Cockpit Social Infrastructure:
A Case for Planning Support Infrastructure

Till Degkwitz, HafenCity University, Germany

Daniel Schulz, HafenCity University, Germany

Jörg Rainer Noennig, HafenCity University, Germany

https://orcid.org/0000-0002-1681-7635

ABSTRACT

Web-based geographic information systems (GIS) and planning support systems are widely adopted as digital tools to support planning practices. The respective solutions tend to be isolated implementations aimed at a single planning purpose due to the specific requirement concerning their data, methodology, involved stakeholders, etc. With data platforms, GIS infrastructures, and the possibility to use web-based software that relies on open standards, creating a planning support infrastructure is more feasible than ever. Such infrastructures can create opportunities for governments to draw on existing systems and create the potential to improve planning practices through enhanced information and analysis. This paper describes the development of the cockpit social infrastructure, a planning application that serves as an interface between Hamburg's urban data platform and the municipal planners of social infrastructure. Its unique institutional setting as well as its reliance on an open standard software architecture make it a unique case for potential planning support infrastructure.

KEYWORDS

Cockpit Social Infrastructure, CoSI, GIS, Hamburg, Planning Support System, Social Infrastructure, Urban Data, Urban Data Hub, Urban Planning

INTRODUCTION

The Cockpit for Social Infrastructure (CoSI) was initiated by the Hamburg Senate in late 2017 and saw the completion of its first development stage in early 2020. It was implemented by the CityScienceLab (CSL), the Urban Data Hub (UDH) and the Senate of Hamburg. It is designed as a web-based Geographic Information System tool to support experts from local authorities in the cross-district, cross-thematic planning for social infrastructure. While Geertmann and Stillwell (2009) define GIS as "[...] general purpose tools for capturing, storing, manipulating, analysing and displaying spatially referenced data, applicable for many different spatially-related problems [...]" they define Planning Support Systems (PSS) as containing a combination of theory, methods, data, information, knowledge and instruments that are related to planning combined integrated in a framework and available via a graphical user interface. In its current state CoSI contains few elements of the latter and will only develop towards a comprehensive PSS in the coming years with the introduction of

more planning specific methods. We nevertheless want to draw on the PSS literature, as it provides us with a framework to analyse and interpret the tool in the context of this case-study.

CoSI takes full advantage of the Hamburg's urban data infrastructure and aims to introduce a city-wide applicable tool for planners to conduct holistic, knowledge based planning, grounded in the latest and regularly updated statistical data combined with functionalities to assist urban planners. Its unique institutional setting as well as its reliance on existing open standard software architecture make it a unique case to analyse and shed light on its potential to serve as a prototype for planning support infrastructure. CoSI yields this potential through its unique emergence within Hamburg's urban data infrastructure, its strong focus on participatory development methods and its future embeddedness in a pan-German data cooperation the Connected Urban Twins (Bundesministerium des Innern, für Bau und Heimat, 2020). Furthermore, as a tool that has gone from vision to being listed as an integral part of Hamburg's digital agenda (Senate of Hamburg, 2020) in just two years, we see CoSI fit to serve as a success story that, as Geertman (2017) suggests, PSS research should focus on. Especially research towards planning support infrastructures might help to close the implementation gap - the gap between PSS supply and demand.

The remainder of the paper is organized as follows. The next part will give a brief introduction to the theoretical background of this work. Subsequently the paper will focus on the developmental context of CoSI as this is of importance not only to its success but also for its potential as a planning support infrastructure or ecosystem. We will therefore take a closer look at the UDH in the third part as well as the emergence of CoSI within the work group of Hamburg's social planners in part four. The fifth part consists of a detailed description of the tool. We then investigate CoSI's impact and infrastructure potentials in parts five and six, before closing with an outlook on CoSI's future and a final conclusion

THEORETICAL BACKGROUND

Spatial data and their corresponding distribution systems have nowadays been widely deployed across all levels of government, civil society, businesses and other organizations in their strive for a deeper and data-based understanding of processes (Burrough and McDonnell, 2011). The steady rise of open and urban data infrastructures has given this development yet another push as GIS provides a fundamental interface for these platforms (Pettit et al., 2020; Johnson et al. 2017). While, as the name suggests, these systems are general purpose tools for the dissemination of spatial data and knowledge, they can furthermore comprise functionalities for capturing, storing, manipulating and analysing for spatially-related problems (Geertmann and Stillwell, 2009). Planning Support Systems on the other hand are designed to support efficient planning practices and decision-making (Batty, 2007). PSS consists of a combination of theory, methods, data, information, knowledge and instruments that are related to planning which are combined and integrated in a framework that is accessible via a graphical user interface (Geertmann and Stillwell, 2009). This aforementioned set of diverse requirements that PSS tools encompass paired with a lack of consistent legal mandates and funding, naturally leads to a strong use-case focus in many cases of PSS development (Goodspeed and Hackel, 2017). Klosterman seems to foresee and address this already in 1997 when he argues that PSS should not only be a collection of tools but rather develop towards an information infrastructure that facilitates sustainable structures for interaction among planners and other stakeholders.

With GIS representing the heart of PSS (Klostermann, 1997), a well developed spatial data infrastructure (SDI) can serve as a cornerstone in the possible emergence of a sustainable PSS ecosystem (Campagna, 2014). This assumption is of particular importance in the light of current advances in open standards, open source software and open interfaces. The interoperability and standardization of GIS interfaces and formats by the Open Geospatial Consortium (OGC) or the Infrastructure for Spatial Information in the European Community (INSPIRE) could ensure scalability and interoperability (Jeppesen et al., 2018; Cetl et al, 2019). This trend is paired with the increasing

capabilities of web-based GIS systems providing access to GIS and PSS without the necessity of heavy client side software (Farkas, 2017). While web technology based user interfaces do still rely on technical expertise for customization, they do make this process less time and cost intensive especially when they are able to reuse back-end infrastructures and front-end code. Recent cases like the Australian Urban Research Infrastructure Network have highlighted how PSS can be embedded within extensive digital data infrastructures (Geertman et al., 2017; Pettit et al., 2020), thus creating what we will call a planning support infrastructure.

We want to emphasize again that CoSI is currently not a fully developed PSS but rather a sophisticated GIS tool to support decision making in social infrastructure planning. It currently only provides a small number of functionalities that are based on social infrastructure specific planning methods. But with the next phase of technical development starting this year and the integration in the upcoming pan-German data infrastructure in the context of the Connected Urban Twin (CUT) project, it will expand its data, its thematic focus, its planning specific methods and functionalities as well as its community of users (Bundesministerium des Innern, für Bau und Heimat, 2020). We therefore see its potential to develop towards a planning support infrastructure and choose to analyse CoSI with a strong focus on the PSS literature.

