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# Enhancing development trajectories of synthetic environments

Roy Damgrave *, Eric Lutters (1)

*Department of Design, Production and Management, Faculty of Engineering Technology, University of Twente, Enschede, The Netherlands*

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ABSTRACT

This research presents a framework that supports all stakeholders in the development of a Synthetic Environment. Guidance and support are provided throughout the entire process of development. Multiple disciplines are involved in this process, and the communication and collaboration between them is facilitated in such a way that mutual understanding is enhanced. Moreover, the rationale of decisions made throughout the development can be documented and accessed in such a way that all stakeholders can review and comprehend these decisions in relation to the prior and underlying decision-making processes.



## 1. Introduction

Synthetic Environments (SE) are design environments that bring together real and virtual components to allow for adequately experiencing shared information [1]. They range from small setups, representing e.g. working with a new machine, to large systems for the conjoint development of an aircraft interior. Synthetic Environments are composed out of a wide variety of tools, techniques, hardware and software components. To ensure that an SE meets all functional specifications and requirements with adequate quality, the process to configure an SE requires structure, vigour and predictability, but also flexibility and adaptability. At the same time, many different stakeholders are involved in the creation of an SE, ranging from engineers via marketers and maintenance staff to end users.

Establishing and employing SEs is often hampered by a lack of insight in the consequences of implementation. Moreover, during implementation of an SE, many stakeholders cannot yet signify or formulate how the SE could have the most relevance for them.

The research described here provides an approach for SE development, comprising the entire SE life cycle and spans multiple levels of aggregation (i.e. strategic, tactical, operational). Obviously, multiple stakeholders and multiple perspectives need to be involved in such a way that mutual understanding is enhanced [2]. This is facilitated by enabling communication and collaboration, but foremost by maintaining an overview of the configuration process that underlies the momentary status of the SE development. Also, design rationale is captured, so all stakeholders can review and comprehend decisions as well as the preceding and underlying decision-making processes.

The proposed framework renders the development cycles of SEs more predictable and make the SEs more adaptable and better configurable. Additionally, the resulting SEs will be better tailored to the perspectives of all stakeholders. The framework should not dictate or predefine the SE development process, but should function as a tool for enhancing this process. Furthermore, the framework should be able to reuse and build on the developed methods and processes from earlier and other development or research projects.

## 2. Scope and aim

The development of an SE is, essentially, a typical design trajectory, including all the variety in stakeholders, perspectives and aspects that play a role in development cycles for products or product-service systems [3–5]. This renders many design methods and methodologies valid, but these are not self-evidently effective for, or tailored to, the specifics of developing an SE. These specifics relate to, for example, the extreme configurability of SEs, the SE being a combination of a design/development/configuration effort and the potential re-usability of (components of) an SE and the knowledge thereof [6]. At the same time, quite some experience is available on implementing SEs [6]. By combining such domain knowledge with a design strategy that does justice to all stakeholders/perspectives involved, a design approach for SEs can be devised that effectively and efficiently facilitates SE developers in a structured and predictable manner.

### 2.1. Outline of the approach

One of the major risks in developing an SE are misalignments between stakeholders. Also, stakeholders relying on incomplete, unreliable, misinterpreted or uncertain information can hamper or endanger the development cycle. Thus, having one collective reference or starting point is pivotal in SE development. Actually, it is even more important than in product development, as an SE usually is merely a temporal cumulation of its constituents, subsequently or simultaneously serving stakeholders with different intents and aims. Moreover, some end-users will only occasionally interact with an SE, some may be responsible for building, adapting or maintaining SEs on a professional basis and

* Corresponding author.
*E-mail address:* r.g.j.damgrave@utwente.nl (R. Damgrave).

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others may be suppliers of hardware, models or methods. A support framework is introduced to provide all stakeholders with a common basis. This framework is the reference for all interactions, information/knowledge exchange and coordination activities in SE development. To allow for such functionality, the framework should offer a shared information repository throughout all development phases. For purposeful (re-)use of the information content, the framework should also provide insight in the network of relations and dependencies that connect initial stakeholder requirements to the eventual elements that together shape the Synthetic Environment.

In a sense, this depiction of the framework for SE development presents it as a kind of market-place, where negotiations and trade-off take place, in the context of both the external limitations/constraints as well as the set aim and rationale of the SE under development. Here, also the relevance of the (subjective) preferences of individual stakeholders come to fruition. This market-place metaphor might do justice to the flexibility and adaptability that is required in the process, but the structure, vigour and predictability of the approach might not thrive on it. Therefore, the framework should be able to render an overview of the design freedom that the stakeholders (still) have in de development cycle. This so-called 'solution space' is the interpretation and instantiation of the initial requirement specification of the SE, while also representing the boundaries, (subjective) preferences, decisions and considerations, as set by all stakeholders involved. The solution space also addresses all external factors that have been captured.

