dibbets, 2002; Stellingwerff, 2005). Gero (1998) described situatedness as "where you are, when you do, what you do matters". The model situates the involved individuals with suitable and preferred visual information as a basis for (common) understanding and to take action. It provides a context for conversation, observation and construction, not only in spatial terms but also in cognitive terms. It helps setting the problem by 'naming' the things to which will be attended to, and frame the context in which they will be attended (Schön, 1983). So it can be considered as a form of framing, or framing of

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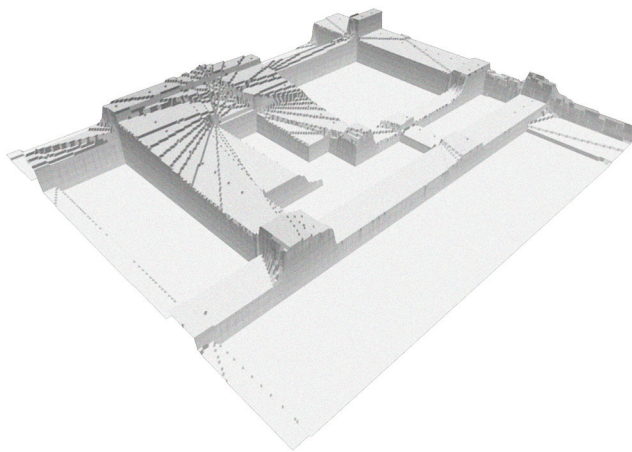


Figure 3: Example of a spatial symbolic landscape model. Analysis of 'visual magnitude' (how higher how more visible) of an urban setting (model by S. Nijhuis)

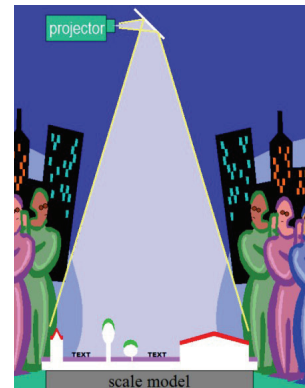


Figure 4: Basic setup of an augmented scale model. First test application for participatory debate about Brussels' Neighbourhood Contracts (source: Stellingwerff & Kuhk, 2004)



thoughts. In this respect the frame holds what individuals see; reframing leads to seeing something differently. In this way the model enhances the landscape architect's capacity to capture, store, manipulate, manage and reflect on what he sees (i.e. 'seeing that', 'seeing as' and 'seeing in') (Schön & Wiggins, 1992).

The degree to which the model can create visual replication of a existing or conceived situation are an important aspect of this 'seeing'. The visual forms, the objects and their proportions, level of detail, texture, tone, colour are properties related to the model itself. *Evocation* and *serendipity* are important 'functions' in this matter. Evocation is about appearance, expressiveness and the potential to inspire; the condition to understand and bring up ideas. Serendipity is the potential to grasp ideas while not intentionally looking for it (Stellingwerff, 2005). Field of view (i.e. overview or detail), possible multiple viewpoints on the same object, tangibility and dimensionality are decisive sensorial aspects of the conversation with models which offer advantages over other forms of representation.

- 4 *Dimensionality* is a property used to increase its readability and also to add layers of information for purposes of communication and knowledge discovery. Besides the fact that a three-dimensional model is usually more easy to understand because of its parallel to the three-dimensional world we live in (and offers direct cues to visual depth-perception), the assumption is that expanding the dimensions of an indispensable variable will make visual representation of higher dimensional information more successful (Wilkinson, 2005; Tufte, 1990; MacEachren, 1995). The three dimensions of a spatial model do not have to match a (scaled) real-time situation as in naturalistic models, they can be abstract models as well. We can distinguish different models based on the extent to which the dimensions match the dimension of the real world (Bishop & Lange, 2005; Thiel, 1997). The first group of models is *spatially iconic*: the dimensions match the real world. There is concordance with the actual situation in reality now or in the future. When one of the three dimensions, usually the vertical, is used for something other than the geographic dimension of height, the visualisation may be described as *spatially semi-iconic*. The third group is *spatially symbolic* and refers to the fact that the axes of the display environment are quite unrelated to real world dimensions (e.g. statistical landscapes) (see figures 1, 2 and 3).