Drawing on Geertman (2006) in their qualitative study of the Southern California Association of Governments' Scenario Planning Model, Goodspeed and Hackel (2017) identify core lessons to consider when creating a PSS infrastructure: Utilize participatory design, support a variety of planning practices, address indirect costs to users, encourage collaboration among multiple users within each organization, give stakeholders appropriate access, be mindful of the framing and embrace the technology's transformational potential. We will reference these factors at different stages of this publication and discuss the implementation of them in the context of CoSI. We also want to add a technical focus to these factors and take a close look at the underlying technical details that we deem crucial for potential planning support infrastructures (or PSS infrastructure).

The Urban Data Hub

With IT systems being developed independently in almost every governmental agency over the past decades, the landscape of urban data is fragmented and often not interoperable (Fraunhofer-Institute, 2018). In many cases the city's data sources are siloed in highly specialized IT applications with non-interoperable data types. In addition, the lack of open APIs hampers the data exchange between institutions. This again leads to data redundancies through repetitive data collection, and to diverging sets of information concerning the same topic due to varying data collection methodologies (Barns, 2018; Sewadeh and Sisson, 2018). In the worst case, data is so hard to find within the city's public entities that it becomes completely neglected as the base of a decision making process (Fraunhofer-Institute, 2018). The Urban Data Hub, as a cooperation between the State Agency for Geoinformation and Surveying (LGV) and the CityScienceLab at HafenCity University, tries to address these topics and find city-wide solutions for these challenges. As an organisational unit it consults on issues related to data technology, services, interfaces and formats, it investigates needs for research and development and implements new components. It also operates the Urban Data Platform (UDP). The UDH aims at opening data silos and making the wealth of urban data available across governmental institutions, with the goal of fostering knowledge based decision making in urban planning and creating a well-informed public that, at best, can monitor the city's development (Senate of Hamburg, 2020).

It is crucial to understand the Urban Data Platform as a separate platform from Hamburg's open data portal, which was established in the light of a new transparency law that became effective by October 2012 (§1 Absatz 1 HmbTG; Senate of Hamburg, 2013).[1] The latter seeks to provide citizens with access to a multitude of downloadable files, whereas the UDP contains both public data and internal data for the city's administration and provides machine readable access (Transparenzportal Hamburg, 2020; Landesbetrieb Geoinformation und Vermessung, 2020a).

The current data pool of the UDP covers, among others, topics like demographics, health, mobility, building and housing, environment and climate, culture, sports, education and science (Landesbetrieb Geoinformation und Vermessung, 2020a). The total number of data sources as by August of 2020 amounts to 418, the number of public web GIS layers sum up to 1377. Around 10 million files are downloaded per year and by July 2020 the platform had monthly rates of 15 million internal and 30 million external accesses (Landesbetrieb Geoinformation und Vermessung, 2020a and 2020c). These statistics are available to the public via the Urban Data Platform cockpit, which was developed to provide a monitorial data visualization of the UDP's progress over the last couple of years.[2]

Since its introduction, the UDP's data has been made available to the administration and (in part) the public through various web-based geoportals, visualizing the GIS data as interactive maps and linking the raw data from the UDP. These portals are based on the open-source framework *Masterportal*, to which we will say more later. The portals, especially the comprehensive *FHH-Atlas* (Freie und Hansestadt Hamburg) for internal use, have become an important asset in administrative decision making and communication, as the high number of accesses and statements from within the administration suggest.

Since the success of open urban data systems depends on the data quality and their practical usage (Janssen, 2012), one thematic focus of the UDH, besides un-siloing data, is the extension of its current analytical capabilities of the platform. Appropriate data provision is the requisite first step prior to the usage of urban data, but remains just the starting point for a compulsory set of tools and analyses to be provided by governmental institutions. Public authorities and their staff need to be enabled to efficiently generate reports and charts, combine data from multiple sources and at one point run their own big data analysis or simulations (Landesbetrieb Geoinformation und Vermessung, 2019). CoSI was one of these cases, designed to put data to use in the public administration.

As mentioned in the previous point, open standards, open source code and open APIs are essential when trying to create reusable and transferable software solutions. In the case of the Urban Data Platform maintaining the aforementioned openness is achieved by its focus on standards like the DIN SPEC 91357 for open urban platforms which is an adaption of the EIP-SCC (European Innovation Partnership on Smart Cities and Communities) reference architecture (Cuno et al., 2019). Compliance with these standards lead to the development of the platform with a system-of-systems approach that does not aim at replacing existing IT-systems, but rather enabling them to communicate with and through the UDP (Späth and Knieling 2019). The point about the Masterportal will provide more in-depth information about the technical specifications and the open standards of the UDP. As will be discussed later in this paper, CoSI benefited immensely from the knowledge and the data infrastructure described above.

Inception

In 2017 the *Quartiersinitiative Urbanes Leben* (QuL; Quarter Initiative Urban Life) seeked to rethink the way social infrastructure planning was practiced. The status quo in 2017 was the publication of reports focussing on the development in social infrastructure in the districts, sometimes with sub-reports about separate district areas. The reports usually had a length of about 60 pages and often analysed developments and trends over the last 5 years in the corresponding district (Bezirksamt Bergedorf, 2016 and 2017). But as demographic changes sped up, districts diversified and grew faster than before, the QuL recognised the need for changing the established reporting practice, and for digital assistance to their reporting practice. A further demand for the QuL was a new approach in planning that could bridge district boundaries and foster a change of perspective, away from administrative areas towards a spatial conception oriented towards social life and conditions. Planning was to be better aligned with urban realities, and potential redundancies in social infrastructures (as resulted from discipline-specific, district- or borough-focussed planning) should be avoided in the future (Bürgerschaft der Freien und Hansestadt Hamburg, 2018). Another major shortcoming of the conventional reports was the labour- and time-intensive process of data gathering and analysis, as

