UNIVERSITY OF LIVERPOOL | Heseltine Institute for Public Policy, Practice and Place

*A Good Practices Reference Guide*

Prepared for: **Heseltine Institute for Public Policy, Practice and Place,** and the **Geographic Data Science Lab, University of Liverpool** and **Liverpool City Region Combined Authority**


# *Building Data Ecosystems to Unlock the Value of Urban (Big) Data: A Good Practices Reference Guide*

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# ABBREVIATIONS

| | |
|---|---|
| **AI** | Artificial Intelligence |
| **CMS** | Content Management System |
| **DIN** | Deutsches Institut für Normung (in English, German Institute for Standardisation) |
| **EU** | European Union |
| **H2020** | Horizon 2020 European Programme |
| **ICT** | Information and Communication Technologies |
| **IoT** | Internet of Things |
| **ISO** | International Organisation for Standardization |
| **IT** | Information Technology |
| **LCR** | Liverpool City Region |
| **LCRCA** | Liverpool City Region Combined Authority |
| **LIS** | Local Industrial Strategy |
| **PPP** | Public–Private Partnership |
| **SME** | Small and Medium Enterprises |
| **UK** | United Kingdom |

# GLOSSARY

**Algorithm:** in mathematics and computer science, an algorithm is a set of instructions, typically to solve a class of problems or perform a computation.

**Artificial Intelligence:** in Computer Science, AI is intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans.

**ICT:** an extensional term for information technology (IT) that stresses the role of unified communications and the integration of telecommunications (telephone lines and wireless signals) and computers, as well as necessary enterprise software, middleware, storage, and audiovisual systems, that enables users to access, store, transmit, and manipulate information.

**IoT:** the extension of internet connectivity into physical devices and everyday objects. Embedded with electronics, internet connectivity, and other forms of hardware (such as sensors), these devices can communicate and interact with others over the internet, and can be remotely monitored and controlled.

**Open Data:** datasets provided by public authorities and public enterprises to the general public.

**Open Source Software:** Open Source Software complies (with its code) with the following requirements: (1) free redistribution, (2) free source code, (3) free for modifications and derived works, (4) integrity of the author's source code, (5) no discrimination against persons or groups, (6) no discrimination against fields of endeavour, (7) unlimited distribution of licence, (8) licence must not be specific to a product, (9) licence must not restrict other software, and (10) licence must be technology-neutral.

**Open Standards:** in general, Open Standards for protocols, data formats and data models are understood as standards captured within publicly available documentation.

**Smart City:** a city is smart when investments in human and social capital as well as traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with wise management of natural resources, through participatory governance.

# FOREWORD

As part of a wider suite of actions designed to prepare their cities for what has been variously termed a fourth industrial revolution, a cyber-physical revolution, Industry 4.0 and/or Society 5.0, municipal leaders from across the world are increasingly harnessing a new generation of smart technology encompassing AI/autonomous systems, the 'Internet of Things' (IoT)/5G, and quantum leaps in data science, infrastructure and capacities. At the heart of the 'Smart City' is *big* data, provocatively titled 'the new oil'. To unlock the full economic, social, and environment potential of big data, it is now supposed that cities will need to radically increase access by public, private and third sector stakeholders to urban big data. But convening data owners, building data platforms, coping technically with a data deluge, promoting Open Data, and developing new institutional mechanisms for data sharing, all bring to the fore profound logistical, ethical, commercial, and political challenges.

**The challenge for city leaders and muncipal authorities**

And so a key question now presents to architects of the Smart City:
*How can urban data ecosystems be designed, built and governed to enable city leaders and muncipal authorities to exploit more fully the powerful data revolution and effectively tackle critical economic, social and environmental challenges in a way which is democratic and ethical, and which maintains ongoing stakeholder – and public – trust?*

Put more simply:
*How can city leaders and municipal authorities increase access to and enable better harvesting of urban big data whilst maintaining buy-in from stakeholders and citizens?*

As elsewhere, Liverpool City Region (LCR) is actively courting a fourth industrial revolution and engaging the Smart City agenda. There is clearly much work to do. As the Liverpool City Region Combined Authority (LCRCA) has only recently been established, it is no surprise that a formal city region data strategy has yet to be developed. Moreover, whilst at various points constituent local authorities and other stakeholders have sought to craft a new data vision for their areas, sustained follow-up and lasting impact has been lacking. The Smart City agenda, it seems, has suffered from a number of faltering starts and thus far made only intermittent progress. In consequence, whilst there are a wide variety of excellent national, regional, and local datasets tracking social, economic, and environmental conditions and trends within the Liverpool City Region, these datasets exist in scattered formats, are generated and owned by different institutions and according to different protocols, often lack interoperability, and are insufficiently shared and exploited.

But today there is emerging a more sustained will locally, and a galvanised sense of purpose to accelerate the innovation and adoption of smart technology and to pioneer and scale data-driven solutions. A historical moment of opportunity beckons.

Within the LCRCA and local authorities, there has recently emerged a heightened awareness of the need to audit the fitness of purpose of the existing LCR data landscape and infrastructure, and to scope out new models of data production, gathering, stewardship and sharing. This awareness will undoubtedly be intensified as the new Local Industrial Strategy (LIS) gains traction in 2020 and beyond, foregrounding as it does the importance of AI and big data to the local economy. There is much to build upon, and genuine cause for optimism. LCR boasts a number of strategic assets, which if fully harnessed could provide significant comparative advantage. These include (but are not limited to) its capacity to deploy 5G networks, the Hartree/Daresbury Supercomputer, a digital skills programme, the Sensor City initiative, LCR Activate, a strong body of transport data, and a Consumer Data Research Centre based at the University of Liverpool. Meanwhile, recently launched and planned projects include the Digital Spine, a Civic Data Trust/Cooperative, an AI Solutions Hub, and a number of Transport for the North data innovations.

The University of Liverpool is committed to supporting LCRCA, local authorities and other public, private and third sector stakeholders to further build a data ecosystem for LCR which is capable of rivalling international peers. As part of this work, in March 2020 the Heseltine Institute for Public Policy, Practice and Place will host an international symposium entitled *Building Smart Cities with Citizens and for the Public Good*. To inform this symposium and at the behest of the Institute, international experts based at BABLE UG/Fraunhofer FOKUS in Germany have undertaken a review of international good practices in the development of urban data ecosystems. The premise of this review is that current interest in developing an improved data ecosystem for the Liverpool City Region might usefully be energised and informed by a greater awareness of innovative strategies, policies, investments and projects being undertaken in other cognate cities, and the important lessons which have already been learned elsewhere.

In choosing case examples to illustrate good practices, the authors of this guide have been attentive to the particularities of LCR. But it is important to note that the aim of the review is to provide a panoramic snapshot of widely regarded international exemplars, and not to articulate a data vision or the like for Liverpool City Region. Translation of good practices into bespoke LCR interventions presents a related but separate task. Whilst gestured to in a concluding 'food for thought' section, this latter task falls beyond the scope of this review and constitutes in itself a significant body of work that demands careful consideration and substantial local consultation. How LCR might transfer and embed policies and interventions which have been successful

elsewhere will ultimately depend upon the nature of the Smart City it aspires to be – a determination requiring local dialogue and yet to be fully considered. This, then, is a Good Practices Reference Guide that we anticipate will be helpful in informing, equipping and briefing, rather than shaping and directing, the local conversation as it moves forward.

