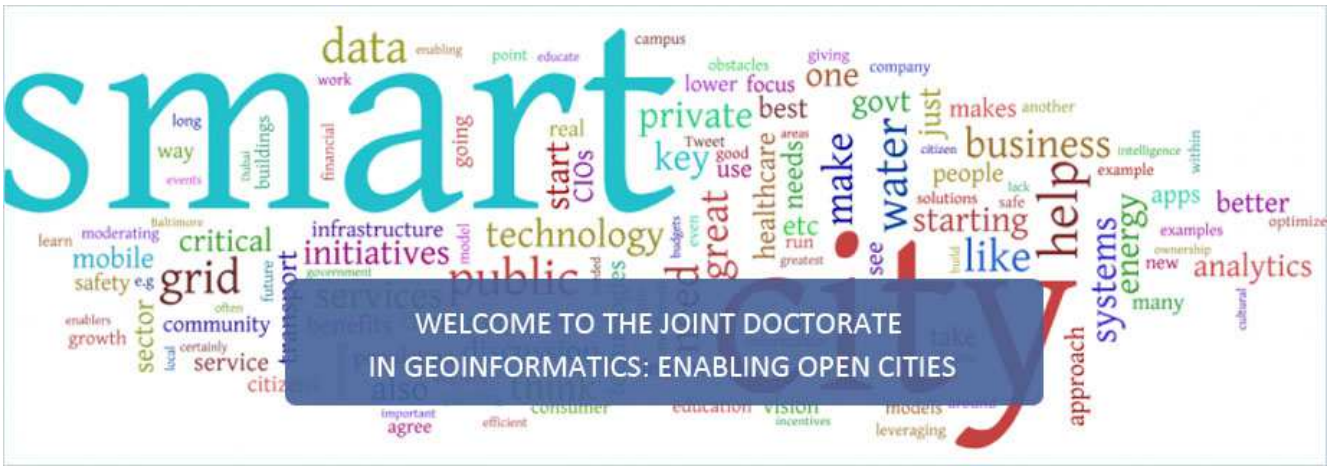

D.8.2 Open City Toolkit Outline

Joint Doctorate in Geoinformatics: Enabling Open Cities

Grant Agreement number 642332 — GEO-C — H2020-MSCA-ITN-2014.

October 31st, 2016

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EXECUTIVE SUMMARY

The term ‘smart cities’ has been coined in recent years for initiatives that monitor and analyse different aspects of urban life, and manage service provision intelligently. The GEO-C project (Joint Doctorate in Geoinformatics : Enabling open cities) aims to contribute methods and tools to realise smart and open cities, in which all groups of society can participate on all levels and benefit in many ways. The Open City Toolkit will be the main physical outcome of the project, with 15 doctoral researchers contributing components to the joint product. In essence, the Open City Toolkit (OCT) is a collection of five types of components: a set of tools to improve transparency; a curated set of examples of open source apps, open data and services; an abstract architecture which describes how apps, services and data can be integrated in order to realise a smart open city; an explicit linkage between (related) resources that are useful to realize an open city; and guidelines on how to realize an open city. Currently, the OCT features a transparency module (which provides more information about datasets used by an app), templates for interactive guidelines (which are the first step in documenting lessons learned in the project), a CKAN instance (which collects all the resources in the project), as well as a Dev-Corner (which collects snippets for developers interesting in re-using resources of the platform). GEO-C is funded by the European Commission within the Marie Skłodowska-Curie Actions, International Training Networks (ITN), European Joint Doctorates (EJD).

1. INTRODUCTION

Urbanisation has been a key trend for centuries and is expected to continue throughout the 21st century as well. Cities have to continuously strive to provide a sustainable, safe and liveable environment for their ever-increasing populations. In recent years, the term 'smart cities' has been coined for initiatives that monitor and analyse different aspects of urban life, and manage service provision intelligently. A key gap in this area relates to how people can understand the processes driving smart cities and their services, and how they can gain a sense of control rather than being controlled by the services provided by a smart city.

The GEO-C project (Joint Doctorate in Geoinformatics: Enabling open cities) aims to contribute methods and tools to realise smart and open cities, in which all groups of society can participate on all levels and benefit in many ways. There are a number of definitions of the smart city concept (for examples of reviews, see Nam & Pardo, 2011; Yin et al., 2015). In what follows, a smart city is defined after Yin *et al.* (2015) as "a system integration of technological infrastructures that relies on advanced data processing with the goals of making city governance more efficient, citizens happier, businesses more prosperous and the environment more sustainable". This definition is adopted in the work because it accounts for four different perspectives which are currently found in the literature, namely:

- the technical perspective (i.e., a smart city is dependent upon various technological infrastructures);
- the system perspective (i.e., a smart city integrates these different technological infrastructures);
- the data processing perspective (i.e., a smart city relies on advanced data processing); and
- the application domain perspective (i.e., improve governance efficiency, citizens' happiness, businesses' prosperity, and environmental sustainability).

Toolkits are a key resource in the smart city context. Within this context, they denote a collection of versatile, adaptable software components that target one issue or one audience[1]. They have, as der Graaf (2014) indicated, two possible benefits: (a) they assist in systematically outsourcing certain design tasks from public institutions to users (i.e., citizens); and (b) toolkits tend to reduce the threshold for engagement by enabling and facilitating user participation in product or service development corresponding to their individual needs. Degbelo, Bhattacharya, *et al.* (2016) provided an evaluation of existing toolkits in the context of smart city. Their evaluation included nine toolkits and covered dimensions such as topical coverages, institutions developing them, user-centeredness, the degree of integration (i.e., interconnectedness) of the toolkit's components, openness of the toolkit's components, deployment in a city (i.e., whether or not the toolkit or its components have been used in any city), maintenance, publication format and publication year. Their evaluation led to the following nine[2] observations (see Degbelo, Bhattacharya, *et al.*, 2016):

- the topical coverage of current toolkits is relatively broad (O1);
- the EU consortium (through research projects), and private companies are currently the main drivers of toolkit development for smarter cities (O2);

[1] The definition is adapted from (Monroe, 2000).
[2] These observations are numbered from O1 to O9, and referred to using these identifiers later in the document.

