Towards a Smart City Blueprint Template

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***Abstract*— A common approach transforming a city into a smart city is to study successful transformation approaches. However, there is no recommended adaptation process for smart city transformation, thus often resulting in manual, project-based and costly efforts. In this paper we propose a methodology, tools and a process which guides through the documentation and transformation process when transferring smart city innovation to other cities. Considering public value as main result of the smart city value chain, an adaptation of the business canvas to a smart city canvas allows a holistic view on the most important aspects during smart city transformation. Moreover, a blueprint template is proposed together with a process which has proven to be a valuable tool for the adaptation of successful smart city concepts to other cities. The approach has been validated in the context of a large-scale smart city innovation project.**

Keywords- Smart City; Blueprint Template; Transformation Process; Public Value.

I. INTRODUCTION

An increasing number of cities use data from citizens and devices in order to use resources efficiently and design smart services, thus becoming a smart city. Although there is no shared definition of smart city available, in [1] a taxonomy of pertinent smart city application domains is elaborated. Instead of just automating routine functions for individuals, buildings or traffic systems, a smart city should monitor, understand, analyze and plan its situation in order to increase efficiency, equity and the quality of life for its inhabitants in real time [2]. Often, smart cities are seen as a composite of various networks, which continuously collect data regarding the movement of people and materials and use them for decision-making. Cities, however, can only be smart if they have intelligent tools which are able to integrate and synthesize data for a specific purpose.

It is common to use smart city platforms to process sensor data, open (government) data, social media data, as well as data from third party providers and private users. Many smart city projects describe the need for such a platform [3][4] as a valuable driver in the promotion of smart city innovation.

Within the CPaaS.io research project [4], the developed smart city platform had to be validated through several large-scale use cases from different contexts such as (high) water management, (sports) event management, emergency medical care, smart parking and public transportation [5]. Instead of starting from scratch for every use case, the authors searched for ways to re-use knowledge and experiences from prior use cases.

Although there exist information frameworks for the creation of smart cities (e.g., [6]), to date there is no common process or even a recommendation for developing a smart city project beyond the commonly acknowledged trinity data – platform – smart applications. Often, the wheel is re-invented, although the transformability of use cases and applications from city to city would be possible thereby re-using experience and know-how. The following research question was used as guidance throughout the research: "How can successful smart city concepts be used for smart city transformation?". Or, more precisely: "Which are appropriate methods, tools and processes for performing and documenting smart city transformation?". This paper proposes a blueprint process and a template covering technical and organizational aspects.

Since every city has specific characteristics, smart city applications are not transferable without adaptation to its context. To support the documentation and adaptation of smart city applications, a blueprint approach is proposed, guiding through the problem-solving cycle and assisting in the abstraction and concretization process of a smart city application and thus in the adaptation process.

The blueprint template covers important categories along the value chain [7] of smart city applications. The objective of the blueprint template is to create a description of the system without enforcing specific implementation methods. It considers processes, architecture views, hardware, software, possible project and communication plans. Further aspects support the creation of public value within a smart city application as well as the operation and optimization of an application set in place.

To simplify the adaptation of a smart city blueprint, a so-called *One-Pager* shows the most important aspects of the blueprint. The One-Pager guides through the development of the blueprint and shows which aspects need to be re-evaluated when adapting an existing blueprint to another city.

The paper is structured as follows: After presenting the research design conducting our findings in Section 2, the tools and processes are introduced in Section 3, where the derivation of the smart city value chain is also discussed, and the blueprint template based on it is justified. In Section 4, the checklist-based adaptation process is presented, and in Section 5, the validation of the approach is discussed within the context of a practical, large-scale smart city innovation project.

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II. RESEARCH DESIGN

The development of the blueprint template and process was conducted in a classical three-step approach: analysis, design and validation. In the analysis phase, relevant literature was searched on smart city blueprints, on public value of governmental initiatives, on the value chain of smart city applications, on the future of smart cities and on specification guidelines in the smart city context. The literature research was conducted in various online resources in spring 2018. However, in none of the papers a blueprint template, framework or specification guidelines for smart city applications was presented.