Figure 1: Stakeholder mapping
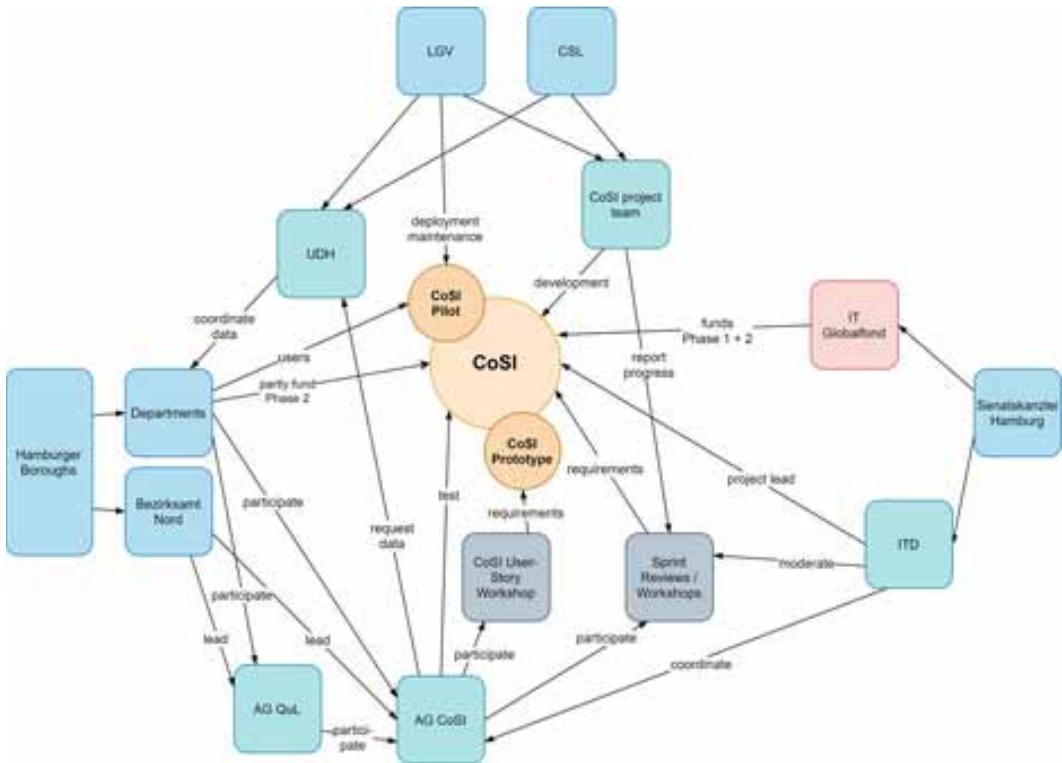
topics to be addressed by the reports were as manifold as the stakeholders present in the QuL. As the landscape of specialised IT systems appeared fragmented and a multitude of formats and APIs had to be synchronised, the idea emerged to establish a more sustainable data infrastructure that would aim at solving the addressed problems not only for QuL reports, but potentially for similar future reports and planning situations. This led to the involvement of the Urban Data Hub in the CoSI project, as the described problems virtually coincided with UDH´s primary focus of work.

The QuL was formed from the state authorities' district representatives, namely for the Authority for labour, social security, family and integration, the Authority for health and consumer protection, the Authority for urban development and housing, the Authority of interior and sports, and the Authority for finance. The CoSI workshops were attended by a changing group of 15 to 25 people, with each authority being represented by at least one expert - usually experienced officers with many years of professional experience. Led by the district Hamburg North and the UDH, a characteristic and continuous challenge during these interdisciplinary workshops was the creation of a joined understanding of the core data and the functional requirements for the first version of CoSI. Further issues were the financing as well as the division of labour and responsibilities between the involved parties with the department for IT and Digitalization (ITD) holding the formal project lead and oversight responsibilities. Figure 1 shows a detailed mapping of all involved stakeholders.

In a data-focussed workshop conducted in 2018, a list of more than 200 potential datasets was compiled. Narrowed down in following meetings, the ultimate list represented the most essential datasets that were of interdisciplinary importance for social infrastructure planning. The time-consuming nature of defining metadata models, data owners, upload and transfer routines made this reduction of datasets a crucial step for the progress of CoSI. As necessary negotiations increased with the number of participants, the final data workshops were conducted in smaller groups with

Figure 2. Development process

only leading members of the QuL and the UDH being present. Also due to these experiences, the CoSI-team finally decided for an agile software development methodology, to keep this process as flexible as possible and prevent extensive negotiations between the stakeholders on matters of core functionalities before establishing a common basis for discussion and an understanding of potential and restrictions of a digital tool.

The development team consequently was also assembled as an interdisciplinary group of software engineers and scientifically trained urban planners to ensure an efficient translation of demands into technical tasks. From the QuL participants, i.e. the future users, a review committee (AG CoSI) was assembled, meeting on a biweekly basis to discuss progress, future steps and data requirements with the developers. The timeline Figure 2 illustrates the development process until today. As will be discussed in the point Infrastructure Potential, this measure proves invaluable for the Agile design process since it facilitates understanding between developers and users and allows the developers to proactively pitch features to the stakeholders they deem valuable from a planning standpoint.

Architecture, Data, Functionality

This point will take a close look at the front-end architecture in which CoSI is embedded in - the Masterportal, the data it is using and finally CoSIs core functionality. But first we want to highlight the importance of the prototype that preceded the tool. The prototype played an important role in the tools framing to the new potential users and crucially influenced all successive decisions in its development.

Prototype

Parallel to the data workshops, a browser-based prototype was developed by the CSL to showcase and communicate the vision of the tool to the QuL as well as to representatives of the administration and to members of the city parliament (see Figure 3). The prototype highlighted the designated predictive design functionalities, aiming to visualize what-if scenarios in digital city models, which form a core research focus of the CSL. Specifically, the prototype modelled simplified future developments

Figure 3. Prototype on a touchable and infoscreen device

scenarios for a construction site that would bring approximately 2500 new inhabitants to a quarter with currently 9000 residents, and estimated the impacts on the local social infrastructure.

As the initial application context was defined through the QuL process - which rendered inter-stakeholder negotiation and information exchange a core objective - the prototype was designed as a workshop tool to be used on an interactive touch table hosting the maps with an additional info-screen displaying relevant information. Similar setups, though with different content and/or user groups, had already been tested in the CSL in the context of other participatory projects, such as DIPAS (Digital Participation System) and Finding Places. (Noyman et al., 2017; Lieven, 2017). To illustrate the added value through extended visualization capabilities, the what-if scenarios as shown in the prototype were precalculated for the given cases and rendered as GIS-Layers hosted for that purpose at CSL. Thus, they were not dynamically generated and drawn from an evolving data infrastructure but rather served as mock-data and basis for further discussion amongst the stakeholders. The core strength of such a setup lies less in its actual analytical capabilities, but in lowering the threshold of usage, and making the analytic results tangible also to non-tech-savvy users. The experiential and interactive nature of the prototype paved the way for the next level of co-creative and collaborative development, by establishing a common understanding of the tool. With the prototype providing a basis for discussion, the outlines of a pilot were drafted which was envisioned to be tested throughout the actual planning process in the above-mentioned quarter. As the stakeholders intended to incorporate CoSI in their every-day work, the focus for the designated final product shifted from a touch-table-centered workshop tool to a single-user desktop application. As the demand for more diverse data sources and customized analyses grew at this point of development, the full integration of the tool into Hamburg's digital infrastructure was targeted, in order to enable dynamically running calculations on continuously updated data hosted by the UDP.

Masterportal

The pilot's functionality was built as a plugin for the LGV's open-source web GIS *Masterportal* (Senate of Hamburg, 2020; Landesbetrieb Geoinformation und Vermessung, 2019). As a configurable online application, it was designed to work as the backbone for the city's interactive map services, both on the public internet as well as the administration's intranet. Developed since 2014 by the LGV and published under MIT licence, it is continuously extended with new features and compatible with a multitude of open standards and formats, such as WFS or GeoJSON, thus allowing the CoSI development team to focus on the analytical features, while assuring maintenance in production. The Masterportal is currently being used by over 50 web-map portals in institutions and municipalities throughout Germany (Landesbetrieb Geoinformation und Vermessung, 2020b).