These types of (conventional) models are in fact *non-discursive forms* of representation, next to *discursive forms*. All the information is simultaneously available; so the relations of the visual structures are grasped in one act of vision, or can be scanned at will because of its static nature. Besides, we can consider models also as discursive forms of representation by augmentation with projection of dynamic digital visual representations and/or sound. This implies that extra information is partially, successively, or temporally available for perception, achieving its significance in the course of a specific time sequence and rate of perception (Thiel, 1997). In the next section we will illustrate some discursive applications of models in landscape architecture based on their performance.

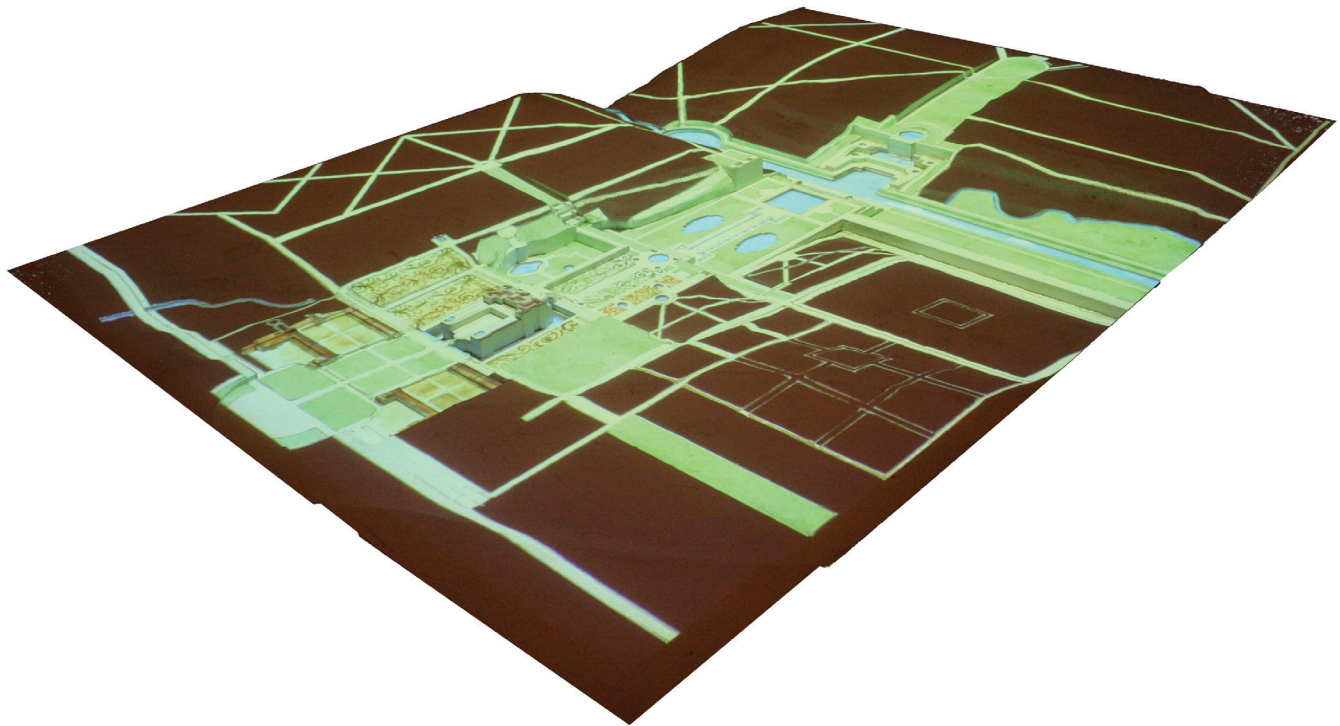
#### 4. Applications of augmented models in landscape architecture

As we have seen the concepts of situatedness, dimensionality and augmentation are important factors in the performance of models in landscape architecture. Next to the valuable and widespread non-discursive applications of models, it is worthwhile to consider discursive applications of models as mode of operation in landscape architecture research and design. We can already increase the dimensionality of a model by static projection of digital visual representation (e.g. drawings, maps, aerial photographs, etc.) for purposes of visual thinking or visual communication: they become (non-discursive) augmented models. By doing so not only the dimensionality increases but also the advantages of a physical three-dimensional model merge (especially situatedness) with the benefit of digital projections (i.e. the possibility to switch projections).