- few toolkits follow a user-centered approach during their development (O3);
- few toolkits provide an integrated solution for smart cities; instead many offer a plethora of independent software components to choose from (O4);
- only few toolkits make all their components freely accessible for re-use (O5);
- information about the maintenance of the toolkits is, in most cases, not available (O6);
- many toolkits analyzed have deployed their components, i.e., they provided examples of use of (at least some of) their components in cities (O7);
- existing toolkits are mainly published as software components (O8);
- toolkits for smarter cities are, by and large, at an early stage of their development (O9)

The Open City Toolkit (OCT) intends to address some of these gaps, integrate research done within the GEO-C project, and facilitate re-use of open data by public and private stakeholders. Section 2 outlines the components of the OCT, and Section 3 highlights its main innovations. Section 4 presents the implementation work done so far, Section 5 introduces the release plan, and Section 6 concludes the document.

2. VISION OF THE OPEN CITY TOOLKIT

The OCT will be the main physical outcome of the GEO-C project, with all doctoral researchers contributing components to the joint product. In essence, the OCT is a collection of tools, processes, specifications and guidelines to empower citizens to participate in and shape the future of their cities, and to deliver services based on open data that are useful for citizens, businesses and governing bodies alike. The OCT is both technology-driven (i.e. based on digital technologies) and citizen-centric (i.e. aiming at addressing needs of citizens). It includes five types of components[3]:

- **A set of tools to improve transparency (C1)**: to enable citizens to see apps, datasets and services available, and how they are used;
- **A curated set of examples of open source apps, open data and services (C2)**: these are apps and services that deliver useful services to citizens and city councils, and are free to use;
- **An abstract architecture (C3)**: it describes how apps, services and data can be integrated in order to realise a smart open city. This abstract architecture will be built upon open standards;
- **An explicit linkage between (related) resources that are useful to realize an open city (C4)**: this involves a set of APIs and specifications to link the different resources of the OCT (apps, services, datasets, and guidelines);
- **Guidelines on how to realize an open city (C5)**: these are interactive guidelines describing lessons learned, experiences and insights gained during the course of the project regarding citizen engagement activities, the use of open data and services, the overcoming of the digital divide, and the transition process to a smart city.

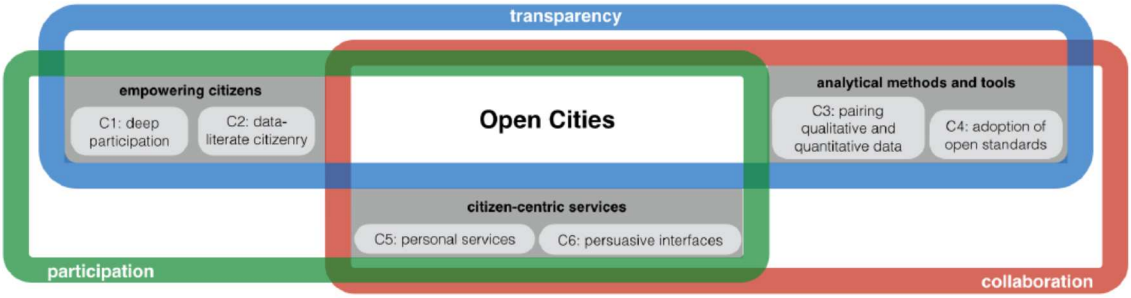
The vision of the OCT was expounded in (Degbelo, Granell, *et al.*, 2016; Trilles *et al.*, 2016).

2.1. PROBLEMS TACKLED THROUGH THE OCT

Broadly speaking, the OCT aims at tackling citizen-centric challenges in the smart city context. Degbelo, Granell, *et al.*, (2016) offered a synthesis of these challenges and grouped them into three research themes, namely: empowering citizens (R1), analytical methods and tools (R2), and citizen-centric services (R3). Each of the research themes includes two more specific challenges (see Figure 1). R1 includes deep participation (i.e., work ***with*** the community, and not just for the community) and data literate citizenry (i.e., democratize data literacy skills). R2 includes pairing quantitative and qualitative data (i.e., provide analytical methods which are able to cope with both types of data) as well as the adoption of open standards (i.e., provide open standards for the access and use of city data). R3 includes personal services (i.e., provide customized services) and persuasive interfaces (i.e., create new types of user interfaces which present information in such a way that citizens are persuaded to change their behavior and take actions accordingly). With respect to the observations reported in Section 1, the OCT mainly addresses gaps (O4) and (O5).

[3] The types of components are numbered from C1 to C5, and referred to using these identifiers later in the document.

Figure 1: Citizen-centric challenges addressed by the OCT grouped into three research themes: empowering citizens, analytical methods and tools, and citizen-centric services (source: Degbelo, Granell, et al., 2016).



2.2. TARGET AUDIENCE OF THE OCT

The OCT adopts an inclusive approach, that is, it aims at enabling all groups of society to make their cities more efficient. These groups include citizens, city councils, private companies, and researchers. Below are examples of benefits for potential users of the platform (the benefits are mentioned as examples, they are not the prerogative of a group of users):

- **The civil society**[4] can visualize the current state of the open data and smart city landscapes through interaction with the indicators from the OCT; in addition, they can download apps from the store of the OCT and install them on their mobile phones;
- **City councils** can download and configure the OCT to support the transition of their cities to a smart and open city;
- **Researchers** can make use of the interactive guidelines of the OCT to communicate to non-academic audiences the insights of their research on open smart cities;
- **Software developers** can fork the source code of the OCT on GitHub, extend it with modules delivering useful services to citizens, and redistribute the modified code without restrictions;
- **Children** can become more environmentally aware through contributions of data to, and visualization of data from the OCT.