Each portal built with the Masterportal uses specific configuration files to define the services used (URL of the geodatabase, addresses and parameters of the layers to be loaded), the base modules of the Masterportal used, and some standard attributes such as portal name, imprint, etc. Its modular structure is typical for contemporary, scalable software projects, where individual modules (such as functions, menus, views, etc.) can be added, modified or removed later without affecting the core architecture of the software. In the case of the Masterportal, the modular structure additionally fulfills the function of providing exactly those functions and modules that are needed for the portal/context-specific. Functionality - which is entirely executed on the user's browser window - and data management are hereby strictly separated. As the UDP, the Masterportal was developed with open GIS standards in mind, building directly on the OGC architecture from backend (postGIS, deegree server, etc.) over web services (WFS, WMS) to frontend (OpenLayers).

Data

At CoSI's core lies the layering and aggregation of regularly updated statistical characteristics of administrative districts, the *Stadtteil-Profile*[3], which are supplied by the State Office for Statistics (*Statistikamt Nord*), and various thematic data drawn from the UDP. Based on queries taken from the user story workshops it provides the planners with a number of analytic functions to identify socio-demographic relationships, to recognize trends and to determine relationships between the existing social infrastructure supply and the relevant target groups. Through accessibility and network analyses, the tool helps to find suitable locations and potentials for infrastructure development. The results of these analyses are visualized directly from CoSI and used as a basis for decision-making and discussion. The workflow follows a three-step logic from 1) the visualization of data, 2) the analysis, i.e. the contextual linking of information, to 3) the simulation of the effects of potential measures.

The *Stadtteil-Profile* are available for all administrative levels of the city of Hamburg: statistical areas, districts, boroughs and the entire city. Depending on the administrative level, they comprise over 60 indicators, which can be divided into following categories: population, area, households, social security contributions, social security beneficiaries, unemployment, elderly care, real estate, and traffic. These datasets also include historic data, collected from 2004 (depending on the dataset) onwards (Statistikamt Nord, 2004), which is represented as time-series in the data service and extended annually (Statistikamt Nord, 2020)[4]. These time-series form the basis for CoSI's analytical capabilities and planned predictive features.

The thematic datasets on the other hand are drawn from the existing UDP, although also here the project catalyzed the integration of new sources. The tool distinguishes between visualization layers (layers loaded as WMS, only to be displayed but not usable for correlation with other layers) and analytical layers (layers loaded as WFS and prepared, so that they can be used for calculations based on the *Stadtteil-Profile*). At the end of the first development phase these analytical layers comprised: sports facilities, kindergartens, schools, green spaces and "Hamburg Aktiv" (sports, leisure and educational programs). During the piloting phase these were extended by layers for homeless shelters, social counselling centers and community centers for social psychiatry.

Figure 4. CoSI UI and Dashboard
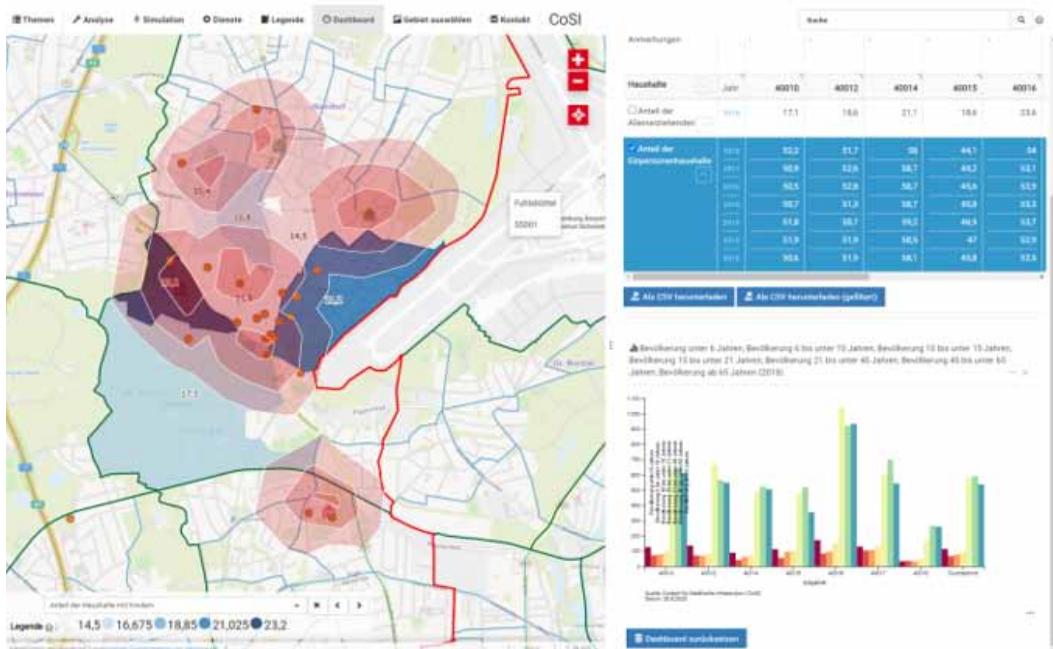
Functionality

Based on the outcomes of a number of user-story workshops conducted in 2018/19 and a close collaboration between the developers and the future users, a series of modules was developed that integrate into the already established workflows of the planners. The general idea of all modules in CoSI is to generate tangible analyses, visualize the results and export these results for further processing. Hereby the CoSI-Dashboard (described in the following paragraphs) forms the central viewport for all output and can be used to visualize, filter, store, process and export the results (see Figure 4)[5]. A complete and comprehensive overview of all features (in German) can be found in the CoSI repository.[6] They include dynamic, context-sensitive display of data in the map and table, basic chart creation and indicator correlation, timeline animation, accessibility analysis (HeiGIT, 2019), supply analysis and district query by attributes (CityScienceLab, 2020).

The dashboard forms the centerpiece of all current functions and those proposed for further development in CoSI. All analyses with the map-based tools, as well as the underlying data sets, converge here. It displays selected areas at any given time as well as the corresponding reference areas (of the superordinate administrative unit) with all *Stadtteil-Profil* indicators in tabular form and contains a number of statistical analysis tools, such as diagrams, correlations or generating new time-series as ratios of others. In addition, the analytic results of all other CoSI modules can be displayed in the dashboard, where they can be used for further evaluations or presentations, arranged in a free layout and exported to other applications.

DISCUSSION

The discussion is divided into three parts. We will first look at the impact that CoSI had on the UDP and the availability of social infrastructure data and especially demographic data. The following part will analyse CoSI in the light of its potential to set an example as a planning support infrastructure. The final part of the discussion will take a brief look into the future of CoSI.

Impact

Following the description of the components, we want to describe the measurable impacts the tool has had so far. Since the conducted user survey is at its current state for internal use only, the focus of this section will lie on CoSI's effect on Hamburg's urban data. Breaking down silos and the introduction of new planning practices are key for PSS infrastructure in embracing a technology's transformational potential (Goodspeed and Hackel, 2017).