Additionally, papers on best-practice methodologies on innovation creation, architecture guidelines, specification guidelines, business model creation and operation models were searched in the same way for importance on the planned template design.

During the design phase, a generic grid was suggested based on the value creation of smart city applications according to [8]. The definition of vision, mission and strategy is an adaptation of the Business Model Canvas from [9] with focus on the generation of public value.

As a result, a four-phase blueprint template is suggested considering the phases initialization, conception, realization and deployment and operation, as common in project management [10], accompanied by a process guiding users through the development of a blueprint instance.

During the third step the blueprint template process is validated against use cases of the CPaaS.io project [4], in which the authors of this paper participate. This validation process is still ongoing, initial results are promising as they confirm the usefulness of the tool in capturing information and some of the cities we are in contact with have expressed interest in using such templates for their upcoming application implementations. These activities will help us to improve the blueprint template further.

III. THE SMART CITY BLUEPRINT TEMPLATE

The blueprint template covers important categories along the value chain of smart city applications. The objective of the blueprint template is to create a description of the system without enforcing specific implementation methods. It considers processes, architecture views, hardware, software, and possible project and communication plans. Further aspects support the creation of public value within a smart city application as well as the operation and optimization of an application set in place.

A. Value Chain of Smart City Applications

In business, the concept of a value chain is commonly used. Porter [7] defined five primary activities of a company that lead to profit: sourcing logistics, production, distribution logistics, marketing and sales, and customer services. In addition, he defined the following supporting activities: infrastructure, human resources, technology development, and procurement. A city however has different goals compared to a business-oriented company: While a company's primary goal is to increase profits, a city strives to create public value. Introduced by Moore [11], the concept of public value describes the value an entity contributes to society, e.g., increasing the quality of life for its population, supporting transparency and democratic processes, or other useful services a city may provide to residents or enterprises. Such services are especially important where market mechanisms alone are not providing the desired service levels, like in health care or public transportation [12].

So how could a value chain for a smart city be defined? The base currency for a smart city is data, which leads to information and insights, and thus to new services and better and faster management of city processes. Laaboudi and D'Ouezzan [8] postulate that the value chain of a smart city consists of the following elements:

- Data Collection: Data collection from a wide range of devices such as mobile devices, sensors, home applications, vehicles or data from 3rd party applications via interfaces.
- Data Carriage: Network technologies like fiber, wireless, telecommunication infrastructure or Low-Power Wide-Area Network (LPWAN) or other connectivity components to transfer the collected data.
- Data Storage: Data centers, cloud or other storage capabilities to store the collected data.
- Data Analytics: The heart of the value chain that brings smartness into a smart city application. Dedicated platforms are used for standardization, communication of information and transforming data into linked data with semantic context.
- Data Marketplace: Exposing data, authenticating users, authorizing access as well as possible billing or booking capabilities. The marketplace is a central element to open data strategies for cities.
- Application Layer: The application layer is dedicated to creating, developing and improving a smart city application. It represents the tools and services, as well as APIs for the city and the users.

All these elements need to be considered when creating a smart city application generating public value. However, not every element may be essential for value creation in every smart city application, some applications may only address a few elements. Usually however, most elements of the smart city value chain need to be addressed.

Regarding supporting activities, the following can be identified: sourcing of vendors (hardware and software), governance and risk management, data protection and security, as well as financing. Thus, the model of Porter is adapted as shown in Figure 1.

Sustainable and optimal development of a smart city application is based on a city's vision with focus on public value, a network of organized actors, a set of codes and technologies and values that governs all stakeholders. In this sense, governance is needed around a common vision for the transformation of cities.

B. Structure of the Smart City Blueprint Template

The smart city blueprint template consists of four parts (see Figure 2) which relate to the four typical phases of most

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projects [10] plus a *One-Pager* giving a summary and overview of the blueprint and its use case. In the following, we will describe these parts in more detail.