[4] The civil society is defined here as the "aggregate of non-governmental organizations and institutions that manifest interests and will of citizens" (http://www.dictionary.com/browse/civil-society?r=66, last accessed: October 27, 2016).

3. INNOVATIONS OF THE OPEN CITY TOOLKIT

This section discusses in detail the main innovative features of the OCT. The contributions of the Early Stage Researchers (ESRs), the OCT transparency module, the interactive guidelines, and the developer corner are now presented in turn. With respect to the five types of components introduced in Section 2, the transparency module is an example of tool to improve transparency (C1). It relies on the registration of applications and datasets which are explicitly linked through a logging mechanism (see Section 3.2). Both the interactive guidelines, and the developer corner are means of transferring the knowledge acquired during the project to the target audience of the OCT (C5): interactive guidelines provide some guidance as well as a documentation of lessons learned during the project to citizens, city councils, private companies and researchers; the developer corner provides developers (which could be companies) with ready-to-use snippets to build their own open city app. The contributions of the ESRs to the OCT are diverse (C1, C2, C5) and are presented in detail in the next section.

3.1. COMPONENTS DEVELOPED BY THE EARLY-STAGE RESEARCHERS (ESRS)

This section introduces the components developed by the ESRs within GEO-C, and relates them to the typology introduced in Section 2; an overview table will be provided at the end of this section. Over the last year, the ESRs have made substantial progress in clarifying both their scientific and practical contributions within the project. Nonetheless, the following list remains provisional to some extent and is still subject to changes.

The first research topic's contribution (ESR01) to the toolkit will be a new tool to enable public displays to facilitate the dialogue between different stakeholders within participatory processes (C2), guidelines (C5), usable apps (C2), and survey results (C2). The second research topic (ESR02) will contribute to the OCT with Geo-games apps to convey environmental information (C2), models, methods as well as questionnaires to get knowledge about users' awareness towards nature. Online hosted materials (booklets, additional documentation, etc.) could be guidelines (C5) on how to incentivize environmental awareness in children[5].

The third research topic (ESR03) will provide guidelines (C5) and a prototype of a service to visualize open geospatial information for new inhabitants (C2). The envisioned prototype is a visualization tool to guide forced migrants in their new cities. The fourth research topic (ESR04) would be delivering a PPGIS (Public Participation Geographic Information System) app (C2), a web questionnaire, a tool to directly measure place attachment/sense of place spatial dimension in city context (C2), a tool to directly measure social capital spatial dimension in city context (C2), and a service to create new participatory geographies in real time (C2). The fifth research topic (ESR05) would be delivering digital questionnaires, models for online participation, and an online tool for engaging people to deliver data about governance (C2). Under this, the OCT will publish guidelines and models (e.g., a predictive model of e-participation adoption (C5)). The

[5] ESR02 has started the design of the game to increase environmental awareness in children, doing a first experiment with school children at the Anne-Frank-Gesamtschule Havixbeck on September 12, 2016 in Havixbeck, Germany. Unexpectedly, ESR02 dropped the GEO-C program at the end of September 2016. Negociations with the project officer are ongoing to clarify how to proceed with the vacuum left by her leave.

next research contribution to OCT (ESR06) plans to produce a set of apps (C2), sensor data collected from participants (C2), an online tool (C2) for citizen sensing which would be a prototype to display questions to participants, design for complex scenarios of questioning, designing models in JSON to apps yielding tools and apps for questionnaires.

The idea behind the topic of (ESR07) is to provide the OCT with a set of web and mobile services that integrate transport data from citizens, sensors, mobile devices, and open repositories to provide efficient feedback (C2). It would be a compilation of anonymous datasets (C2) collected from citizens to complement urban transport analysis, and interaction prototypes for transport users and guidelines for environmental awareness promotion and green living action campaigns oriented to city councils and urban planners. These could be delivered as app/dataset/guidelines for sensor data collection, interactivity with citizens. Another component of OCT (ESR08) would be a tool for Quality of Life monitoring (C1, C2) by identifying quality of life parameters viz. air quality and the studies quantifying such factors based on models and statistical measures. The contribution would yield a model helping to predict air quality, pollution control, entropy, air flow based on multivariate spatial temporal studies, which would in turn contain land use regional applications, and apps for monitoring quality of air. A further OCT contribution (ESR09) includes a WebGIS service (C2) provided for city models on climate change, a computational model in R, and an app (C2) for climate change. Another line of work within the project (ESR10) is currently producing a method to extract mobility patterns in a city, providing open source code for the method (C2), and testing the method using data sources (e.g., bicycle routes data from Helsinki).

The next OCT tool (ESR11) would include first, a guideline (C5) to categorize/assess a set of web service available in a city, evaluating its availability and its effectiveness inside the analysis process of a validator system called Spatial Funnel; second, the research plans to provide a "Spatial Funnel" system, where analysts could filter and validate the available web geo-services for their thematic analysis; third, a guideline will be created to rate and evaluate possible uses for this available data based on Spatial Funnel filters, suggesting to analysts possible uses for these web geo-services. Another tool in the OCT (ESR12) will be on modelling plots to output estimated intensity function for crime data which is seen as a point process on the linear network, also summary statistics like plots and charts (C1, C2) on web GIS data analysis.

(ESR13) is currently working on guidelines for privacy design (C5) for mobile communication and social networks. The work plans also to provide an app (C2) for privacy visualization which enables the selection of different options of privacy protection. (ESR14) plans to provide a proof of concept platform for context aware computing (C2), creating methodologies for a device-environment communication tool to show context aware behavior. The design will give ontologies of devices and subsystems, both for context aware behavior. This will be a native Android app (C2) with a database having context aware designs between system and device. Another contribution to the OCT (ESR15) relates to the development of a conceptual socio-technical model of interactions, capturing dataset of conversations (C2), recordings and ethnography, curated set of designed conversations and technical configurations. Table 1 summarizes the planned contributions of the ESRs to the OCT.