However, in the discursive mode of operation extra layers of visual information are added sequentially to the models – like a film, animation or switching projections by choice – and in presentational models usually accompanied by sound (i.e. narrator, voice-over). In other words: the physical model provides for a 'situated setting' (cognitive, perceptual and physical context) and the augmented information is partially, successively, and temporally available for perception extending the possibilities for exploration, confirmation, synthesis and presentation of ideas, forms and relationships. This is proven to be useful in exhibition settings, where augmented presentational models were used to explain the development of designed landscapes (e.g. Vaux le Vicomte, Vaux, France) (figure 5) and geographical landscapes (see section 4.1) to a

wider audience. An interesting application of an augmented evaluative/synthetic model for purposes of design generation, testing and development can be found in Piper et al. (2002). It showcases how the landscape architect can think visually and interactively using the model for a 'reflective conversation' (Schön, 1983) (figure 6). Augmented evaluative models are also proven to be useful in public participation processes, where models were used to discuss interactively different scenarios in urban development (e.g. Stellingwerff & Kuhk, 2004). Furthermore, augmented analysis models help to acquire situative and contextual information in order to develop object-related and typological design knowledge (see section 4.3) (figure 7).

and academic settings. The examples illustrate the different modes of operation which exemplify the earlier introduced typology based on performance. We will start with a presentational model illustrated by the project 'Landscape projections Kennemerland' (section 4.1), followed by an evaluative model illustrated by the project 'Railway- zone Delft' (section 4.2) and ending with an analytical model illustrated by the project 'Urban landscape Florence' (section 4.3).



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*Figure 5: Augmented 'presentational model' of Vaux le Vicomte near Paris explaining the development of the designed landscape dynamically (image courtesy M. den Ruijter, 2009)*



Figure 6: Generation, testing and development of a landscape design using an augmented and interactive 'evaluative/synthetic model'. Illuminating Clay by the Tangible Media Group, MIT (source: Piper et al., 2002)

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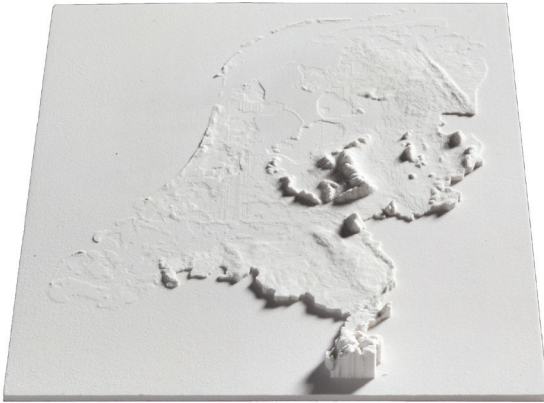


Figure 7: An example of an augmented 'analysis model' for means landscape architectonic analysis of the Netherlands. GIS-CAM generated three-dimensional print of the relief of the Netherlands (l), and projection setting (r) (by S. Nijhuis, 2011)







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Figure 8: Landscape projections  
Kennemerland: display, model  
and use (image courtesy Tinker  
imagineers)

## 4.1 Presentational model: Landscape projections Kennemerland

We have participated in a permanent exhibition on garden and landscape for the Beeckestijn Podium for Garden and Landscape Culture (Velzen-Zuid, The Netherlands). The intention of Beeckestijn's exhibition is to help its visitors to discover and experience the coherence and the interaction between humans, garden and landscape gardens. An important element of the exhibition is a large landscape model of Kennemerland (Noord-Holland, the Netherlands) for which we conducted the research, provided landscape projections and supervised the construction (Nijhuis, 2011a) (figure 8).