Our March 2020 symposium provides a further opportunity for colleagues from academia, central and local government, elected offices, policy and practice consultancy, journalism, think tanks, activist groups and beyond to take stock of the status of the local conversation and how it might be advanced. To this end, this Guide is being published alongside a concise *Position Statement* from the Heseltine Institute, written to contribute to the establishment of a roadmap for a smarter Liverpool City Region. In this parallel Position Statement you will find a discussion of the potential meaning and implications of international good practices for LCR stakeholders. It is our intention at this juncture only to add a fresh voice to the existing pool of expertise, and we resist offering formal prescriptions and directive recommendations. We are conscious that many local leaders, institutions, organisations and businesses have much to say on this topic. There is no shortage of creative thinking and potential future imaginaries. It will be for city region leaders to gather and synthesise good ideas, determine local priorities and build local consensus on what a smart Liverpool City Region might look like, and who will be responsible for building it.

We support efforts to unlock the inherent value within LCR datasets which has yet to be fully capitalised upon. We believe this will require local datasets and datasets with local expression to be opened up to a wider range of public, third sector, and private and profit-seeking businesses. But terms should be set on who will have access to which data and for what purposes. Regulatory frameworks need to be developed and applied.

Whilst we believe that the idea of the Smart City is full of possibility, we note that the ownership, stewardship and deployment of smart technology and data has provided cause for concern and caution. In particular, the origins and development of smart technology within a framework of what Shoshana Zuboff (2019) calls 'surveillance capitalism' have given rise to technology that is not only configured primarily to serve the interests of a predatory 'big other', but which is also substantially and manifestly under-regulated – as highlighted by long-standing concerns over unaccountable corporate monopolies, privacy and security of personal data, (unconscious) bias in algorithms, and digital inequalities and addictions. The problem is not smart technology per se; it is that this technology is being enabled and constrained by a very particular politico-institutional dynamic, a new mode of capital accumulation whose business model is the extraction of value from personal data with little juridical, regulatory or ethical oversight. For Zuboff, surveillance capitalism is propelling smart technology and over-determining its trajectory, and in so doing is colonising and compromising other alternative politico-institutional logics.

Whilst a powerful coercive force, surveillance capitalism is not inevitable. Infact AI and data driven solutions are essentially benign, everything depends upon the political constitution and architecture of data ownership and sharing arrangements, specifically how they these arrangements are designed, regulated and governed and whether they command a social licence. Whether or not AI and the data revolution will lead to a better tomorrow will depend upon social and political choices we make today.

Public bodies will surely lead the Smart City, and public-to-public data exchanges will be of vital importance and will need their own rules of engagement. But we judge that the market must play a central role in the search for data-driven solutions; it has enormous resources, talent, dynamism, expertise, and innovative capacity that should be harnessed. But clearly the market needs to be properly regulated, incentivised and disciplined, including through levers available to municipal authorities operating at the city region level.

At the heart of our contribution, then, is the question: *how might metropolitan authorities like the LCRCA and LCR's six local authorities build Smart Cities in collaboration with citizens and for citizens, dedicated to the cause of enabling public, private and third sector actors to capitalise on big data whilst also serving the public good?*

We thank the authors of this Guide, Alanus von Radecki, Nikolay Tcholtchev, Philipp Lämmel, and Gretel Schaj for calling attention to the key issues which cities and city regions need to confront when embarking upon a comprehensive digital and data transformation, and for highlighting the good practices of cities and city regions whom have navigated these issues especially effectively.

This Guide, our accompanying Position Statement, and our March symposium point to the central challenge of unleashing the potential presented by big data whilst preserving and championing 'tech and data management for public good'. Through our activities and outputs in 2020, we hope to contribute to the clarification of what a citizen-centred 'Smart Liverpool City Region' might look like, and how we might build it.

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Zuboff, S. (2019). *The Age of Surveillance Capitalism: The Fight for a Human Future at the New Frontier of Power*. London: Profile Books.

# SYNOPSIS

A real moment of opportunity exists for LCR to accelerate its smart, digital and data transition, develop and scale its data ecosystem, and implement smart and data-driven solutions to pressing economic, social and environmental problems. The extant energy, strengths and assets of the city region are cause for great optimism. LCRCA and LCR local authorities are acutely mindful of the Smart City agenda and the importance of high-performing data infrastructures; there are good links with industry, and SMEs are displaying ever-evolving leadership abilities. Comparative advantage is furnished by assets such as the 5G network programme, a supercomputer at Hartree/Daresbury dedicated to industrial R&D, the digital skills programme, the Sensor City initiative, LCR Activate, LCR's extensive base of transport data, and the Consumer Data Research Centre based at the University of Liverpool. Meanwhile, planned projects include the Digital Spine, Civic Data Trust, AI Solutions Hub, and Transport for the North.

Despite these promising foundations, LCR still faces significant challenges which will need to be confronted and overcome if further progress is to be made. Building a Smart City in the political-economical-institutional context of a city undergoing urban regeneration and renewal presents its own unique challenges; whilst not inevitably the case, it is likely that the task of building will be more difficult and complex – albeit more crucial – in this context. Furthermore, there are more specific challenges that relate to the institutional landscape and the lack of a clear local data strategy. There is no overarching and commonly agreed strategy or plan, technical framework, sense of mission, or set of data standards to orientate, galvanise and align local stakeholders. As a consequence, data is being insufficiently shared and its value under-exploited.

The purpose of this Good Practices Reference Guide is to profile recently completed and ongoing good practices in the building of Smart Cities and data ecosystems in so-called 'Lighthouse Cities' which might prove instructive for stakeholders in Liverpool City Region, as they too work to build the city region's digital and data infrastructures and capabilities. The Guide has been prepared at the behest of the Heseltine Institute for Public Policy, Practice and Place at the University of Liverpool and the Liverpool City Region Combined Authority (LCRCA) by international experts Alanus von Radecki, Nikolay Tcholtchev, Philipp Lämmel, and Gretel Schaj, based at BABLE UG/Fraunhofer FOKUS in Germany. To complement this Guide, the Heseltine Institute is also publishing a separate *Position Statement* which commences the task of considering the potential impacts and implications of good practices for LCR, along with questions pertaining to policy choices, capitalising on learning, and policy transfer.

The core challenge facing municipal leaders as they work to engage the Smart City agenda is how to radically expand access for public, private and third sector actors to data so that they might more fully unlock its potential to assist with the search for solutions to critical economic, social and environmental problems, whilst maintaining stakeholder and citizen buy-in. High-performing data ecosystems should only exist to help municipal authorities to improve the lives of their citizens.