Table 1: Planned contributions of the ESRs to the OCT

	Planned contribution	Contribution type
ESR01	Tool to facilitate dialogue between different stakeholders via a public display, guidelines, usable apps, surveys	C2, C5
ESR02	Geo-game apps, guidelines on how to incentivize awareness in children	C2, C5
ESR03	Visualization tool to guide forced migrants in their new cities, guidelines	C2, C5
ESR04	A tool to directly measure place attachment/sense of place spatial dimension in city context, a tool to directly measure social capital spatial dimension in city context, a PPGIS app	C2
ESR05	Online tool for engaging people to deliver data about governance, guidelines for e-participation adoption	C2, C5
ESR06	Online tool for citizen sensing, sensor data collected from participants	C2
ESR07	Web and mobile services to integrate transport data from citizens, sensors, mobile devices, and open repositories	C2
ESR08	Tool for Quality of Life monitoring, guidelines	C1, C2
ESR09	Webgis for climate impact study; app for climate change	C1, C2
ESR10	Tool to extract mobility patterns in a city	C2
ESR11	Tools for web based geo services; guidelines	C2, C5
ESR12	Plots and charts on web GIS data analysis	C1, C2
ESR13	App for privacy visualization, guidelines on privacy design for mobile communication	C1, C2, C5
ESR14	Native android App to show context aware behavior of devices	C2
ESR15	Recordings and ethnography; curated set of designed conversations and technical configurations	C2

3.2. THE OCT TRANSPARENCY MODULE

In their analysis of benefits and adoption barriers for open data, Janssen, Charalabidis and Zuiderwijk (2012) also introduced five myths regarding open data. One of these myths is that open data is a matter of simply publishing public data, i.e., the data can be made available without additional activities. Janssen, Charalabidis and Zuiderwijk (2012) also reminded that open data has no value in itself; it only becomes valuable when used. Open, in this context, means "that anyone can freely access, use, modify, and share for any purpose" (*The Open Definition*, 2016).

As Janssen, Charalabidis and Zuiderwijk (2012) pointed out "[o]pen data on its own has little intrinsic value; the value is created by its use". This notwithstanding, information about the use of open data is, currently not available in most cases. That is, there are presently lots of open data portals providing a bunch of open datasets, some statistics about the most viewed open datasets, but no actual information about their actual use in an application[6].

The objective of the OCT transparency module is to improve this situation, and provide a means of documenting the use of open data in a smart city context. The OCT transparency module provides technical means of linking apps to the datasets that they use, as well as some statistics about the frequency of retrieval of a specific dataset. Said another way, the OCT transparency module helps to answer the questions: what are datasets available in my city? How often are these datasets used? And which apps use these datasets? An essential technical means of realizing this is the use of semantic Application Programming Interfaces (APIs). The design of semantic APIs and their different layers were discussed in detail in (Degbelo, Trilles, *et al.*, 2016). The main features of the OCT transparency module are summarized below:

[6] The European Union Open Data Portal (http://data.europa.eu/euodp/en/data/; last accessed: September 30, 2016) is a typical example of this.

- App registration: each developer (individual or organization) can register its app and get and API key. This API key is used later to identify apps which access some datasets;
- Logging: this functionality helps to record all activity related to an app (i.e., the types of datasets which it accesses);
- Dataset registration: through this functionality, developers can register their own dataset to the OCT transparency module, so as to make it visible to other users (e.g., citizens, city councils, companies, developers) of the module.

Figure 2 shows a screenshot of the OCT transparency module (the current prototypical version is accessible at giv-oct.uni-muenster.de:8080).

3.3 INTERACTIVE GUIDELINES

The innovative features of the OCT are intended to make cities more efficient and transparent based on the combination of data, information, API, software and technology in general. The idea of putting together open source apps, open data, open services, and tools for enabling transparency through APIs, has a clear technical character. Like many smart city projects elsewhere (e.g., City SDK[7], FIWARE[8]), the OCT also takes a technology-driven approach to making cities a better place through digital technologies. Nevertheless, a defining and novel characteristic of the OCT is the concept of Interactive Guidelines or City Stories, as a way to deliver successful (or not) experiences and lessons gained during the course of the project addressing the second main objective of the OCT: to take a citizen-centric perspective to solving citizens and stakeholders needs.

In what follows, we develop some considerations on the need of the concept of Interactive Guidelines (or City Stories). We use metaphors to explain the benefits of Interactive Guidelines. Next, we describe the main facets that shape an Interactive Guideline, and finally introduce some technical considerations.

Figure 2: the OCT transparency module provides a dashboard-like visualization about datasets and apps usage, increasing thereby transparency. Three apps (for illustrative purposes) are shown on the figure: 'Test_17.8', 'Test_6.10', and 'XmasMarket'. Test_17.08 is the most active of the three with about 358 accesses to exiting datasets in the platform (i.e. API calls).

[7] http://www.citysdk.eu/ (last accessed: October 21, 2016)
[8] https://www.fiware.org/ (last accessed: October 21, 2016)

3.3.1 THE "GET STARTED" TUTORIAL METAPHOR

Easy-to-follow, concise tutorials to get started with a technology, programming language, or hardware component are an important resource for novice users of a technology. Based on precise and practical knowledge, early learners can quickly get the main concepts of a new subject and their connections with other subjects or topics in order to understand the big picture. Obviously, the devil is in the details and becoming an expert is not so easy and immediate. The benefit, though, is that due to this initial help in the form of curated materials, new learners get often motivated to become self-learners and to practice themselves until reaching a consolidated stage. It's like riding a bicycle: one can only learn to ride a bike by trying and trying again, and maybe falling down a few times. Without the first experiences to successfully ride the first few meters, one can read many books about riding but never manage to do it.