The Urban Data Hub is a comparably recent initiative, constantly growing in the number of accessible data sources and expectedly many of the city's numerous datasets are not yet included in the Urban Data Platform. At the time of writing, the demographic data available on the platform is six years old and only includes a fraction of the administrative detail levels and indicators that are included in the *Stadtteil-Profile* (Landesbetrieb Geoinformation und Vermessung, 2020d). Up-to-date demographic data is fundamental as it represents some of the most basic information about the city's inhabitants and is used in the context of urban data platforms for multiple calculations, indicators or simply for monitorial purposes (Kitchin et al., 2015; Moschen, 2019). The *Stadtteil-Profile* are publicly released as spreadsheets by the Statistical Office of Northern Germany on a yearly basis since 2003 and currently include around 63 indicators for 1056 administrative areas of various sizes (Statistikamt Nord, 2020)[7]. Since the datasets concerning the statistical areas are only available for internal administrative use due to data protection laws, only borough and district data will be publicly released. The UDP's web GIS currently provides a total of 1404 accessible layers of which 115 are associated with social infrastructure and demographic data.[8] Including data sources provided by the public administration CoSI led to around 192 new layers that will be published as open data.[9] 14 of these were previously available but only for the year 2014. The newly published 126 borough and district layers from the *Stadtteil-Profile* will now also include historic data - partially dating back 16 years. These numbers illustrate CoSI's strong impact on the availability of datasets. Also, the inclusion of historic values and the current evaluation of standardised data formats to incorporate time-series on all regularly updated datasets, mark another essential step in the advancement of the UDP.

Since the end of the first active software development phase by January 2020, CoSI has been rolled out and actively used by the public planning authorities for social infrastructure across districts and departments. It has received very positive feedback from officials in the city of Hamburg, and beyond. CoSI, which is now listed as an integral part of Hamburg's digital agenda (Digitalstrategie), is planned to be adapted to a wider range of topics in the following development stages (Senate of Hamburg, 2020).

Infrastructure Potential

The core assumption of this paper is that CoSI can in parts serve as a valuable example for the creation of a planning support infrastructure. We now want to evaluate this assumption by taking a closer look at the previously mentioned core lessons by Goodspeed and Hackel (2017) for this matter.

"Due to the complexity of creating a PSS and the diversity of local stakeholders, all regions hoping to create a PSS infrastructure should plan a similar participatory design process" Goodspeed and Hackel (2017). As previously elaborated, the definition of the planning topic 'social infrastructure' was extremely broad and brought together a similarly diverse group of stakeholders. As described in the points above, it was imperative to give the stakeholders, i.e. the future users, absolute control over the priorities and features incorporated as well as to ensure a transparent communication of progress, challenges and caveats. Experience from different software projects in the public administration the CSL was involved with shows that information about needs and demands in the one direction, but also about technical feasibility from the other, gets lost in the translation from the professional domain of users to that of developers, leading to a mismatch between product and expectations and prolong the process altogether (cf. Lehtinen et al. 2015). Due to the urban planning expertise present in the development team in CoSI's case the bi-weekly review workshops could be used efficiently for bilateral discussions about functionality and data; and the developers could themselves tender ideas

to the stakeholders where they saw fit. In order to develop a successful PSS application it is vital to pay close attention to the demands and characteristics of planning practice (Geertmann and Stillwell, 2009), which CoSI emphasized through the adoption of participatory design processes.

As CoSI is not yet a fully fletched PSS, it is therefore not possible to make a final judgement on the lesson of how big the variety of supported planning practices will turn out to be. But if the established processes continue in the next stages of development, it is likely that the stakeholders' diversity paired with the established participatory processes will eventually manifest itself in CoSIs functionality as much as it did in the data diversity. The stakeholders' ability in the negotiation process to define a core dataset, highlighted the groups focus on a tool that overarches topics and districts. The collection and consolidation of siloed data is complex and time-consuming (Sutherland and Cook 2017) and often turns into a bottleneck activity due to multiple factors: ownership restrictions, lack of confidence and trust, divergence of standards, lacking software and technical capacities (Welch et al., 2016). With this obstacle cleared, the UDP as the data backbone and the UDH establishing upload and data sharing routines to ensure its topicality, the primary focus can now shift towards the introduction of scenario planning capabilities and planning specific methods.

These remarks about data infrastructure by the UDH connect directly to the next lesson for PSS infrastructure: the importance to address indirect costs to users. Goodspeed and Hackel (2017) explicitly stress the cost and time intensity of reporting and evaluating data. This paper elaborated on the role of the UDH as the central body for data management in Hamburg in previous points. Un-siloing social infrastructure data was carried out during the active development of CoSI but is continued beyond this phase. The UDH carrying out these tasks free of charge is not only considerably lowering the financial risks involved but also establishes sustainable routines for update and access processes. This knowledge and managerial foundation around urban data is a crucial element of why CoSI might be a good example for planning support infrastructure. Additionally, it is noteworthy how the financial burden and risk of developing and introducing a new digital tool shifted during the development process from the Senate of Hamburg - the state government - to a consortium of individual departments who now finance the follow-up project jointly, which shows the personal interest and investment of the actual users in the tool. Introducing new digital tools, thus promoting digitalization, is often framed as an important location factor in government statements. The subsequent initial state funding and top-down setting of project outcomes can lead to hidden costs and risks for the future users as they cannot directly control the priorities set in the project and the actual impact of the imposed instrument (cf. Lapointe and Rivard 2005, Brigger 2020). Even though CoSI had similar preconditions, owing to the participatory design process outlined above, it was nevertheless possible to create acceptance and even personal commitment among the users ultimately leaving them to advocate for the follow-up bottom-up, having their departments taking direct financial control over the process.[10]

While the aforementioned participatory processes ensured appropriate access to all direct planners of social infrastructure, we support the argument of a necessity to connect the project to a wider range of stakeholders outside the QuL and the direct stakeholders of social infrastructure planning. We strongly support the argument that tools like CoSI should potentially be made accessible to the public. A certain set of planning tools also must be available to the citizens to enable them to monitor governmental activities or the progress of public policies (Pirozzi, 2016). A growing public awareness could ensure the project's longevity, foster the expansion to new topics and support further development towards a planning support infrastructure.

As Goodspeed and Hackel (2017) cite Orlikowski and Gash (1994), the way in which a new tool is introduced and its supposed purpose, scope and place within the work environment is framed, as well as the priorities set during development and communication, will strongly affect the expectations and reception among the stakeholders. Here, project team as well as the administration coordinators emphasized heavily the importance of a) tailoring the tool to the established workflows of planners to create acceptance even among longtime practitioners in the field and b) not to imply any semantics

or suggest that CoSI would automate any decision making and impose normative interpretations of data. From the workshops and discussions with the stakeholders conducted in advance it was clear that in order to quickly roll out CoSI for active application and testing without impediment of lengthy regulatory, legal and political negotiations it was necessary to stress that CoSI in its present stage would rely on the planners own expertise to draw conclusions from the analyses and data and not suggest any expert knowledge itself.