A range of good practices are profiled, including but not limited to policies and projects in the especially innovative European cites of Vienna, Cologne, Milan, Eindhoven, Greater Manchester, Tallinn (Estonia), Barcelona and Greater Dublin. We examine case studies which illustrate good practices with respect to four action areas and across twelve key issues:

- The **groundwork and preparation** required when starting to organise a data ecosystem (*rationale for data plans, stakeholder mapping, data audits*)
- The **governance, management, ethics and regulation** arrangements necessary to set the basic framework (*governance and management, governing for public good: building Smart Cities with and for citizens, governing data ethically)*
- The **technical infrastructures and challenges** which are fundamental for an integrated ecosystem (*building Open Data ecosystems and fostering interoperability, investing in data infrastructure: hardware and software, data security, data visualisation*)
- **Resources, finance and economics** questions which need to be asked of data-driven ecosystems (*financing models and procurement, cost–benefit analysis*).

Stakeholders in LCR may find it beneficial to use the framework to think about the progress which is being made locally in each of the action areas and with respect to each of the twelve key issues. More importantly, they might use the framework to consider the extent to which there is and can be alignment across the entire data ecosystem.

Whilst it is not the purpose of this report to make formal recommendations as to which of the practices might be transferred to LCR, nor what LCR should or should not do next, we end by offering food for thought which we hope local stakeholders will find stimulating and useful. Our thoughts are tentative, provisional and offered in the spirit of enriching local dialogue. We:

a) Note the importance of building data ecosystems at the scale of LCR, and identify LCRCA as well-placed to coordinate this endeavour
b) Ruminate on whether a *Future Innovation Office* (based in LCRCA, for example) or the like might serve as an important progenitor of an LCR data ecosystem
c) Acknowledge the recent institution of a *Civic Data Trust/ Cooperative* and consider the scaling of this institution into a wider city region data hub
d) Signpost the importance of LCRCA and all six constituent local authorities working in partnership, and reflect upon whether a *Joint Taskforce* is needed to help knit together data plans, policies and interventions
e) Venture the view that a *Regional Innovation Think Tank* or similar, working as an advisory group, could enable a wide range of stakeholders to articulate their views to any Joint Taskforce
f) Underscore the need for LCR to embed itself more centrally in policy learning networks.

# 1. INTRODUCTION

The purpose of this Good Practices Review is to profile successful and well-regarded Smart City experiments and data ecosystem building projects in Lighthouse Cities, with a focus principally (but not exclusively) upon European cities. We anticipate that this Guide will prove instructive for stakeholders in Liverpool City Region (LCR), as they too work to build the city region's digital and data infrastructures and capabilities.

Cities and city regions worldwide are increasingly harnessing the potential of Smart City solutions, especially those which create and deploy big data to tackle critical societal challenges, address key public policy problems, and enable public, private and third sector stakeholders to provide better delivery of products and services. Their goal is to enact and exploit a technically, socially, economically, and environmentally successful digital transition. At the heart of any high-performing Smart City is a high-performing data ecosystem. However, developing and transitioning to an integrated municipal data infrastructure, where data is widely and easily shared and used, requires sustained effort. Few cities are already in a position to fully harness and embrace the data revolution; most are only now actively working to build their data infrastructures to be fit for purpose.

Through inspiration and trial and error, lessons are starting to be learned. It is clear that architects of Smart Cities need to address at least four fundamental action areas across at least twelve key issues:

- The **groundwork and preparation** required when starting to organise a data ecosystem (*rationale for data plans, stakeholder mapping, data audits*)
- The **governance, management, ethics, and regulation** arrangements necessary to set the basic framework (*governance and management, governing for public good: building Smart Cities with and for citizens, governing data ethically)*
- The **technical infrastructures and challenges** which are fundamental for an integrated ecosystem (*building Open Data ecosystems and fostering interoperability, investing in data infrastructure: hardware and software, data security, data visualisation*)
- **Resources, finance and economics** questions which need to be asked of data-driven ecosystems (*financing models and procurement, cost–benefit analysis*).

A wide range of good practices are profiled in this review. These include projects currently being undertaken in Vienna (Open Source Database), Cologne (Big Data Visualisation), Milan (Sharing Cities Urban Sharing Platform), Eindhoven (Smart City Data Platform in Strijp-S), Greater Manchester (Data-Enabled Innovation Challenges), Tallinn/Estonia (X-Road, Data Exchange Platform), Barcelona (Big Data Integration Solution, and Citizen Science and IoT Data Governance Pilot), and Greater Dublin (Dublinked Data Portal). Given the importance of these particular projects, alongside e-copies of this Good Practices Reference Guide, extended deep dive 'Use Cases' for each city will be made available on the Heseltine Institute website: **www.liverpool.ac.uk/heseltine-institute/reports**[1] (BABLE, 2019).

Whilst we believe that the good practices we chronicle might usefully inform municipal leaders and key stakeholders in Liverpool City Region (LCR), it is not the purpose of this report to make formal recommendations as to which of the practices might be transferred to LCR, nor what LCR needs to do next. This constitutes a significant task in itself, and in the final analysis is contingent upon an audit of existing assets and limitations, and a well-considered judgement concerning the kind of Smart City region LCR wishes to become. To supplement our Good Practices Review, the Heseltine Institute is also publishing a separate *Position Statement* which commences the task of considering the potential impacts and implications of international good practices for LCR. Nevertheless, in closing, and based upon a limited number of interviews with local actors, we do offer food for thought which local stakeholders may find useful, at least as a catalyst for advancing the local conversation.

1 As part of the BABLE's Use Case database, there is also the opportunity to contact the Use Case's owner, who participated in implementing and managing the project.

# 2. BUILDING DATA ECOSYSTEMS TO UNLOCK THE VALUE OF URBAN (BIG) DATA: A GOOD PRACTICES REFERENCE GUIDE

## A Framework: Action Areas and Key Issues to work through when building a High-Performing Urban Data Ecosystem

In this section, we profile international good practices by identifying four fundamental action areas and exploring exemplar case studies which speak to twelve key issues therein. Our framework is not intended to be an exhaustive checklist, nor a list of isolated actions to be ticked off. The four action areas and twelve key issues identified need to be considered together, for they are necessarily inter-related. In particular, Key Issue 1, *Cities' rationales for data plans,* constitutes the core point of departure and defines the choice sets available regarding measures designed to tackle Key Issues 2–12. It provides a strong orientation for the entire data ecosystem, and presents as the most important key issue to address as it helps to calibrate data ecosystems so that they express local democratic values and exist to serve the public good, focus effort, ration scarce resources, and maximise impact for a given spend. A strong sense of purpose also acts as a progenitor of new bespoke policy ideas, interventions and practices.

Stakeholders in LCR may find it beneficial to use the framework to think about the progress which is being made locally in each of the action areas and with respect to each of the twelve key issues. More importantly, they might use the framework to consider the extent to which there is and can be alignment across the entire data ecosystem.