Getting started with projects and experiments is also the hardest part to realise Smart City initiatives. But once a city has gone through the first steps, it may get engaged to go further. This common belief is exemplified by a 2015 guidebook authored by The World Bank and European Network of Living Labs (ENoLL) (Eskelinen et al., 2015). It reports a collection of case studies of (mostly) European cities where citizen-driven innovation has led to successful results and impacts. The aim of the guidebook is to inspire city mayors and public administrators to begin addressing their city's problems and issues through citizen-driven innovation inspired by the case stories reported. Each case story analyses a particular issue or aspect in a narrative way through the following self-descriptive headings: description, context, challenges, actions, results, impacts, and scaling up.

The guidebook approach is a good start towards the conceptualization of Interactive Guidelines. Indeed, we borrow the actual organization of the case stories as defined in (Eskelinen et al., 2015) for our purpose. Nevertheless, there are two aspects that might be improved. First, case stories are uniquely described in a narrative manner. This is necessary to figure out the problem, results and impacts of the solution being described in each case story, but fails to indicate how it can be adopted, adapted or repurpose in practical sense. The point is that we consider "interactive" a defining feature in the concept of Interactive Guideline; it is not a static, mere description of the contained facets of a case story, but includes media content, interactive elements and links to actual open source apps, open data, open services being used in the guideline.

The second limitation refers to the scope of the guidebook: case stories are exclusively focused on big cities. Medium-sized and small-sized cities are practically absent. This is not a trivial aspect, in particular in the European context, as we argue with a couple of facts. On one hand, Murgante and Borruso (2014) cited a "the Economist" study (Hilber, 2012) that highlighted that despite the United States and the European Union have a comparable total population, in the U.S. 164 million people live in 50 major metropolitan areas, while in Europe there are only 102 million metropolitan areas inhabitants. Murgante and Borruso also gave a relevant fact: "In Europe 67 percent of urban inhabitants live in medium size urban centres, smaller than 500,000 inhabitants; while less than 10 percent are located in major metropolitan areas bigger than 5 million inhabitants". On the other hand, a recent study developed by Deloitte for ONSTI (Observatorio Nacional de las Telecomunicaciones y de la Sociedad de la Información), a Spanish Observatory for Telecommunications and Information Society, is also constrained by the particular geography of city size in Spain (Deloitte, 2015). It analyzed the current distribution and development of services for smart cities for Spanish

municipalities', grouped municipalities into two classes: either greater or lesser than 100,000 inhabitants. The most relevant aspect of the report is just how the two groups are defined. It assumes that "municipalities with less than 20.000 inhabitants have been excluded because they have special difficulties in starting smart cities projects".

Are medium- and small-sized cities impeded to start off and develop smart city projects? Whereas a great portion of the population in Europe lives in medium- and small-sized cities, most related literature (reports, white papers, guidebooks, etc.) is, if not all, centered on big cities and major metropolitan areas. We realize that major cities can be regarded as early adopters in developing smart city projects. Yet, this does not mean that other types of cities, with less population but being important city hubs according to the demography of European cities, are inevitably excluded from this sort of "get-started tutorials" in order to guide them through the first experiences with smart city projects. Otherwise, they will never ride.

Furthermore, the role of Interactive Guidelines is to compile city stories, experiences and lessons that stem from the activities developed during the GEO-C project to promote the dissemination of real smart city projects, along with their results and impacts, to encourage others can reproduce such projects in other settings, and to democratise smart city initiatives to any city regardless of its size.

3.3.2 The six facets of Interactive Guidelines

As commented earlier, we borrow the organization of case stories from (Eskelinen et al., 2015) to design the structure of the GEO-C interactive guidelines. Each guideline is summarized by a short description that acts as a title, followed by these six self-descriptive features:

- Context
- Challenges
- Actions
- Results
- Impact
- Scaling Up

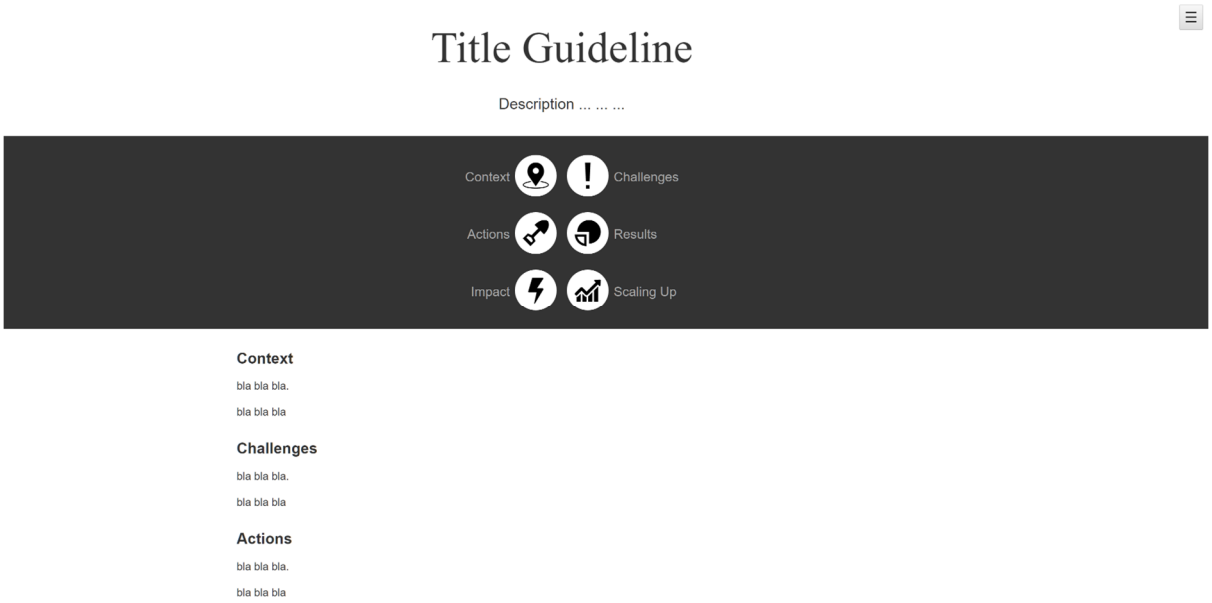
The novelty lies in providing multimedia content, links and dynamic and interactive elements interwoven within the static narrative of a guideline. Along with the descriptive narrative, the inclusion of multimedia features, dynamic elements and links to actual software, tools, data, and other materials being used in a guideline offer a holistically way to evaluate, both conceptually and technically, whether an interactive guideline can be reused, adapted or repurposed for similar city issues.