The final lesson that Goodspeed and Hackel (2017) mention, is to embrace the technology's transformational potential. They emphasize how PSS infrastructures can break down silos between departments and foster new ways of planning. They see these potentials hindered by a lack of resources and capacities. While the point that the UDH is a crucial element that provides both of these for free has already been stressed, now is the time to highlight the unique software architecture and open source collaboration that make CoSI most interesting as a case for planning support infrastructure.

Technically, the CoSI application was developed solely as a front-end application based on web technology - a separate, specific portal on basis of the aforementioned Masterportal. This resulted in a web GIS application that is completely independent of its data basis and is accessible from any standard PC of a respective user.

As a publicly funded open source project, CoSI's code base is open for any adaptation or use by third parties and can be linked to any database that provides data in a standardized WFS format. Only the format of the described timelines, as present in the statistical data, deviates from universal OGC standards, although CoSI's dashboard also recognizes non-timeline data by default. Thus, CoSI is designed to be easily adapted to other contexts, data or communities, as long as the data are prepared and formatted accordingly. As intended by the Masterportal´s design, all portal specific configuration is set up through a config-file without an adaption of the core code itself, allowing an editor to connect a different database, set the geographic context and even change info texts from a single access point. Still, in the current development stage, there are limitations to the concept described above. There are a limited number of specific configurations distributed over CoSI's modules that require any developer or editor to replace certain references in multiple files of the code.

While designing a software in the most adaptable and reusable way possible might be a general aim of developers, creating an application that is actually in practical use in different projects is often a completely different challenge. The Masterportal code base, this crucial piece of technical infrastructure on which CoSI is based, is already being used by over 50 institutions and municipalities throughout Germany (Landesbetrieb Geoinformation und Vermessung, 2020b). The CUT project will further accelerate the dissemination of UDP components in German municipalities, as it is designed to build on the current platform and extend it by 3D data formats and functionalities to create digital urban twins.

Especially in this ecosystem where planning systems and urban data platforms are well connected within a city, paired with the infrastructural ties between local governments "[...] PSS can potentially enable better coordination between city, state and federal planning and infrastructure agencies, thus promoting a multi-scaled approach that improves local and national data sharing, modelling, reporting and scenario planning" (Pettit et al., 2018).

Outlook

In the first development phase the technical and logistical foundation, including a continuously maintained application and an engaged user base, have been built up. Thus, besides extending CoSI's thematic scope and stakeholder group, the natural next step for both the UDP and CoSI as its interface is the expansion of analytical and predictive functional capacity. Whereas the current CoSI focussed on establishing a tangible, user-friendly interface between Hamburg's municipal planners and the UDP data, extended prognoses, simulation and the exploration of what-if scenarios will be core research items conducted in the upcoming phases. This will encompass conventional prognostic methods as provided by the *Statistikamt Nord* as well as explorations of new modelling methods. Therefore, CoSI

will successively be integrated with other tools and projects within a growing ecosystem of GIS-applications in the city of Hamburg. One of them being the federally funded research project *Connected Urban Twin* (Bundesministerium des Innern, für Bau und Heimat, 2020) in which a consortium from Hamburg, Leipzig and Munich aims to develop innovative simulation and analysis tools for complex urban systems utilizing Big Data approaches and artificial intelligence such as neural networks. How reliable and valid such methods can be needs to be evaluated thoroughly, as public planning decisions face high levels of scrutiny and accountability (cf. Schulz et al., 2020). As the public interest in urban data modelling grows and more research and open source projects emerge in the field, the creation and exploitation of synergies becomes increasingly important. As CoSI uses open standards, it will be able to incorporate both data generated in other projects[11] as well as provide its tools and API to others. Thus, the Urban Data Hub and CoSI demonstrate how planning support infrastructures can be established whose multiple analytical modules benefit each other.

As mentioned in the previous point, CoSI has so far been a tool solely available to experts, though its functionality could provide citizens with capabilities to monitor the socio-economic development of their city. Acknowledging data protection regulations, however, we do not see substantial hindrances that would prevent this tool from being made publicly available. It can be expected that the level of detail combined with the analytical features of the tool will create substantial public awareness for key challenges and developments in the context of social infrastructure. This in turn might discourage the administration from making CoSI publicly accessible. Still, publishing CoSI would move people further to the center of Hamburg's digital agenda and promote a culture of collaboration and partnership with citizens. As Morozov and Bria (2018: 31) put it " [t]he public sector can do a great deal to sustain and empower community networks and movements and give people more tools and legal instruments to collectively self-organize and gain power to change society."

CONCLUSION

This article followed the suggestion by Goodspeed and Hackel (2017) who urge to devote more research and thought towards a coordinated PSS infrastructure. The case of CoSI is of particular interest for this research topic because of its institutional setting, its participatory design methods as well as its unique technological properties and technological ecosystem. CoSI was initiated by the Senate of Hamburg and the QuL, prototyped by the CityScienceLab, technically supported by the Urban Data Hub and since then developed by all of the previously mentioned parties. It is highly transferable and interoperable through its focus on open standards and open source components and with its integration in the Masterportal ecosystem and the CUT, connected to major crossroads of pan-German urban data and planning infrastructure. Again, even though CoSI is currently more a sophisticated web GIS than a PSS, we see great potential in tools like CoSI that follow an open technical approach, focus on integrating into existing urban data infrastructures and try to involve a similarly heterogenous group of stakeholders and engage them in participatory development processes.

ACKNOWLEDGMENT

REFERENCES

Barns, S. (2018). Smart cities and urban data platforms: Designing interfaces for smart governance. *City*. *Cultura e Scuola*, *12*, 5–12. doi:10.1016/j.ccs.2017.09.006

Batty, M. (2007). Planning Support Systems: Progress, Predictions, and Speculations on the Shape of Things to Come. *CASA Working Paper Series*, no. 122.

Bergedorf, B. (Ed.). (2016). *Bergedorf-Kerngebiet - Sozialraumbeschreibungen im Stadtteil Bergedorf*. Available at https://www.hamburg.de/contentblob/7075328/87eb1460ef647de9fa97ba836bbc7d01/data/sozialraumbericht-2016-do.pdf

Bergedorf, B. (Ed.). (2017). *Vier- und Marschlande - Sozialraumbeschreibungen*. Available at https://www.hamburg.de/contentblob/9473098/7348603487c1c5977380c6aca2d93d23/data/sozialraumbescheibungen-vm-do.pdf

Brigger, P. (2020). *Bei der Digitalisierung zählt das Bottom-up-Prinzip*. Available at https://www.springerprofessional.de/en/transformation/aus--und-weiterbildung/bei-der-digitalisierung-zaehlt-das-bottom-up-prinzip/17625150

Burrough, P. A., & McDonnell, R. (2011). *Principles of geographical information systems: Spatial information systems and geostatistics*. Oxford Univ. Press.

Campagna & Ivanov. (2014). From Spatial Data Infrastructures to Planning Support Systems. *1st International GEOMAPPLICA Conference*.