It goes without saying that no SE is the only possible option to achieve a certain goal. Therefore, any solution space for an SE is an instantiation of a possible solution. With this, the solution space is related to a 'discussion space', which captures an overview of these possible solutions. As such, the discussion space is the overlap of all the input by the stakeholders. It captures the mutual interests, all requirements and connected information content. The origin of this is the set of stakeholders involved, each providing their contribution to the process. This collective contribution is referred to as the 'scouting space', consisting of a 'blueprint' for every stakeholder.

With this, the approach starts by collecting information from stakeholders by means of the blueprints. Conjointly, these form the 'scouting space', from which the discussion space is the repercussion. As an accompanist of the development activities, the solution space renders the current state of affairs. Eventually, the framework brings together all intersections into an integrated foundation for SE development.

The following section belabours the individual elements of the framework in more detail, starting with the blueprints.

## 3. Components of the approach

### 3.1. Blueprint

The first step to come to a functional SE is to provide the stakeholders with means to gather and document their requirements on the SE. For this purpose, a blueprint aids a stakeholder to connect his goals and context to the (desired or envisaged) functionality of the SE. Fig. 1 gives an overview of such a blueprint, where the main elements of the SE are addressed. The current portfolio of nine elements is based on theoretical research and practical experience. Each element in the blueprint is an information container for documenting relevant information from the perspective of one stakeholder [7]. With this, the stakeholder is provided simultaneously with a 'backbone', a 'checklist' and a 'notebook' to express requirements. Thus, the stakeholder has a structured manner to work from the core of Fig. 1, capturing the intent or stated purpose [1] towards the formulation of his functional contribution to the SE.

Obviously, the experience gained in setting up an SE can be effectively reused in other projects. For this reason, the structure of a blueprint can be updated as more SEs are build. Moreover, new insights and increased knowledge can be used to update blueprint structures. This yields a set of template blueprints that are effectively

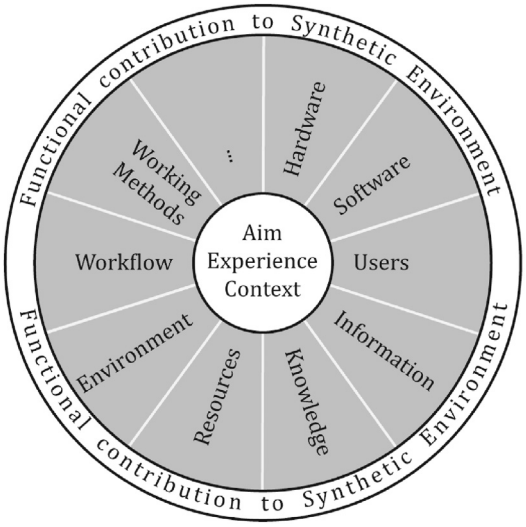


**Fig. 1.** Template blueprint with main elements.

tailored to the needs of specific types of stakeholders. This not only increases the efficiency of capturing the stakeholders' viewpoints, but it also facilitates stakeholders in maintaining an overview of their own perspectives as concerns completeness and focus.

An additional advantage of using template blueprints is that the input of all stakeholders can be integrated in a structured and reproducible manner. In this, the information provided by stakeholders working at different levels of aggregation, completeness, certainty and reliability can be brought together, without any judgement on priority and sequence. As the blueprints provide a taxonomy of elements that are expected to contribute to the discussion space (Section 3.3). Therefore, there is no need for a blueprint to enforce or pre-determine the demarcation or scope of the requirements that are formulated. The amount of documentation related to the different elements can vary, according to the interests, priorities and expertise of the stakeholders. Given the character of, and idea behind the blueprint, its elements are foremost ways to cluster the requirements [8] rather than a prescribed subdivision. Any blueprint template will therefore be a facilitator rather than a standardised straitjacket. Moreover, all elements can be used to express information on the different levels of aggregation that the stakeholders may be interested in, from strategic (e.g. provider of the SE), via tactical (e.g. operator configuring the SE) to operational (e.g. client that will use the envisaged SE).

### 3.2. Scouting space

Individual blueprints will not allow for purposeful decisions or constructive alignment in the development cycle of the SE. An additional layer is required to process the blueprints, while also suggesting viable solutions paths to arrive at an adequate SE. Interrelating blueprints will interrelate stakeholders, and will ensure that common concerns or potentialities emerge. The aggregated blueprints establish a convex hull that delineates the scope and interest of the joint stakeholders. This convex hull is defined as the scouting space of the SE development cycle.

As the size of a scouting space increases (for larger and complex SE developments with many stakeholders), it is an excellent means to distinguish overlaps and contradictions amongst stakeholders. Comparing scouting spaces amongst projects, also indicates voids and potential omissions. Moreover, the scouting spaces allows stakeholders to empathise with other viewpoints, and with considerations at other levels of aggregation. The blueprints will thus act as a base and trigger for discussion, in which the information content serves as a structured foundation.

The scouting space is not a sequel to the use of the blueprints, it rather is a dynamic representation thereof, allowing stakeholders

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