**A framework: action areas and key issues to work through when building a high-performing urban data ecosystem**

**Action Area 1 – Groundwork and preparation**

- *Key Issue 1 – Rationale for data plans: specifying values, aims and objectives which undergird data ecosystem planning*
- *Key Issue 2 – Stakeholder mapping: mapping key stakeholders and user groups in city data ecosystems*
- *Key Issue 3 – Data audits: undertaking audits of key datasets most often used in data ecosystems*

**Action Area 2 – Governance, management, ethics and regulation**

- *Key Issue 4 – Governance and management: identifying effective governance mechanisms both for plan design and implementation*
- *Key Issue 5 – Governing for public good: building Smart Cities with and for citizens*
- *Key Issue 6 – Governing data ethically: providing practical guidance on how questions of data ethics might be handled*

**Action Area 3 – Technical infrastructures and challenges**

- *Key Issue 7 – Building Open Data ecosystems and fostering interoperability: suggesting institutional and cultural reforms which may be needed if datasets are to be rendered interoperable, and establishing protocols for data collection, collation and sharing*
- *Key Issue 8 – Investing in data infrastructure: hardware and software, and identifying technological and infrastructural improvements which underpin effective data ecosystems*
- *Key Issue 9 – Data security: protecting data privacy and confidentiality and mitigating against breaches of data firewalls*
- *Key Issue 10 – Data visualisation: reflecting upon data visualisation and the value of developing a city dashboard or equivalent*

**Action Area 4 – Resources, finance, economics**

- *Key Issue 11 – Financing models and procurement: resourcing Smart City infrastructure and maximising spend*
- *Key Issue 12 – Cost–benefit analysis: undertaking a cost–benefit analysis of the implementation of a new city-based data management plan.*

# Action Area 1
# GROUNDWORK AND PREPARATION

## KEY ISSUE 1 – RATIONALE FOR DATA PLANS

Cities must always begin by asking a number of critical questions: why should we build a Smart City? Which values and principles should underpin our work? What can we do with smart technology that we could not do with simple technology? The biggest mistake to make is to fetishise technology and fall prey to unrealistic boosterism. The purpose must always be to appropriate technology to address a key economic, social or environmental problem, rather than to view the building of a data ecosystem as an end in itself. Smart Cities should exist only to provide more powerful solutions to societal problems. Accordingly, a clear rationale for developing a data infrastructure must be considered as an essential resource – indeed, a strong mission is considered by many as a type of critical infrastructure in itself (Robertson, 2017).

So why do cities engage with smart technology and pursue data-driven solutions? Some examples serve to reveal the principal mentalities at work.

**Motives for engaging Smart City technology and data-driven solutions: case examples**

**London's Roadmap – Smart London Together**

This initiative, launched by the Mayor of London in June 2018, is intended to be a **flexible digital masterplan** for the city (Government of London, 2018) with a strong focus on collaborating with companies, universities, London's boroughs, and other stakeholders. The roadmap consists of five missions, the second mission being to strike a new deal for city data. Mission Two recognises data to be an infrastructure as important as roads, railways and energy networks. This data mission includes **four main activities**, including: (a) to launch the London Office for Data Analytics (now superseded by the City Data Analytics Programme), (b) to develop a city-wide cyber security strategy, (c) to strengthen data rights, accountability and trust, and (d) to support an open ecosystem. The objective is to increase data sharing to make more data available, to guarantee security and resilience across the city, to raise awareness among the public about the benefits of data while emphasising data ethics, and to strengthen data governance and reinforce openness and transparency in government.

**Barcelona's Digital City Plan**

Barcelona developed its Digital City Plan in 2016. The plan serves as a **roadmap** for the activities and projects led by the municipality. The roadmap is divided into **three axes**: **government**, **companies and social organisations**, **and citizenship**. For the first group, the aim is to guide transformation and digital innovation in the public sector by improving public services, digital infrastructures, and the data infrastructure. For the second group, the goal is to promote and reinforce the innovative ecosystem that guarantees access to public procurement for SMEs. Finally, for the third group, the aim is to empower the citizenry by offering a wide digital skills programme, and facilitating a participative democracy and digital sovereignty (Ajuntament de Barcelona, Octubre, 2016).

**Data Excellence Strategy – City of Vienna**

In 2019, the city of Vienna approved its Data Strategy (Stadt Wien, 2019) which includes measures to guarantee that data is of high quality and is reliable. The strategy has a **roadmap** with timelines for all activities, and sets 2023 as the year when Vienna will become a 'Data Excellent' capital city. The strategy applies the *open by default* principle to public data, and implements several measures and strategies in three main areas: **data governance**, **data quality management**, and **enterprise data management**. In comparison to the other cities presented in this section, Vienna's strategy is unique in its special focus on data and how it establishes practical mechanisms and principles to achieve its goal. This strategy belongs to a group of guiding documents that the local government has developed to foster the Smart City agenda, such as the Open Government Model and Open Data Charter. The overarching **framework** of this strategy is the 'Smart City Wien Framework Strategy', drafted by the local government along with civil society, research institutions and the private sector, and later approved by the City Council. The strategy defines a main goal for 2050, which is to have '*the best quality of life for all inhabitants of Vienna, while minimizing the consumption of resources. This will be realized through comprehensive innovation,*' (Smart City Wien, 2019). The strategy defines three focus areas – Resources, Quality of Life, and Innovation – and commits the government, the private sector, research institutes, and civil society to working towards the goal.

**Graz's Digital Agenda**

In 2017, the Austrian municipality of Graz started the process of drafting a Digital Agenda for the city that could establish basic principles to address the challenges of the digital world. The government encouraged public discussion via a web-based platform, which allowed citizens and other local stakeholders to share their points of view. The Agenda comprises **12 guiding principles** that offer a strategic, ethical, formal and technical framework for existing and future digitalisation projects. The principles focus on promoting innovation, enhancing responsibility, guaranteeing transparency, encouraging open dialogue and discussions, increasing citizen and stakeholder participation, ensuring inclusion and security, updating regulation, modernising and increasing the efficiency of the local administration, boosting the digital infrastructure, supporting digital education, promoting job opportunities, and enhancing the local economy (Stadt Graz, 2018).

**Roadmap to a Digital City – New York City**

In 2011, New York City's local government developed a report which analysed the current situation of the city and proposed a **roadmap** to embrace its potential as an international leading digital city. The roadmap covers **four central points**: **industry** (supporting the digital sector), **engagement** (citizen-centric digital experience), **open government** (technology and culture), and **access** (internet connectivity for everyone). The plan aims to guarantee good access to internet, to release more Open Data, visualise it and develop apps, to increase the local government's interaction and communication with its citizens, and to enhance the digital sector by creating new opportunities and expanding and training the workforce (The City of New York, 2011).

**Dublin's Digital Masterplan**

In 2013, the city of Dublin developed a masterplan with three main components: **vision and guiding principles** explaining their activities, two **toolsets** to better plan and execute initiatives, and the specific **actions** or activities to be pursued. The Digital Maturity Scoreboard (one of the tools adopted) defines six layers of digital activity that the city must build in order to become a truly digital city. These are city governance, building ubiquitous city networks, leveraging urban data, fostering digital services capability, digital access and skills proficiency, and city impact realisation (Digital Dublin, 2013). In addition, the masterplan recognises the importance of collaborating with all local stakeholders to make Dublin a global digital city.

**Greater Manchester Digital Strategy**

In its digital strategy for 2018–2020, Greater Manchester agreed upon a **vision** and **action plan** for a pathway towards gaining worldwide recognition for developing digital technology, as well as enabling residents to have the highest quality of life and supporting the creation of high quality jobs with an increased productivity level. In the context of the strategy, Greater Manchester envisions becoming a recognised data and digital exchange hub. Digital data, along with automation, connectivity, and digital customer access, is considered an enabler for digital technologies which have the capacity to improve life quality and provide opportunities for the city region to grow (Greater Manchester Combined Authority, 2017).