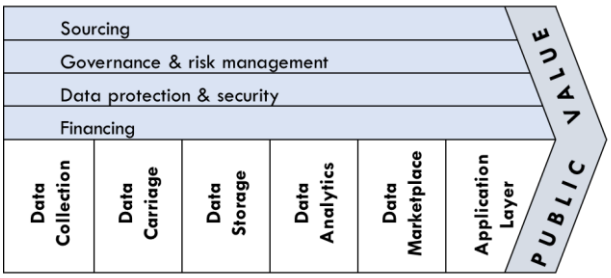

Figure 1. Smart city value chain (adapted from [7, 8]), generating public value based on data usage and on supporting activities.

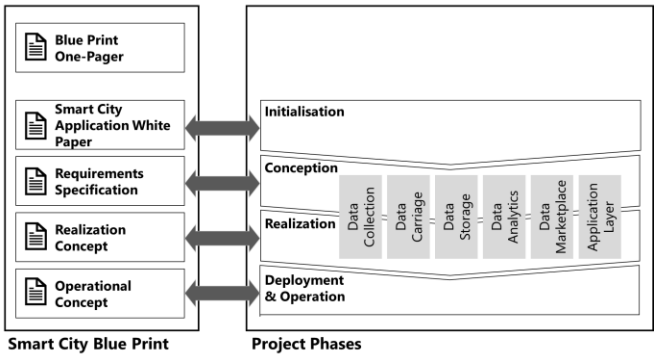

Figure 2. Structure of a smart city blueprint and relationship to project phases

C. Smart City Application White Paper

The Business Model Canvas defined by Osterwalder and Pigeur [9] is a well-recognized tool in the business world for the creation of innovation and the associated development of new business fields. With few adjustments due to the different goals for business and cities discussed above, a similar conceptualization for the smart city context is proposed (see Figure 3).

Contrary to the business model canvas, in the smart city canvas the focus is on the *public* value proposition, and on beneficiaries instead of customer segments. For the same reason also the customer relationships and channels elements of the Business Model Canvas are replaced with a single relationships element which is used to capture all stakeholder relationships, both positive and negative, as Smart City projects typically involve a multitude of different stakeholders.

This smart city canvas is the central piece and starting point of the smart city application white paper within the initialization phase (see Figure 2). In addition to the canvas, the white paper should provide an overview of services, standards and technology, especially on IT topics. This includes user descriptions, case studies and market research results.

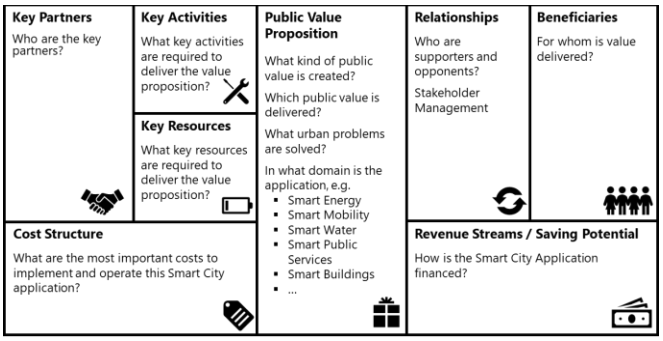

Figure 3. The smart city canvas is an adaptation of the business model canvas of Osterwalder and Pigeur [9]

D. Requirements Specification

The following specification guidelines are based on the IREB Standard, which includes a toolset of different methodologies for the management of requirements [13]. The requirement specification should begin with the description of the planned system, giving an overview of the application to be created. Furthermore, it should be ensured that the system boundary and the system context are defined before the requirements are collected. This is relevant for the definition and understanding of the requirements of the system under consideration.

To structure the requirements catalogue in a uniform and retrievable manner, they are categorized according to the elements in the value chain of smart city applications. Such a split is also helpful when developing the application, as each part may possibly be developed as a separate component. As a first step, it is thus advisable to identify which elements of the value chain are affected and play an important role in the application at hand. Table I provides a simple but useful tool for such analysis, also listing initial questions to help elicit requirements. In addition, for each element a sentence template for how to formulate the requirements has been defined. For example, the sentence template for the Data Collection element looks as follows:

The system can/should/must collect data from <source> about <topic>.