3.3.3 A first attempt to materialise Interactive Guidelines

Capadisli, Auer and Riedl (2015) have proposed a linked scientific publication approach for authoring and representing scholarly content based on Web technologies. The publication approach uses Dokieli, an open source tool which facilitates article authoring, article annotation and notification of changes to peers. Though Dokieli is still at an experimental stage, and has been originally devised to improve scholarly exchange, its objectives and features overlap with the goals of the interactive guidelines. For example, as regards the goal, Dokieli "works towards acid test and user stories where authors and all Webizens can publish and consume, and participate in discussions meanwhile having

human and machine-friendly information all within their control"[9]. As regards the features, Dokieli provides the embedding of media objects (e.g., audio, video and slideshow), tables, as well as interactions (e.g., executable code, edition/review of a material, multiple views of a material). For this reason, Dokieli is used as a starting point for the implementation of the interactive guidelines in the project. In particular, we're currently exploring the features of Dokieli which could be re-used, and adapted for the open city context. Figure 3 presents a screenshot of the current interface for interactive guidelines, with the six sections previously introduced. The online templates for interactive guidelines are accessible at http://lsivirtual27.dlsi.uji.es:81/dokieli. The current version of the catalog to list all interactive guidelines in the project, organized by theme, so as to enable quick browsing and discovery of guidelines is accessible at http://lsivirtual27.dlsi.uji.es:81/test2/.

Figure 3: A screenshot of the current interface for interactive guidelines. Interactive guidelines within the GEO-C project will feature six sections, namely context, challenges, actions, results, impacts and scaling up.



3.4 THE OCT DEVELOPER CORNER

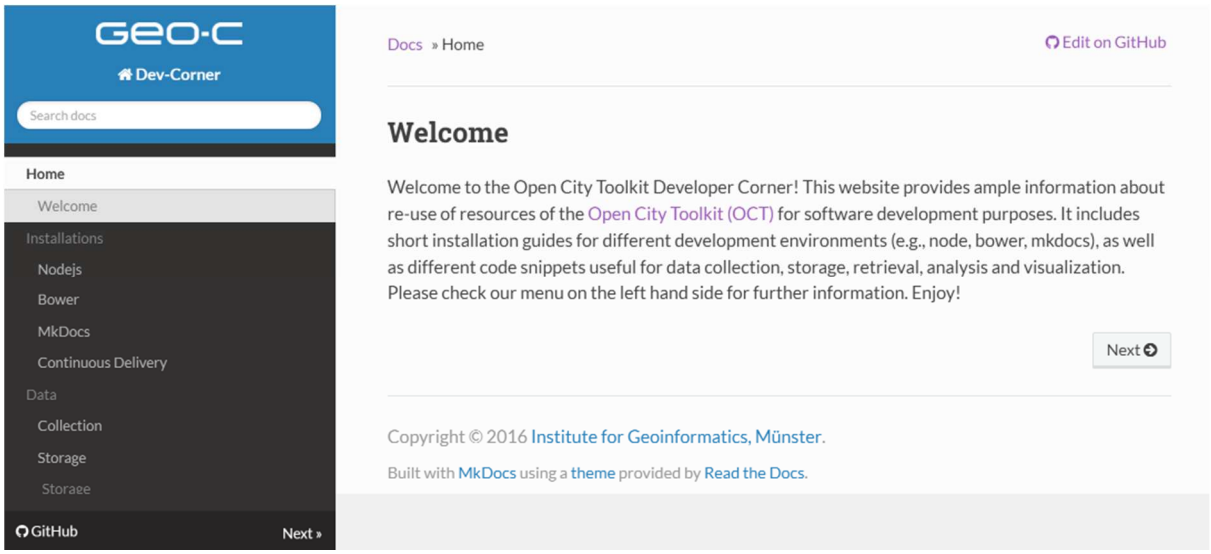
In order to facilitate the usage of the OCT, a collection of tutorials is provided. These snippets are offered using a website, called the OCT Developer Corner (see Figure 4). It includes short installation instructions for different development environments (e.g., node, bower, mkdocs), as well as different code snippets, in different languages, useful for data collection, storage, retrieval, analysis and visualization using the OCT.

The Developer Corner (or Dev-Corner for short) provides a handful of short code fragments related to the OCT. These snippets are classified by functionality: storage, retrieval and visualization. For each functionality, some operations are offered and presented for different programming languages. The project has installed an instance of CKAN (http://giv-oct.uni-muenster.de:5000/) to catalog all resources. The Dev-Corner provides already some snippets to interact with that CKAN instance. For instance, to store data, it offers four different operations using the DataStore API. The DataStore API offers the ability to insert a new data, or existing data can be updated or deleted. To

[9] See https://github.com/linkeddata/dokieli

retrieve data, three different operations are detailed. The first operation, Datastore_search, uses the DataStore API. The DataStore API also has the ability to search and filter data without the need to download the entire file first. The other two operations, retrieve a specific resource and retrieve all resources from a group, use the general API provided by CKAN to interact with CKAN sites and their data. Finally, to visualize data, the Dev-Corner currently provides two examples in order to use different datasets from other public open data portals. The Dev-Corner can be explored at http://giv-oct.uni-muenster.de/dev-corner/.

Figure 4: The OCT Developer Corner collects installation instructions and code snippets for developers to start building their own applications.