**Munich's Digital Transformation**

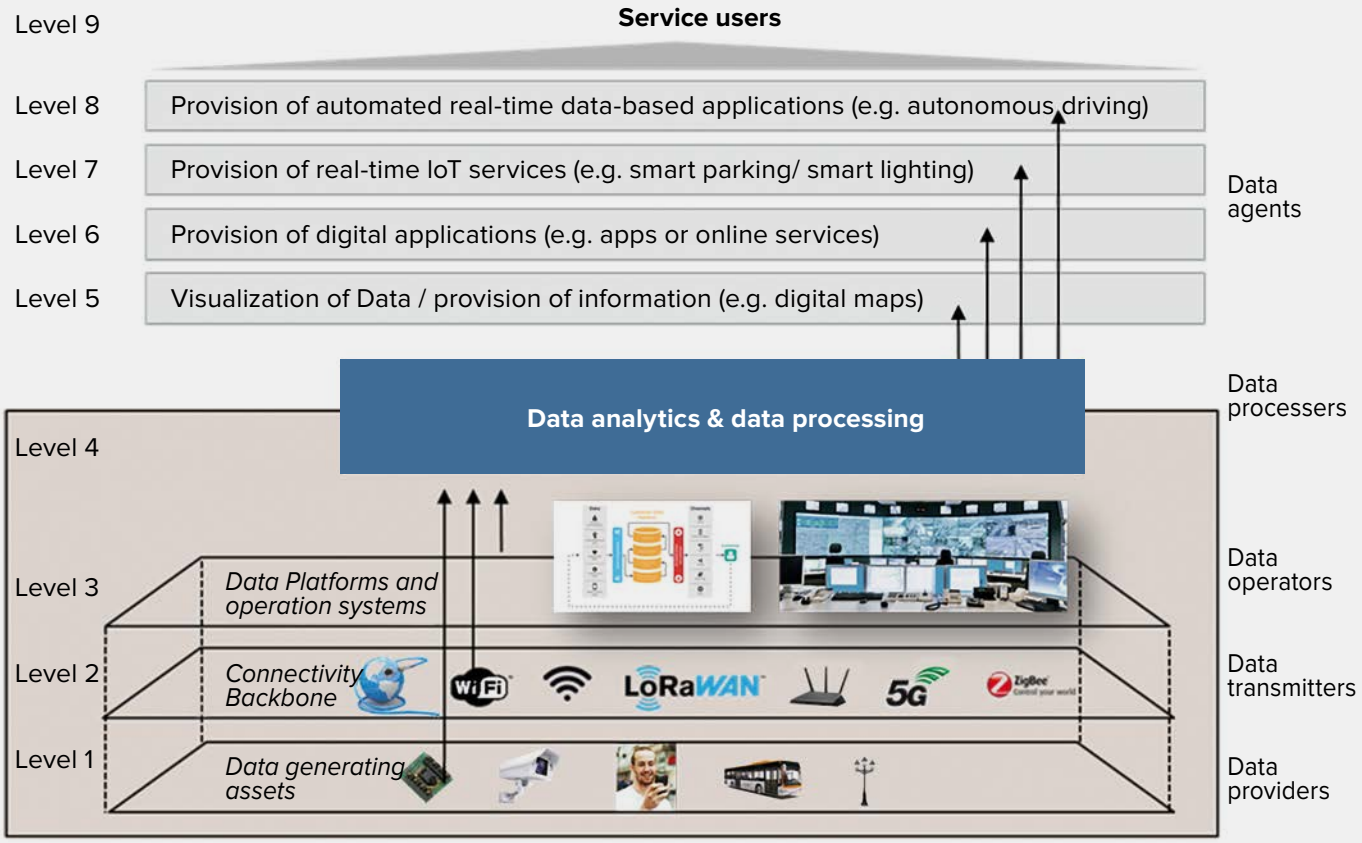
In 2018, the city of Munich updated the **guidelines** for its **digital transformation** and included six **new principles**. The document recognises the opportunities that digital technologies and data offer to local governments and their goals of improving public services and quality of life. The principles include the following topics: digital services of general interest, transparent and trustworthy handling of data, digitalisation for sustainable development, design innovation, digital administration and cultural change, and digital communication and participation. Here, data is again an element that will serve the successful digital transformation of Munich, but which needs to be managed and handled appropriately. Overall, digitalisation is seen as an opportunity to improve public services or to create new ones, and to expedite the sustainability agenda – understood as improved resource consumption and efficiency (Fraunhofer IAO, 2019).

In general, these Smart City strategies express a vision, establish priorities, and organise activities to achieve pre-set goals. A clear sense of mission is essential to orientate government activities and policies, as well as to align stakeholders' visions. Many strategies distinguish between the goals, activities and expected roles and responsibilities of government, companies, civil organisations and citizens. Strategies often temper naked economic growth imperatives and stress the importance of using digitalisation to increase quality of life, government transparency, business productivity, and job availability.

Ensuring local consensus from the outset is an essential task of strategic mission plans. How strategies and agendas have been produced varies, but in most cases they include efforts to integrate feedback and ideas from different stakeholders and citizens. Citizen buy-in (or not) follows from the visions of the type of Smart Cities municipal leaders want their metropolitan areas to become. For example, value-based Smart City strategies can help to determine whether more surveillance-based approaches are adopted or not. For instance, San Francisco recently banned the use of facial recognition technology (The New York Times, 2019), whereas in comparison, Chinese cities are expanding its use (Financial Times, 2019). Banning or allowing the use of certain technologies might exceed the scope of particular digital or data strategies; however, these strategies can nonetheless be used

**Figure 1**

## Stakeholder mapping




**Source:** Fraunhofer IAO, 2019

to provide additional guidance on ethics and principles that local governments need to consider, follow, or implement. Strategies which bear the stamp of local histories, politics, and cultures and which are subject to democratic oversight are most likely to be ones that endure and are impactful.

### KEY ISSUE 2 – STAKEHOLDER MAPPING

Municipal authorities cannot build effective Smart Cities by themselves. Smart City solutions draw upon data, technology and computing power from a wide variety of organisations and institutions. Solutions will only be impactful if all stakeholders are aligned and galvanised around a common sense of purpose. Mapping stakeholders and clarifying available competence sets, understanding interests and expectations, and auditing resources and assets therefore presents as a first core task.

Academic literature on Smart Cities has identified the following key stakeholders: academic and research institutions, local and regional administrations, financial suppliers and investors, energy suppliers, ICT sector representatives, citizens, governments, property developers, non-profit organisations, planners, policy makers, experts and scientists, political institutions, and the media (Jayasena, et al., 2019). But such classification is too primitive. It is essential that more sophisticated and nuanced understandings of stakeholders are secured. Advanced stakeholder mapping can be done in different ways[2], depending on purpose. Cities must research the variety of mapping techniques available and which most suit their needs. Figure 1 shows stakeholder mapping on nine different levels, corresponding to their functions within the digital urban economy. Such a value chain approach can prove useful for helping municipal leaders gain a better grasp of what is most applicable to particular stakeholders and over which issues. Stakeholders can belong to different categories at the same time. Of course, some companies try to cover the entire value chain. As such, it is imperative that stakeholder mapping is refined and targeted at the correct sub-units within institutions.