The landscape model is 2.20 by 2.60 metres and created of light coloured plywood (*triplex*) sheets and represents an abstract version of the 'bare' natural landscape (contour lines of the relief) as a bases for the projection of a film. The contour lines were derived from a GIS-based (Geographic Information Systems) analysis of a high-resolution elevation model, the *Actueel Hoogtebestand Nederland* (AHN-1, 1997-2003). The abstracted contour lines (dunes, polders, dikes and water) were exported as polygons to CAD. Via a CNC milling bed (CAD-CAM) the sheets of plywood were cut into the different layers of height and later glued together. The presentational model is spatial semi-iconic because the third dimension is referring to proportional height in stead of the actual height of the terrain. The model is augmented by a six-minute film and voice-over, showing the transitional and gradual development of the landscape of Kennemerland in maps— from the early Middle Ages (800 A.D.) to the future (2030).

The descriptive model provides for a common and non-discursive perceptual and physical context for visual communication and presentation to a wider public: the actual landscape. A setting where the development of the landscape is shown and explained in a limited amount of time and space using dynamic and sequential projection, making it a discursive medium. It takes the visitor by the hand telling the story of a landscape by a sequence of maps, an accompanying narration and evocative images, in mean time providing spatial cues and references by the physical model.

## 4.2 Evaluative model: Railway-zone Delft

At the moment, from 2009 till 2017 Delft is having 'an open heart surgery' at an urban level of scale. The disturbing railway track from the sixties will be replaced by a doubled underground track. The reclaimed urban space will be restructured following the plans by the urban designer Joan Busquets. We took the opportunity to construct an evaluative augmented model to show the major changes in the Delft railway area and to explore the potentials of 3D-printed models augmented by multi-media (figure 9).

Although the project was an exercise in 'prototyping techniques' for a group of five third-year students it offered a precedent for building an evaluative model. Besides building the model, main aspects of their project included on one hand the preparation of projection media, such as different maps, user interface elements, and moving objects to explain changing aspects of transportation in the city; and on the other, design and production of a user interface to make the model interactive. In this respect the project drew from previous explorations of the use of models in participatory processes (Stellingwerff & Kuhk, 2004). Especially regarding (1) the low-threshold to understand different projections on top of a printed model; and (2) the potential of adaptable projected user-interfaces for different audiences at different moments, with various purposes, while using one single model as base.

Understanding a complex plan for urban development requests for a precise and clear representation of contextual facts, envisioned possibilities and detailed plans. Especially in debates on future changes of inhabitants' environments, the presentation of plans should allow interaction and adaptation, instead of fixed presentations with all control at the side of the presenter. Pitfalls in understanding of complex urban/architectural data are mostly related to basic perceptive aspects. Orientation, framing, point of view, shared views and mutual understanding of each other's perception are key aspects of participatory models. The model can function as a fixed reference to the variable projected data and the different relative position of other actors in the debate. However, further investigation of the perceptive role of such a fixed reference is needed.



Besides creating a spatial iconic model it was important to add elements which make the model evaluative, interactive and more discursive in nature. Therefore we implemented an adaptable user interface which was integrated in the projected content. This allows making all kinds of interactive presentations with only a few physical buttons. Our students made an interface with buttons from a keyboard that activate various scenarios in a dynamic presentation which make it possible to evaluate them and make decisions.



Figure 9: Augmented evaluative model of Railway-zone Delft with interactive interface to choose projected media

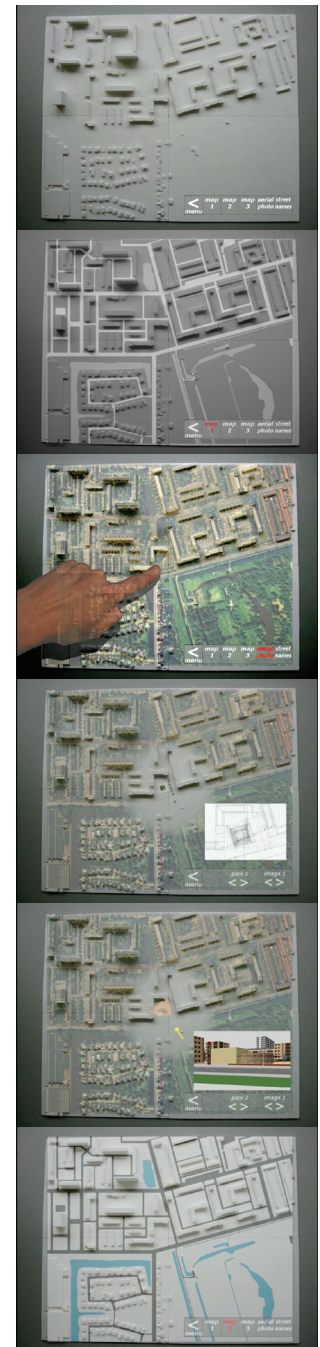


Figure 10: Different representations and planning projections on a white 3D-printed urban scale-model