Sentence templates are an easy-to-learn and easy-to-use approach to reduce linguistic effects [13] – an important issue in multi-stakeholder projects as smart city applications typically are – and are also commonly used in agile approaches like SCRUM.

E. Realization Concept

An important step for the realization concept is listing selected technology toolsets for realizing the application. Similar tables as used in the requirements specification (cf. Table I) can also be used for summarizing the technology options, however, instead of listing requirements, possible solutions are listed here, thus spanning a solution space from which elements can be selected during a transfer and adaptation project. In addition to technology options, the realization concept must also tackle the issues of project methodology, development road map and architecture.

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TABLE I. CHECKLIST TO DETERMINE THE APPLICATION REQUIREMENTS ACCORDING TO THE SMART CITY VALUE CHAIN

Value Chain Element	Requirements	Element affected?
Data Collection	**Is the planned application dependent on collecting data?** What types of data are required to implement the smart city application? Where, how (e.g., sensors) and by whom (e.g., 3rd parties) is the data collected?	☐ yes
Data Carriage	**Is the transfer of data needed for the application?** All functional and non-functional requirements related to data transmission.	☐ yes
Data Storage	**Is persistent storage of data relevant to the application?** How is the data stored? How sensitive is the data? How fast must the data be retrievable? Does the data have to be stored in a certain form? Which semantic standards or guidelines must be observed?	☐ yes
Data Analytics	**Does the application require the data to be analyzed in order to provide value?** How must data be aggregated? Which data is relevant for the analysis? What does the data curation processes look like?	☐ yes
Data marketplace	**Is it intended to sell data?** Who should have access to the collected data? How is the operator of the application remunerated for providing the information? What are the price models and payment modalities?	☐ yes
Application Layer	**Is an interface / API necessary to provide another application with information?** Which interfaces are required? Are actuators required for the application? Is a user interface provided? What actions are users or actuators performing?	☐ yes

Project methodology

Identifying a project methodology for implementing a use case is crucial for the realization concept. There are various project methodologies in use, from classical waterfall-like models to agile approaches like SCRUM. In this context, it is important to decide, to what extent citizen participation should be encouraged, and if co-creation approaches are useful.

Since smart city projects are mostly highly complex projects with multiple stakeholders and sometimes unproven technology, agile project methods are very suitable, as they are designed to deal with changing requirements, to integrate a balanced set of stakeholders and use a controlled, iterative procedure to offer an appropriate, situational response. On the other hand, government agencies often have regulations and standards how public projects have to be executed (e.g., HERMES in Switzerland) that mandate more classical, waterfall-like models of project management.

Project Roadmap

According to Galati [14], smart city planners should develop a realistic path to move from the concepts of their smart city architecture to achieving the application objectives. When planning the roadmap, project managers must consider that there may be delays in projects and that unexpected obstacles may arise. Furthermore, all expenditure should be meticulously managed and monitored. The roadmap in the realization concept must give the necessary, high-level guidance, possibly also coordinating with other smart city applications being developed in parallel. The selection of common platforms, which should be used in a given setting is a typical element of such a roadmap.

Architecure

A sound architecture of the overall smart city application landscape is crucial, since any newly developed application needs to fit into the landscape. In particular when a common smart city platform is already deployed or is planned to be, a common architecture like the functional architecture developed in the context of the CPaaS.io project becomes very useful. The realization concept must address how the application is integrated into the existing landscape. Using views and perspectives as defined by Nick Rozanski and Eoin Woods [15] is recommended to describe the application architecture. Of particular importance for smart city applications are the following perspectives: security, regulation, performance and scalability, usability, availability and resilience, as well as evolution.