2 There are several methodologies to map stakeholders. One of these has been developed by URBACT (European Territorial Cooperation Programme aiming to foster sustainable integrated urban development in cities) and focuses on identifying a first group of core local actors, and through an iterative process engages with a more diverse group of stakeholders. The concept and its tools can be found at https://urbact.eu/urbact-local-groups.

- On **Level 1** we find organisations that produce raw data via sensors or other devices. These could be private companies, municipal service providers, or even individuals with their smartphones. Increasingly, raw data is already being processed within the sensor or the original device (Edge computing).
- **Level 2** belongs to those organisations that manage the transfer of data from the source to the process unit. Usually, these are telecommunication and network management organisations providing fibre optic or wireless communication and transmission facilities.
- **Level 3** is necessary to aggregate various data sources into larger data systems. Interoperable, partially open and increasingly standardised data platforms perform this task. Large IT service providers such as SAP, IBM and CISCO, along with municipal data centres and younger digital start-ups, can be found on this level.
- **Level 4** is multipurpose. Anyone who is granted access to data can analyse and process it and either offer aggregated information, processed data, or a digital service (on levels 5–8). A large number of private companies, municipal service providers and sections of city administrations can be found on level 4.
- **Levels 5 to 8** mark different states of complexity in providing services based on the aggregated and processed data. They range from mere visualisation of data on digital maps as a basis for informed decisions (level 5) to physical applications that act autonomously based on real-time information (level 8).
- **Level 9** contains the consumers of digital city services – these can be any of us (as users), or highly specialised target groups.

## KEY ISSUE 3 – DATA AUDITS

Data strategies need to convene a huge variety of data from a wide range of data owners, including public, private, and third sector actors. Undertaking an audit of what currently exists, in what form and according to what protocols, is an essential preparatory activity. From this, opportunities to pool datasets and gaps in existing provision can be identified. Given the vast repository of data which exists and the tendency for datasets to be siloed and sealed within institutional walls, data auditing can be exhausting, inefficient and unrewarding. Priorities for conducting a purposeful search must be set.

A common data audit strategy followed by local governments is to afford priority to datasets which relate to critical public policy challenges and lend themselves to deposition in Open Data portals. Open Data portals can be built to different scales. As of June 2019:

- **Berlin**[3] has 1,689 datasets
- **Greater London**[4] has 1,254 datasets
- **Vienna**[5] has 470 datasets
- **Barcelona**[6] has 425 datasets
- **Copenhagen**[7] has 270 datasets
- **Paris**[8] has 252 datasets
- **Eindhoven**[9] has 91 datasets.

In addition, there are aggregated Open Data portals such as GovData.DE[10], the Open Data portal of the Federal Ministry of the Interior of Germany which includes Open Data from different German states, such as North Rhine-Westphalia or Hamburg. GovData.DE has 23,198 datasets in total. Another prominent example is the UK Government's data.gov.uk[11], which provides information about 52,311 datasets across different domains.

Not all types of data are of equal importance. In 2013, the G8 discussed topics such as governmental transparency, innovation and accountability, and these discussions led to the creation of the G8 Open Data Charter. This charter offers visions and principles for creating a transparent, modern government, built on Open Data of a high and consistent standard of quality and quantity (G8, 2013). The G8 Open Data Charter summarises the most relevant and high-quality data domains which policy makers commonly require.

3 daten.berlin.de/
4 data.london.gov.uk/
5 www.data.gv.at/suche/?publisherFilter%5B0%5D=Stadt+Wien
6 opendata-ajuntament.barcelona.cat/en/
7 data.kk.dk/
8 opendata.paris.fr/explore/?sort=modified/
9 data.eindhoven.nl/pages/home/
10 www.govdata.de
11 data.gov.uk

**The G8 High Value categories of data**

| Data Category | Example Datasets |
|---|---|
| Companies | Company/business register |
| Crime and Justice | Crime statistics, safety |
| Earth Observation | Meteorological/weather, agriculture, forestry, fishing, and hunting |
| Education | Pupil data, free school meals, exclusions, home to school travel, achievement and attainments |
| Energy and Environment | Pollution levels, energy consumption |
| Finance and Contracts | Transaction spend, contracts let, call for tender, future tenders, local budget, national budget (planned and spent) |
| Geospatial | Topography, postcodes, national maps, local maps |
| Global Development | Aid, food security, extractives, land |
| Government Accountability and Democracy | Government contact points, election results, legislation and statutes, salaries (pay scales), hospitality/gifts |
| Health | Prescription data, performance data, mortality by age, gender and cause |
| Science and Research | Genome data, research and educational activity, experiment results |
| Social Mobility and Welfare | Housing, health insurance, unemployment benefits |
| Statistics | National statistics, census, infrastructure, wealth, skills |
| Transport and Infrastructure | Public transport timetables, access points, broadband penetration |

Meanwhile, according to a study from 2016 (Carrara, et al., 2016), the most popular data domains in Open Data portals in the cities analysed (Amsterdam, Copenhagen, London, Paris, and Vienna) were:

- **Transport**, e.g. public transport journeys by type, bike-sharing stations and usage, traffic flows, casualties, parking lots
- **Environment**, e.g. waste management contracts, air quality indicators, green infrastructure, recycling rates, electricity consumption, heat maps
- **Health**, e.g. birth and fertility rates, disease screenings, hospital admission rates, suicide and mortality rates
- **Administration**, e.g. procurement information, grants data, public accounts balance, public workforce, election results
- **Urban development and geospatial**, e.g. planning permissions, development database, cultural infrastructure, housing zones, brownfields register, green roofs, urban furniture, public toilets
- **Tourism and culture**, e.g. international visitors, number of clubs and restaurants, internet and computer use, museums, Christmas markets
- **Demographics**, e.g. unemployment rate, population trends, migration indicators, population by religion, ethnic groups.

When searching for existing datasets, municipal authorities might usefully give priority to those datasets best equipped to address particular economic, social and environmental challenges. But most Open Data portals have mainly static or historic data; only a few incorporate real-time data. Any data audit should attend to the challenges which confront a satisfactory trawl for local real-time datasets. The power of sensor technology to generate new types of real-time data is opening up a whole new category of data, and it is imperative that data strategies work with a wide definition of what constitutes data and audit and incorporate new genres and forms of big data. Any search for local data needs to be expansive and imaginative.

# Action Area 2

# GOVERNANCE, MANAGEMENT, ETHICS AND REGULATION

## KEY ISSUE 4 – GOVERNANCE AND MANAGEMENT

**Key questions for municipal authorities**

Municipalities are not only experimenting with data governance arrangements, but also starting discussions and cooperating with other cities to share knowledge and experiences as well as to build partnerships. Among the Smart City projects funded and promoted by the European Union is SmartImpact[12], which is focused on developing new ways of managing the complex Smart City ecosystem, including people, processes, politics, and stakeholders. According to this project, a municipal data governance structure needs to provide answers to the following questions (von Radecki, et al., 2018):

- What **strategies** and approaches do cities need to follow to enable third parties to share their data with the city, in terms of regulations and incentives?
- How can a city **remain the decision maker** on data usage in public–private partnerships or in data-driven projects that impact the common good?
- What are the **lines of decision making** and how can cities create transparent systems that show the existing trade-offs between public and private interests?
- What **resources and skills** are needed in a municipality to moderate data-related decision making?
- How can cities successfully initiate and **steer pilot projects** on urban data?
- How do cities ensure **ownership of the data** in public contracts?
- What data should be provided as **Open Data** by the municipality and how can cities decide this?
- How can cities embed their **policy requirements in urban data platforms**?