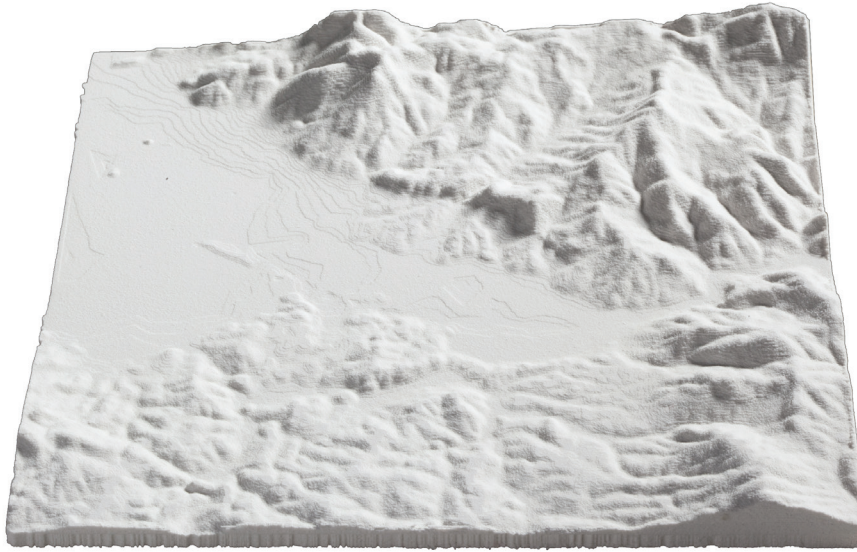
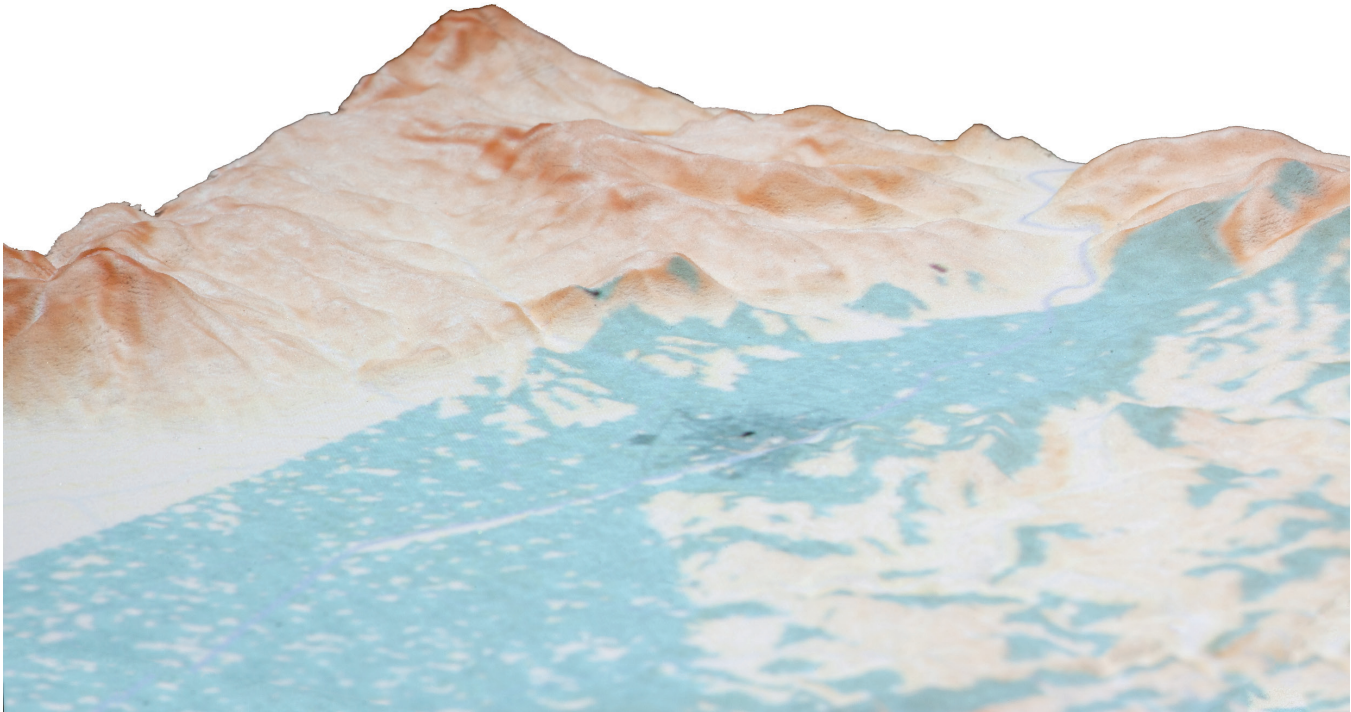