4. WORK DONE SO FAR

This section presents a technical introduction to the components of the OCT developed so far. It provides a complement to the (rather) conceptual introduction presented in Section 3. All components presented are built using open source software, and released on GitHub (https://github.com/geo-c) under an open license (Apache v2 license). In addition to the three main components presented in detail in the following sections, GEO-C has already drafted an architecture to realize open smart cities (see Figure 5). This architecture corresponds to the (C3) component mentioned in Section 2. The figure also presents four different types of interactions envisioned for the platform as a whole.

- **Inspect**: see what is there and how it is currently being used; the number of resources (i.e. apps, services, guidelines, datasets) and information about other resources (i.e. apps, services, guidelines, datasets) to which they are linked;
- **Configure**: adapt the OCT (or its components) to different scenarios from those used in GEO-C;
- **Participate**: add/modify an app, service, guideline or dataset; download and extend the OCT through additional modules; rate, comment and tag existing resources; give opinions about urban issues;
- **Collaborate**: establish connections and links between the OCT and other platforms and/or data repositories; work with other citizens towards a goal (e.g., community mapping).

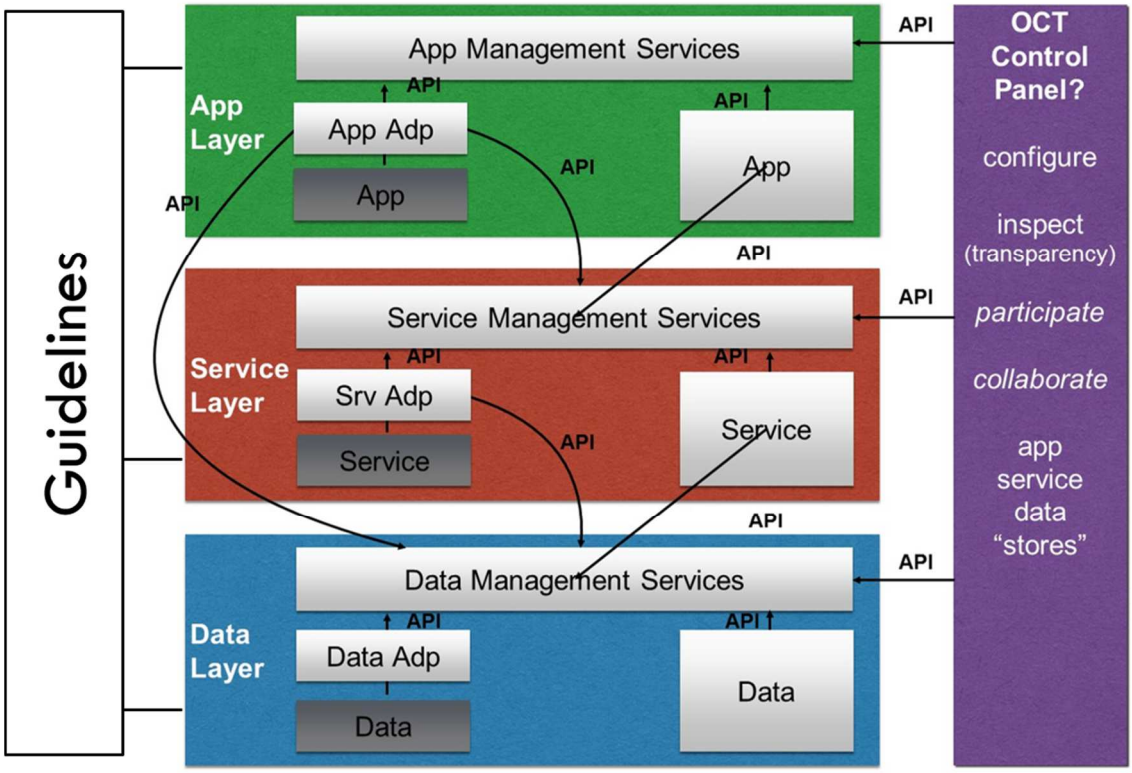
The project has also installed CKAN (Comprehensive Knowledge Archive Network) to catalog its resources, and enriched the basic CKAN features with a number of existing extensions. For instance, the OCT currently uses *spatialUI*, *spatial_metadata*, and *spatial_query* for retrieving spatial data, and *geo_view* as well as *geojson_view* for visualising it. Besides, other extensions have been installed to cover extra functionalities, such as data viewers (pdf, image and text), charts using different visualizations, RDF (Resource Description Framework) vocabularies, local storage, API (Application Programming Interface) for reading, connecting with google analytics, usage statistics, and the creation of documentation pages. Finally, we've developed a CKAN template in order to customize the way to visualize the different resources that the OCT provides. The template is available for re-use at https://github.com/geo-c/ckanext-oct .

4.1. WORK DONE SO FAR: THE OCT TRANSPARENCY MODULE

The architecture of the OCT transparency module is presented in detail in (Degbelo, Trilles, et al., 2016). The implementation of these components is currently being done using the JavaScript development environment Node.js[10]. The main reason for choosing Node.js is its portability; All Node.js applications (irrespective of their functionality) can be run using two commands, namely 'npm install' followed by 'npm start'. That is, any city council could install and run the OCT transparency module with relative ease (i.e., only two commands). The documentation of the semantic API as well as tutorials to register a dataset, and an app to the OCT transparency module are available at http://giv-oct.uni-muenster.de:8080/docs/.

[10] See https://nodejs.org/en/ (last accessed: October 22, 2016) for further details about Node.js.

Figure 5: Provisional architecture of the OCT. Apps, Datasets, and Services are accessible through an API; guidelines interconnect the three layers. There could be four main types of interactions with the platform: inspect, configure, participate and collaborate



4.2. WORK DONE SO FAR: THE INTERACTIVE GUIDELINES

Dokieli provides the possibility to author and format documents using known Web languages such as HTML (Hypertext Markup Language) and CSS (Cascading Style Sheets). JavaScript is used to implement the interaction functionalities for a Dokieli document. Semantic enrichments of documents can be done according to the Linked Data principles[11] using RDFa (Resource Description Framework) annotations. Dokieli provides also means to assign a license to a document, comment it, and share it with peers (and many more). At the moment of this writing, the GEO-C template provided at http://lsivirtual27.dlsi.uji.es:81/dokieli enables a common CSS template for all guidelines within the project. Multimedia (e.g., audio or video) can already be embedded in the template. The template can also be exported as an HTML website and hosted where the user desires (e.g., a personal server). A definite answer to the question 'How much of the Dokieli features are useful in an open city context' is part of an ongoing work.