**Roles and responsibilities**

Managing ever larger quantities of data and organising stakeholders in city regions to extract maximum value from data requires public institutions to countenance organisational change. As new objectives are set and tasks and projects are developed, new job roles will need to be created and new duties and responsibilities assigned. Organising data processes, assigning ownership, selecting and managing software, and defining responsibilities is traditionally known in the business literature as data governance[13]. The goal is 'to guarantee generally understandable, correct, complete, trustworthy, secure and discoverable data,' (Business Application Research Center, 2017). Normally, data governance comprises the following topics: data architecture, data modelling and design, data storage and operations, data security, data integration and interoperability, documents and content, reference and master data, data warehousing and business intelligence, metadata, and data quality (The Data Management Association, 2014).

The hierarchical distribution of emerging data governance and management roles can usefully be conceived through a three-level model (see Figure 2):

a) The operational level (*data management*), where data is used and maintained
b) The enforcement level (*data governance*), where standards and other policies are implemented and data quality is monitored
c) The strategical level (*decision making level*), where policies, responsibilities, rules, and guidelines are defined (Brown University, 2019).

In practice, IT departments in local governments are responsible for managing data, in addition to their conventional responsibilities for managing hardware and software for the rest of the departments and units.

Furthermore, in recent years a growing number of institutions are appointing Chief Data Officers or Chief Digital Officers (CDOs) (Smart Cities Dive, 2018), who have a cross-silo perspective and are in charge of leading local digital transformations. CDOs play an important role in steering and managing changes across their organisation, embedding the use of data, and making processes more efficient, whilst also promoting the development of new digital services for citizens. Among the first steps a Data Officer can take are the following (KPMG, 2017):

1. Create, validate and communicate a data ecosystem vision
2. Form a working group to develop a data and analytics strategy
3. Construct an initial inventory of data assets
4. Gather and evaluate existing data and analytics initiatives
5. Prioritise opportunities to exploit data and analytics assets.

When attempting to increase data sharing between public bodies, departments and organisations, several obstacles present, such as strict legal limits to data exchange between departments, no central data access, no overview of existing data, uncoordinated collection of data, problems with data accuracy and timeliness, different data formats, and different standards (Sautter, et al., 2018). Consequently, it is important that there is a team in municipal authorities capable of troubleshooting issues arising from organisational culture, people's skills and capabilities, data quality, technology, funding, and legal obligations.

**IT departments**

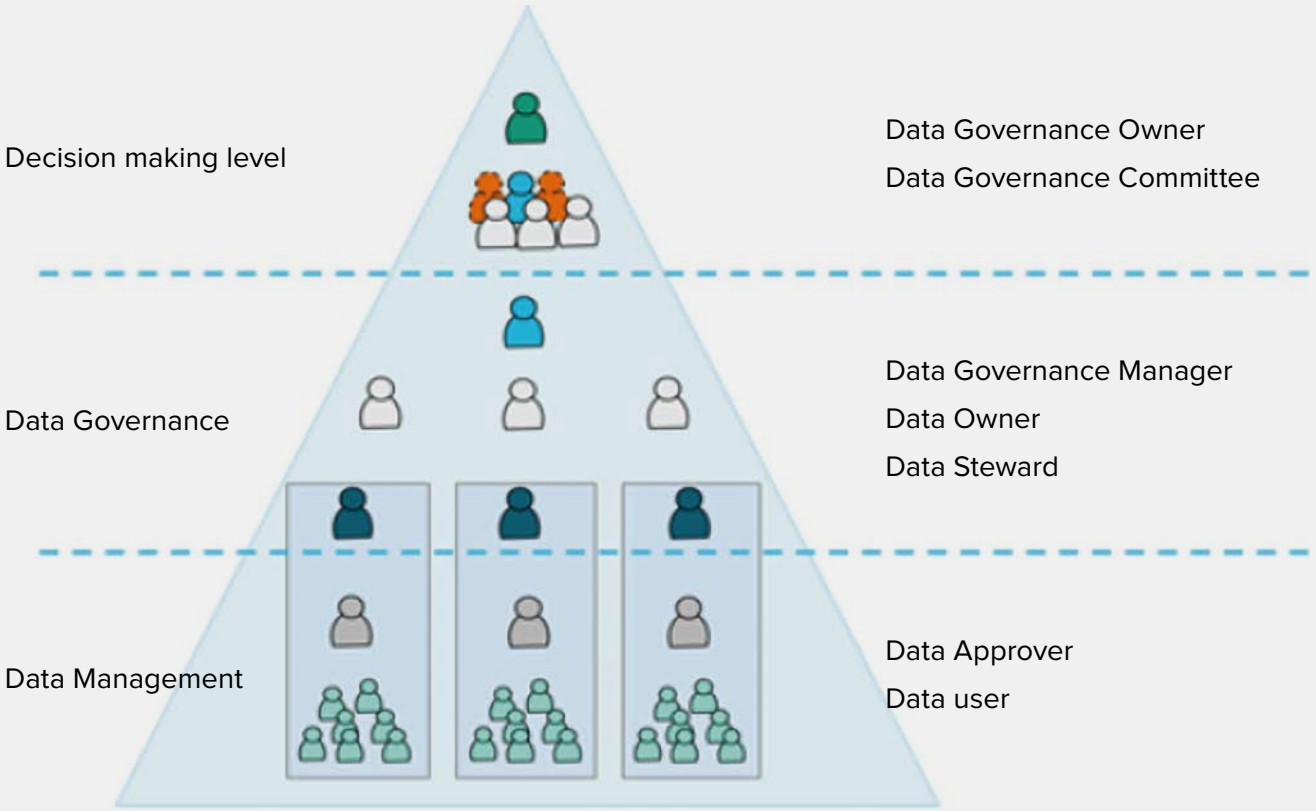
IT departments within public, private and third sector organisations play a crucial role in the operationalisation of data sharing strategies. Based on lessons learned in several different European

12 A partnership of 10 cities sharing experiences of the structures and processes needed to successfully plan, finance, develop and manage a Smart City.

13 The term data governance originates in the business literature as a way to define the organisational aspects of dealing with data inside an organisation. However, and especially with the surge of Smart Cities, it has progressively extended its domain to aspects outside the internal organisation, e.g. regulating data relations with external stakeholders.

**Figure 2**

## Data governance and management roles




**Source:** Fraunhofer IAO, 2019

and national projects, it is clear that an open and agile mindset is a prerequisite for success. In this context, 'agile' refers to the ability to create and respond to *change*. It is a way of dealing with, and ultimately succeeding in, an uncertain and turbulent environment (Agile Alliance, 2019). Teams which embrace multi-disciplinary, inter-sectoral and cross-functional skillsets and where members have autonomy and flexible role descriptions are most likely to succeed.