Cetl, V., Tomas, R., Kotsev, A., de Lima, V. N., Smith, R. S., & Jobst, M. (2019). Establishing Common Ground Through INSPIRE: The Legally-Driven European Spatial Data Infrastructure. In J. Döllner, M. Jobst, & P. Schmitz (Eds.), *Service-Oriented Mapping* (pp. 63–84). Springer International Publishing. doi:10.1007/978-3-319-72434-8_3

CityScienceLab. (Ed.). (2020). *CoSI Repository (GitHub)*. HafenCity University. Available at https://github.com/citysciencelab/cosi-master

Cuno, S., Bruns, L., Tcholtchev, N., Lämmel, P., & Schieferdecker, I. (2019). Data Governance and Sovereignty in Urban Data Spaces Based on Standardized ICT Reference Architectures. *Data*, *4*(1), 16. doi:10.3390/data4010016

D'Amico, G., L'Abbate, P., Liao, W., Yigitcanlar, T., & Ioppolo, G. (2020). Understanding Sensor Cities: Insights from Technology Giant Company Driven Smart Urbanism Practices. *Sensors (Basel)*, *20*(16), 4391. doi:10.3390/s20164391 PMID:32781671

Bundesministerium des Innern, für Bau und Heimat. (2020). *Modellprojekte Smart Cities 2020: Gemeinwohl und Netzwerkstadt/Stadtnetzwerk*. Author.

Education and research in Computer Aided Architectural Design in Europe. (Ed.). (2020). *Proceedings of the 38th International Conference on Education and research in Computer Aided Architectural Design in Europe*. Berlin Technical University.

Farkas, G. (2017). Applicability of open-source web mapping libraries for building massive Web GIS clients. *Journal of Geographical Systems*, *19*(3), 273–295. doi:10.1007/s10109-017-0248-z

FOKUS Rraunhofer. (2018). Urbane Datenräume – Möglichkeiten von Datenaustausch und Zusammenarbeit im urbanen Raum. Author.

Geertman, S. (2006). Potentials for Planning Support: A Planning-Conceptual Approach. *Environment and Planning. B, Planning & Design*, *33*(6), 863–880. doi:10.1068/b31129

Geertman, S. (2017). PSS: Beyond the implementation gap. *Transportation Research Part A, Policy and Practice*, *104*(1), 70–76. doi:10.1016/j.tra.2016.10.016

Geertman, S., Allan, A., Pettit, C., & Stillwell, J. (2017). *Planning Support Science for Smarter Urban Futures*. Springer International Publishing. doi:10.1007/978-3-319-57819-4

Geertman, S., & Stillwell, J. (2009). Planning Support Systems: Content, Issues and Trends. In D. Z. Sui, W. Tietze, P. Claval, Y. Gradus, S. O. Park, H. van der Wusten, S. Geertman, & J. Stillwell (Eds.), *Planning Support Systems Best Practice and New Methods* (pp. 1–26). Springer Netherlands. doi:10.1007/978-1-4020-8952-7_1

Goodspeed, R., & Hackel, C. (2019). Lessons for developing a planning support system infrastructure: The case of Southern California's Scenario Planning Model. *Environment and Planning. B, Urban Analytics and City Science*, *46*(4), 777–796. doi:10.1177/2399808317727004

Hamburg, T. (n.d.). *Hinweise zur API*. Available at http://transparenz.hamburg.de/hinweise-zur-api/

HeiGIT. (Ed.). (2019). *OpenRouteService Repository (GitHub)*. Heidelberg Institute for Geoinformation Technology gGmbH. Available at https://github.com/GIScience/openrouteservice

C. C. Hinnant, & A. Ojo (Eds.). (2017). *Proceedings of the 18th Annual International Conference on Digital Government Research*. New York, NY: ACM.

IEEE Computer Society. (Ed.). (2016). *20th International Conference Information Visualisation (IV)*. IEEE.

Janssen, M., Charalabidis, Y., & Zuiderwijk, A. (2012). Benefits, Adoption Barriers and Myths of Open Data and Open Government. *Information Systems Management*, *29*(4), 258–268. doi:10.1080/10580530.2012.716740

Jeppesen, J. H., Ebeid, E., Jacobsen, R. H., & Toftegaard, T. S. (2018). Open geospatial infrastructure for data management and analytics in interdisciplinary research. *Computers and Electronics in Agriculture*, *145*, 130–141. doi:10.1016/j.compag.2017.12.026

Johnson, P. A., Sieber, R., Scassa, T., Stephens, M., & Robinson, P. (2017). The Cost(s) of Geospatial Open Data. *Transactions in GIS*, *21*(3), 434–445. doi:10.1111/tgis.12283

Kitchin, R., Lauriault, T. P., & McArdle, G. (2015). Knowing and governing cities through urban indicators, city benchmarking and real-time dashboards. *Regional Studies, Regional Science*, *2*(1), 6–28. doi:10.1080/21 681376.2014.983149

Klosterman, R. E. (1997). Planning Support Systems: A New Perspective on Computer-Aided Planning. *Journal of Planning Education and Research*, *17*(1), 45–54. doi:10.1177/0739456X9701700105

Landesbetrieb Geoinformation und Vermessung. (Ed.). (2019). *Geschäftsbericht 2018*. Available at https://epub. sub.uni-hamburg.de/epub/volltexte/2020/103199/pdf/LGV_geschaeftsbericht_2018.pdf

Landesbetrieb Geoinformation und Vermessung. (Ed.). (2020a). *About the Urban Data Platform Hamburg*. Available at http://www.en.urbandataplatform.hamburg/urbanplatformhamburg-en/

Landesbetrieb Geoinformation und Vermessung. (Ed.). (2020b). *Implementierungspartner / Referenzen*. Available at https://www.masterportal.org/referenzen.html

Landesbetrieb Geoinformation und Vermessung. (Ed.). (2020c). *Urban Data Platform Cockpit*. Available at https://geoportal-hamburg.de/udp-cockpit

Landesbetrieb Geoinformation und Vermessung. (Ed.). (2020d). *Geo-Online*. Available at https://geoportal-hamburg.de/geo-online/

Lapointe, L., & Rivard, S. (2005). A Multilevel Model of Resistance to Information Technology Implementation. *Management Information Systems Quarterly*, *29*(3), 461–491. doi:10.2307/25148692

Lehtinen, T. O. A., Virtanen, R., Heikkilä, V. T., & Itkonen, J. (2015). Why the Development Outcome Does Not Meet the Product Owners' Expectations? In *Agile Processes, in Software Engineering, and Extreme Programming: 16th International Conference, XP 2015, Helsinki, Finland, May 25-29, 2015, Proceedings.* Cham: Springer International Publishing. doi:10.1007/978-3-319-18612-2_8

Lieven, C. (2017). DIPAS – Towards an integrated GIS-based system for civic participation. *Procedia Computer Science*, *112*, 2473–2485. doi:10.1016/j.procs.2017.08.182

Morozov, E., & Bria, F. (2018). Rethinking the Smart City: Democratizing Urban Technology. *City Series*, 5.