4.3. WORK DONE SO FAR: THE DEV-CORNER

The Dev-Corner has been implemented using MkDocs. According to the project website, "*MkDocs* is a fast, simple and downright gorgeous static site generator that's geared

[11] For an introduction to the Linked Data principles, see (Berners-Lee, 2006).

towards building project documentation"[12]. As the definition indicates, MkDocs is useful for project documentation, and this is the main reason why it was chosen for GEO-C. MkDocs provides static sites generation, but the *node-cd*[13] module of Node enables continuous deployment. Taking advantage of this feature, we've provided a synchronization between GitHub and the pages generation through MkDocs. That way, any change made on GitHub is automatically reflected on the MkDocs page.

[12] See http://www.mkdocs.org/ (last accessed: October 22, 2016).
[13] https://github.com/A21z/node-cd (last accessed: October 22, 2016).

5. OCT RELEASE PLAN

Table 2 presents the release plan of the OCT. At present, a release per year is planned, where each release features progress made on the different components introduced in Section 2, and expounded in Section 3. The development of the components is iterative, and their evaluation will happen through usability testing (i.e., testing the aspects of efficiency, effectiveness and user satisfaction). The new features in a release are highlighted in **bold** respectively.

Table 2: Release plan of the Open City Toolkit

Release Version	Release Date	Release Features
_v1.0	31.11.2016	- First version of the semantic API which enables: logging, semantic querying, manual addition of new datasets, input data formats supported (JSON), output data formats supported (JSON), types of dataset supported (relational, document-oriented, triple stores) - Draft architecture which describes how apps, services and data can be integrated in order to realize a smart open city - First version of the OCT transparency module: visualization of information about applications which access the datasets; registration of apps to the OCT via an API Key; registration of datasets to the OCT - First version of the Dev-Corner: installation, GitHub synchronization, example snippets - First version of the template for interactive guidelines: categories, HTML/CSS/JavaScript responsive templates - First version of the catalog for interactive guidelines: HTML/CSS/JavaScript responsive template - First set of components developed by the ESRs added to CKAN (with links to GitHub whenever appropriate) - YouTube tutorial about how to use the API to embed datasets in an application published
_v2.0	30.11.2017	- Second version of the semantic API which enables: logging, semantic querying, **addition of new datasets (via a user interface), deletion/update of datasets**, input data formats supported (JSON), output data formats supported (JSON), types of dataset supported (relational, document-oriented, triple stores), **basic spatial search** **- Draft architecture updated** - Second version of the OCT transparency module: visualization of information about applications which accessed the datasets; registration of apps to the OCT via an API Key; registration of datasets to the OCT; **update/deletion of a registered app; update/deletion of a registered dataset** **- First version of the glue: browsing functionality between related apps and datasets** - Second version of the Dev-Corner: installation, GitHub synchronization, **example snippets** - Second version of the template for interactive guidelines: categories, **HTML/CSS/JavaScript responsive templates (updated), embedding media (audio, video) and datasets** **- Second version of the catalog for interactive guidelines: HTML/CSS/JavaScript responsive template (updated)** - Components developed by the ESRs added to CKAN (with links to GitHub whenever appropriate): **update of existing components & addition of new components** **- More YouTube tutorials about how to use components (apps, services, datasets, guidelines) of the OCT** **- Preliminary collection of user stories for the OCT** **- Usability testing of the components and integration of user feedback**
_v3.0	30.11.2018	- Final version of the semantic API which enables: logging, semantic querying, addition of new datasets, deletion/update of datasets, input data formats supported (JSON), output data formats supported (JSON), basic

		spatial search, **addition/deletion/update of the set of categories offered by the semantic API** **- Draft architecture finalized** - Final version of the OCT transparency module : visualization of information about applications which accessed the datasets; registration of apps to the OCT via an API Key; registration of datasets to the OCT; update/deletion of a registered app; update/deletion of a registered dataset; **module to check for errors and notify developers of inactive apps or erroneous links for datasets** - Final version of the glue: browsing functionality between related apps and datasets, **services and guidelines** - Final version of the Dev-Corner: installation, GitHub synchronization, example snippets - Final version of the template for interactive guidelines: categories, HTML/CSS/JavaScript responsive template, embedding media (audio, video) and datasets - Final version of the catalog for interactive guidelines: HTML/CSS/JavaScript responsive template **- Final version of the components developed by the ESRs added to CKAN (with links to GitHub whenever appropriate)** **- Additional YouTube tutorials about how to use components (apps, services, datasets, guidelines) of the OCT** **- Usability testing of the components and integration of user feedback** **- Final collection of user stories & guidelines for the OCT**

6. CONCLUSION

The Open City Toolkit (OCT) is envisioned as an integrated, open source software empowering citizens, providing them with citizen-centric services in the context of a smart city. The OCT is being developed using open source software, and new developments are continually published as open source software components on GitHub.

The project has currently installed CKAN (Comprehensive Knowledge Archive Network) to catalog its resources, and enriched the basic CKAN features with a number of extensions. In addition, GEO-C has already provided a first version of the OCT transparency module which helps to answer the questions: what are datasets available in my city? How often are these datasets used? And which apps use these datasets? Interactive guidelines and a developer corner are the current means of transferring the knowledge acquired within GEO-C to the target audience of the OCT. Interactive guidelines provide some guidance and a documentation of lessons learned during the project to citizens, city councils, private companies and researchers; the developer corner provides developers with ready-to-use snippets to build their own open city app. The OCT is incorporating the results of the various research lines within the GEO-C project.

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