Operational Concept

According to [16], the following aspects should be considered when defining an operational concept:

- Determination of operational requirements
- Description of the system technology
- Description of the organizational plan
- Description of business processes
- Treatment of disorders
- Description of safety aspects

The IT4IT operating model [17] proves to be well suited within the realization concept due to its flexibility, because it can be integrated into existing operating models such as ITIL and COBIT but focuses on the clear embedding and obligation to integrate new applications and suppliers into the operating model. The great benefit of IT4IT as a reference architecture for the IT function lies in its application as a guide.

For a smart city application landscape, it is important to think about the transfer and operation of the platform in advance. By using the IT4IT reference model, a future-proof operation of the application is achieved in view of necessary extensions. In [17], a template is given according to which IT4IT could be implemented.

F. Smart City One-Pager

For orientation, the extensive information described in the previous sections is summarized in the so-called smart city blueprint One-Pager, as shown in Table III. It forms the basis

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for any transfer, as a city official interested in a specific application can quickly gauge if that blueprint is relevant for his or her city, and if yes, it provides an initial list of issues that need to be tackled, and thus to an initial roadmap and project plan. An example of a One-Pager is discussed in section V.

IV. ADAPTING AN EXISTING SMART CITY BLUEPRINT

Developing a blueprint for a targeted city is guided by an adaptation process (see Figure 4), starting with the selection of an appropriate existing One-Pager. The next step focuses on the gaps between that One-Pager and the targeted implementation, where those aspects are identified that must be validated against the blueprint template of the targeted implementation. Finally, the blueprint can be enhanced (e.g., with new options for the realization phase), adapted or completed in an appropriate way.

In Figure 4, the adaptation process is modeled in BPMN notation. Note that it is crucial to take the technical possibilities as well as the cultural context of a city or its region into account.

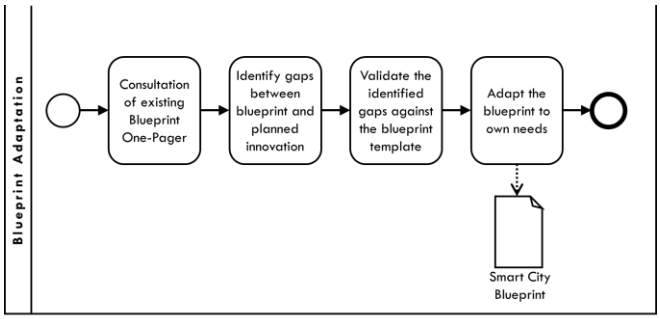

Figure 4. Adaptation process of a smart city blueprint during smart city transformation.

Checklists can assist in identifying existing gaps between the blueprint and the needs of the city that wants to adapt a blueprint. An initial version of such a checklist is given in Table II, referring to sections in the One-Pager. It might be necessary to continuously update this initial checklist with the experience gained in the actual blueprint adaptation processes.

V. SMART CITY BLUEPRINT VALIDATION

The smart city blueprint template provides a tool to guide developers of smart city applications in the initial process, giving a structure for a project plan and listing all aspects that should be considered. Using the blueprint template already at this early stage allows also capturing important information and experiences gained along the way, and thus provides the basis for the transfer to another city.

To validate the practical use, the first step is to fill out the template for selected use cases, leading to concrete blueprints. In a second step, we need to adapt these blueprints to the requirements and the context of other cities and use this adapted template in the implementation of the use case in the respective city, thus verifying that the blueprints significantly facilitate and speed up the implementation process.

In Table III, a preliminary One-Pager is shown for the Amsterdam water management use case from the CPaaS.io project, illustrating the basic use of the blueprint template. Currently, this blueprint and blueprints for other use cases are being detailed and completed. Several cities show interest in using this blueprint approach in their smart city activities, where its usefulness can be demonstrated. Specific interest exists also in using the Smart City Canvas and the One-Pager. For example, we are currently talking to a larger Swiss city to use and adapt the smart parking blueprint originally developed for the implementation in the city of Murcia, Spain. Furthermore, the water management use case shown in Table III has raised the interest of some cities in Japan. The questions listed in Table II will guide this adaptation process.