Moschen, S. A., Macke, J., Bebber, S., & Benetti Correa da Silva, M. (2019). Sustainable development of communities: ISO 37120 and UN goals. *International Journal of Sustainability in Higher Education*, *20*(5), 887–900. doi:10.1108/IJSHE-01-2019-0020

Nord, S. (Ed.). (2004). *Hamburger Stadtteil-Profile 2004 und Umland-Profile*. Available at https://www.statistik-nord.de/fileadmin/Dokumente/NORD.regional/Stadtteil_Profile2004.pdf

Nord, S. (Ed.). (n.d.). *Hamburger Stadtteil-Profile*. Available at https://www.statistik-nord.de/presse-veroeffentlichungen/hamburger-stadtteil-profile

Noyman, A., Holtz, T., Kröger, J., Noennig, J. R., & Larson, K. (2017). Finding Places: HCI Platform for Public Participation in Refugees' Accommodation Process. *Procedia Computer Science*, *112*, 2463–2472. doi:10.1016/j.procs.2017.08.180

Pettit, C., Bakelmun, A., Lieske, S. N., Glackin, S., Hargroves, K. C., Thomson, G., Shearer, H., Dia, H., & Newman, P. (2018). Planning support systems for smart cities. *City, Culture and Society*, *12*(C), 13–24.

Pettit, C., Stimson, B., Barton, J., Goldie, X., Greenwood, P., Lovelace, R., & Eagleson, S. (2020). Open access, open source and cloud computing: a glimpse into the future of GIS. In S. Geertman & J. Stillwell (Eds.), *Handbook of Planning Support Science* (pp. 56–71). Edward Elgar Publishing. doi:10.4337/9781788971089.00011

Pirozzi, D., & Scarano, V. (2016). Support Citizens in Visualising Open Data. *20th International Conference Information Visualisation (IV)*, 271–276. doi:10.1109/IV.2016.45

Schulz, D., Degkwitz, T., Luft, J., & Zhang, Y. (2020). Cockpit Social Infrastructure: Developing a Planning Support System in Hamburg. In *Proceedings of the 38th International Conference on Education and research in Computer Aided Architectural Design in Europe*. Berlin Technical University.

Senate of Hamburg. (2013). *Zweites Open Data Portal für Hamburg?* (Drucksache 20/6961). Available at https://www.buergerschaft-hh.de/parldok/dokument/39788/zweites_open_data_portal_fuer_hamburg.pdf

Senate of Hamburg. (2018). *Zur sozialen Infrastruktur: Was ist die Arbeitsgruppe Quartiersinitiative Urbanes Leben?* (Drucksache 21/14227). Available at https://www.buergerschaft-hh.de/parldok/dokument/63633/zur_sozialen_infrastruktur_was_ist_die_arbeitsgruppe_quartiersinitiative_urbanes_leben.pdf

Senate of Hamburg. (2020) *Digitalstrategie für Hamburg* (Drucksache 21/19800). Available at https://www.buergerschaft-hh.de/parldok/dokument/69512/digitalstrategie_fuer_hamburg.pdf

Sewadeh, M., & Sisson, J. (2018). Disseminating Government Data Effectively in the Age of Open Data. In F. A. Batarseh & R. Yang (Eds.), *Federal Data Science* (pp. 13–28). Elsevier. doi:10.1016/B978-0-12-812443-7.00002-8

Späth, P., & Knieling, J. (2019). Smart City Experimentation in Urban Mobility—Exploring the Politics of Futuring in Hamburg. In A. Lösch, A. Grunwald, M. Meister, & I. Schulz-Schaeffer (Eds.), *Socio-Technical Futures Shaping the Present* (pp. 161–185). Springer Fachmedien Wiesbaden. doi:10.1007/978-3-658-27155-8_8

Stember, J., Eixelsberger, W., Neuroni, A., Spichiger, A., Habbel, F.-R., & Wundara, M. (Eds.). (2018). *Handbuch E-Government*. Springer Fachmedien Wiesbaden.

Sutherland, M. K., & Cook, M. E. (2017). Data-Driven Smart Cities. *Proceedings of the 18th Annual International Conference on Digital Government Research*, 471–476. doi:10.1145/3085228.3085239

Welch, E. W., Feeney, M. K., & Park, C. H. (2016). Determinants of data sharing in U.S. city governments. *Government Information Quarterly*, *33*(3), 393–403. doi:10.1016/j.giq.2016.07.002

ENDNOTES

1   Hamburg's open data portal can be found under http://transparenz.hamburg.de/open-data/
2   The Urban Data Platform Cockpit is available at: https://geoportal-hamburg.de/udp-cockpit
3   Eng.: district profiles; The name refers to the administrative level of the "Stadtteil" which are the second smallest administrative unit in Hamburg and accommodate roughly 10,000 to 30,000 inhabitants, even though the district profiles (*Stadtteil-Profile*) are compiled for all administrative levels.
4   At the time of writing, not all datasets are provided for all years. Parts of the data are also omitted as very small numbers of inhabitants could allow tracing indicators back to individuals.
5   For an in-depth description of all of CoSI's features see the manual, available in the repository, see footnote 6).
6   The CoSI repository is available at: https://github.com/citysciencelab/cosi-master
7   City, boroughs (8), districts (104), statistical areas (943).
8   This calculation sums up the layers from the categories: population; science and education; health; art, culture, sport and leisure; social issues; miscellaneous.
9   63 from the *Stadtteil-Profile* and 33 from different administrative sources, each for boroughs and districts.
10 This situation was reinforced due to the Corona pandemic, leaving the state government with too little budget to fund the next development phase in 2021.
11 e.g., the aforementioned DIPAS, CUT, Urban Data Platform Cockpit.

Till Degkwitz studied business informatics and political sciences at the Leuphana University Lüneburg. Since 2009 he worked as freelance software developer for ad hoc-analytical systems in business intelligence. His current focus are processes of data analysis in urban data platforms and transforming forms of participation in the context of emerging information and communication technologies.

Daniel Schulz studied architecture with a major in urban planning at the TU Berlin, where he worked as a student assistant on citizen participation and digitalization, developing tools for planning, urban research and stakeholder management. For some years now, he has been working as a web developer and media designer with his own company. At CityScienceLab, he has been working on the development of GIS-based planning tools and, as part of the UrbanDataHub, on building Hamburg's urban data ecosystem since 2019.

Jörg Rainer Noennig is Professor for Digital City Science at the CityScienceLab at Hafencity University Hamburg and director of the Wissensarchitektur Laboratory of Knowledge Architecture at TU Dresden. Between 1998 and 2001 he practiced as a freelance and employed architect in Tokyo, among others at Ishiyama Experimental Underground Architecture Factory and Arata Isozaki & Associates. From 2001 he was Research Associate at TU Dresden, where he was appointed Junior Professor for Knowledge Architecture (2009-2015). He has taught at different universities in Japan, USA, China, Italy, Switzerland and Angola. He was Visiting Professor at Universit degli Studi dell l´Aquila and at ISEN Toulon. He has published several books and more than 100 scientific papers and essays. He has won several prizes, scholarships and awards, incl. the Grand Prize of the European Association for Architecture Education (EAAE).