Figure 11: 3D-print of the natural landscape of the surrounding landscape of Florence (t) augmented with a projection of visibility-analysis (b) (model and projections by S.Nijhuis, photography by H. Schouten)

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#### 4.3 Analytical model: Urban landscape Florence

The analytical model was created for an research regarding mapping visual landscape space by means of GIS (Nijhuis, 2011b, 2012). The research purpose was to explore the situative particularities of the (reconstructed) landscape of Renaissance Florence (Italy), especially regarding the spatio-visual relationships of the surrounding villa's and the city. The city is located in the valley of the Arno, and most of the surrounding Renaissance villa's are positioned and orientated towards the city making use of the elevations of the Apennine-mountains and related ridges. In other words: the villa's were allocated in the visual range of the city making use of the natural landscape (see e.g. Steenbergen & Reh, 2003) (figure 11).

In order to get a grip on the visual planning principles, an precise spatial iconic model of the valley was created using 3D-printing. The GIS-CAM procedure made it possible to create a complex high resolution scale model derived from SRTM-height data. The resulting naturalistic 3D-print of the bare natural landscape was augmented with projections of GIS-based advanced three-dimensional visibility analysis. The augmented model offered new insights regarding the spatial particularities of the visual organisation of the villa-landscape by increasing the dimensionality of the analysis, making use of the benefits of a tangible three-dimensional environment and providing a sequential presentation of map-pings.

The 'real three-dimensional world' was augmented by abstract analytical information. In other words: the descriptive model provided for a non-discursive perceptual and physical context for visual thinking. It offered a physical context to situate computational analysis results for further investigation and interpretation. It acted as a perceptual and physical device to absorb partial, successive and temporal information gaining new insights by close observation and serendipity.

#### 5. Conclusion and discussion

Models offer designers useful modes of operation for visual thinking and visual communication. The physical model provides for a 'situated setting' (cognitive, perceptual and physical context) for reflective conversation with individuals and groups of people. Augmentation of models increases their dimensionality in terms of information and offers the possibility to become a discursive form of representation where information is partially, successively, and temporally available in order to convey a specific story or to adhere to specific information needs. It extends the possibilities for exploration, confirmation, synthesis and presentation of ideas, forms and relationships.

The examples showcase that (augmented) models have different modes of operation. For presentation and communication to a wider public, or as a device for exploration and reflective conversation for individuals. In order to get a grip on their particular role in the design process, classification strategies help to generate knowledge in this respect. The introduced typology offers a system to organise models based on their performance in the design process rather than based on the product itself. It offers clues to enhance their performance by research and development converging towards their specific instrumental role, addressing perceptual/cognitive, physical and technical aspects. It opens a wide range of theoretical, methodological and technical topics which have to be elaborated.

Future research has to point out if the introduced typology of models is feasible and valid, but first explorations point out that the typology provides useful clues for further investigation in the role and performance of models in landscape architecture. From the initial experiments, we are convinced that there are a wide range of possibilities for application and development of augmented 3D-models in landscape architecture.



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