TABLE II. CHECKLIST FOR BLUEPRINT ADAPTATION

Section	Checklist questions
Vision	• Does the value proposition cope with the needs of urban environment?
Requirement Specification	• Are there any additional special security risks? • Are frameworks in use, which are not applicable for us? • Are sourcing and vending partners considered who are not suitable for us? • How is the project financed?

Realization	• Is it possible to use the project methodology used for implementation?
	• Can the implementation period be similar or is a massively shortened implementation period targeted?
	• Can the same software be used?
	  ○ Yes
	  ○ No → Does the software intended for use have the same functionality as the one used in the other city?

Tools & Technologies	• Is data collected independently or obtained from existing systems that cannot be used by us? Do we depend on the same data? • Is the technology used for data transmission available in our region and does it operate in the same frequency band? • Does the data storage meet our expectations regarding queries and does it have sufficient protection mechanisms against external access? • Is the syntax and semantics used sufficient for data analysis? • Is recorded content made available to other parties and does the marketplace support your requirements for data transfer or provision? • Should the end application be structured as it is used in the other city? Can the software and any actors involved also be used?
Operation	• How can the smart city application be operated after introduction? • What does the organization look like?

VI. CONCLUSION AND FUTURE WORK

With the presented blueprint approach, a methodology, tools and a process are available for documenting and transferring smart city innovations to other cities. Based on well-proven concepts, such as Osterwalder's Business Model Canvas, Jenny's project phase concept and Pohl's work on

specification, the proposed smart city value chain together with the blueprint template are well suited for specifying a holistic picture of a specific smart city implementation. Moreover, the proposed checklist guides through the adaptation process and helps identifying gaps between an existing blueprint and the needs of a city that is aiming at adapting the blueprint.

To date, all the proposed concepts are developed and documented, and have been validated in the context of a smart city innovation project [4]. By capturing the information of the use cases in the project, we could validate that these tools can not only be used to capture information about specific use cases, but that the structure of the tool is helpful in doing so. Currently, the approach is applied for various other city contexts and use cases for validation purposes, in order to evaluate and possibly adapt the proposed tools and processes. Respective stakeholders from different cities have shown specific interest in the Smart City Canvas as well as the One-Pager. This will enable the next step of validation, applying and adapting an existing blueprint in the context of another city.

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TABLE III. SMART CITY BLUEPRINT ONE-PAGER FOR AMSTERDAM WATER MANAGEMENT USE CASE

Smart City Blueprint One Pager						
Value Proposition – Creation of Public Value		Extreme rainfall and periods of continued drought are occurring more and more often in urban areas. Because of the rainfall, peak pressure on a municipality's sewerage infrastructure needs to be load balanced to prevent flooding of streets and basements. With drought, smart water management is required to allow for optimal availability of water, both underground as well as above ground.				
Requirement Specification						
Ownership / Contact		WaterNet (water utility)				
Affected Value Chain Elements:	Data Collection	Data Carriage	Data Storage	Data Analytics	Data Marketplace	Application Layer
	[x] yes	[x] yes	[x] yes	[x] yes	[ ] yes	[x] yes
Supporting Activities						
	Sourcing	LoRa Network (The Things Network), Polderdak (water buffers)				
	Governance & Risk Management	tbd				
	Data Protection & Security	Remote-control access to valves must be secured, data transmission over secure channels				
	Financing	Government-level funding				
Realization						
Project organisation		Led by WaterNet				
Roadmap		Prototyping individual sites, then boader roll-out				
Architecture		PaaS (Platform as a Service), using CPaaS.io / FIWARE components (e.g., FogFlow for distributed edge computing				
Chain link specific tools and technologies used:						
	Data Collection	Data Carriage	Data Storage	Data Analytics	Data Marketplace	Application Layer
	1. Water-level sen-sors (in buffers as well as in sewage systems) 2. Weather data	LoRaWAN transmissionon (EU 863-870MHz ISM band)	Storing the Data in the FIWARE Orion context broker	Control water buffer valves based on fill levels, expected weather data, and status od sewage system.		FIWARE APIs (NGSI-10)
Operation						
Currently in prototype stage, determining parameters for continuous operation.						

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