In 2001, a team of 17 members developed an *Agile Manifesto* that is still valid and widely used today (Agile Alliance, 2019). Twelve guiding principles were developed; collectively, they place high value on interpersonal interactions and social competencies, because it is the interaction between people (with the help of processes and plans) that is of utmost importance for successful product delivery.

**Twelve guiding principles developed by the Agile Alliance in their Agile Manifesto**

**Principle 1** The highest priority is to satisfy the customer through early and continuous delivery of valuable software

**Principle 2** Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage

**Principle 3** Deliver working software frequently, from a couple of weeks to a couple of months, with a preference for the shorter timescale

**Principle 4** Business people and developers must work together daily throughout the project

**Principle 5** Build projects around motivated individuals. Give them the environment and support they need and trust them to get the job done

**Principle 6** The most efficient and effective method of conveying information to and within a development team is face-to-face conversation

**Principle 7** Working software is the primary measure of progress

**Principle 8** Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely

**Principle 9** Continuous attention to technical excellence and good design enhances agility

**Principle 10** Simplicity – the art of maximising the amount of work not done – is essential

**Principle 11** The best architectures, requirements, and designs emerge from self-organising teams

**Principle 12** At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behaviour accordingly.

**Office of Data Analytics**

A model adopted by several cities and city regions in the UK is the Office of Data Analytics. This institutional innovation is defined as a vehicle for multiple organisations to collaborate, analyse and act upon data sources from multiple public sector bodies to improve services and make better decisions (Eaton & Bertoncin, 2018).

**Examples of Data Analytics Offices**

***The Office for Data Analytics, Avon and Somerset***

The Office for Data Analytics in Avon and Somerset Constabulary is a virtual data hub supported by key staff, with the goal of identifying and protecting vulnerable people at the earliest opportunity. The hub facilitates inter-institutional collaboration and integrates data from national resources, the police, ambulance, and fire and rescue services, public health bodies, local authorities, and third sector partners. This office is developing blueprints for data sharing protocols, data transfers, predictive modelling, visualisation, self-service analytical products, and early intervention approaches (Eaton & Bertoncin, 2018).

***City Data Analytics Programme, London Office of Technology and Innovation (LOTI)***

Focused on the public sector, LOTI aims to provide support with project management, legal issues, technical aspects, and data science, along with providing partnerships within the Greater London Authority (GLA) organisations. In addition, the hub supports local councils' analytical capacity and technical development through a City Data Academy (Eaton & Bertoncin, 2018). LOTI recognises the fragmentation across the London boroughs and the difference in capabilities and digital maturity of each of them, and aims to overcome those challenges by offering digital leadership, promoting collective knowledge, fostering partnerships, and managing data collaboration (Smart London, 2019).

**Thinking strategically and long-term**

Smart Cities are of necessity long-term projects, and commitment beyond political cycles is essential. New York City's Office of Long-Term Planning and Sustainability (OLTPS) is a good example of how a local administration might think and plan long-term. The OLTPS was responsible for conceptualising New York City's 2030 plan, defining indicators for achieving objectives, evaluating the progress of the 25 city agencies in pursuing the plan's targets, and steering local agencies' activities by realigning indicators and strategic measures (Morgenstadt, City of the Future, 2013).

## KEY ISSUE 5 – GOVERNING FOR PUBLIC GOOD: BUILDING SMART CITIES WITH AND FOR CITIZENS

Architects of Smart Cities need to attend from the start to the establishment of governance mechanisms which help to build public trust in data sharing infrastructures. A set of key questions need to be addressed, including:

- Why city leaders need to take public concerns over surveillance capitalism seriously
- What 'data sovereignty' means and why it matters
- How city leaders might build Smart Cities with and for local citizens
- The meaning and implications of principles such as 'tech for good' and 'tech for public good' for Smart City strategies.

A range of institutional experiments are being undertaken to ensure that data ecosystems are citizen-centred, subject to democratic oversight, and exist to serve the public good.

**The Open Data Principle and the Smart Society Charter**

The city of Eindhoven (Netherlands) has started to develop a framework for data sharing. Currently, the city relies on two policies: the Open Data Principle, and the Smart Society Charter. The former asserts that data collected from and in public spaces belongs to the public and should be made public, while observing privacy and security norms. The principles were passed in a Bill by the City Council, thereby becoming a binding regulation. The Smart Society Charter was developed by diverse stakeholders from Eindhoven (including companies, universities, and civil servants) and includes seven principles:

i. The privacy of data users and citizens should be guaranteed
ii. Innovation will be facilitated by making data publicly available and enabling access to IoT and data systems through Open Interfaces
iii. The IoT infrastructure, connectivity, platforms, devices, and services should be built on open or broadly agreed de facto standards
iv. IoT and data developments are expected to provide well-defined, easily accessible, stable interfaces for sharing and reusing existing assets
v. It is recommended to adopt a modular architecture with well-defined Open Interfaces as the core of any IoT or data-driven development
vi. The reliability of components, platforms, solutions, and services must be constantly safeguarded
vii. Providing new technologies and services and collecting and combining data may result in unforeseen effects on society or individuals; therefore, experimentation is encouraged but responsibility should be taken for the consequences.

**Data sovereignty and digital rights**

After a first phase of piloting Smart City technologies, local governments are paying more attention to the role of citizens and their right to access and manage their data. An example of these initiatives is the 'Citizen Data Principles' (EUROCITIES, 2019), which were co-created by Barcelona, Edinburgh, Eindhoven, Ghent and Zaragoza, and further developed by the EUROCITIES Knowledge Society Forum. These principles aim to provide guidance to the local government on how to use data-generated knowledge to improve urban life while preserving European values. The principles recognise and emphasise that:

- Citizen data is a public and individual asset that shall be solely used in the public interest
- Citizen data generates tangible benefits for citizens and society to improve our cities
- Citizens must have access to, and be able to manage, their data
- Personal data must be subject to relevant EU and national legislation
- Transparency and accountability must apply when generating data in the public space
- Safeguards must try to avoid the risk of individuals or profiles being identified
- The integrity, authenticity, consistency and accuracy of data must be preserved
- Open working methods should facilitate data sharing and re-use
- Citizens must be regularly engaged to discuss and agree on any ethical consequences of data collection
- Local governments have a strong role to play as connectors within their local innovation ecosystem and should be given the means to do so.

**Algorithms and Artificial Intelligence**

Another crucial topic which local governments are starting to address is how to guarantee transparency and fairness in the algorithms embedded in tools that inform or make decisions. Many tools are being adopted by public organisations which use algorithms or Artificial Intelligence (AI) to process data and inform decisions. However, in most cases, it is not clear how these calculations are undertaken and what kind of data is used. Some organisations and data scientists are criticising this lack of transparency. In order to be able to assess the use of algorithms and AI, as well as to open AI to public scrutiny, it is important that public servants as well as citizens have a basic understanding of this technology and the impacts it can generate. Furthermore, principles and rules need to be included in procurement processes to guarantee that any tools acquired comply with ethical standards supported by the city.

To this end, the New York City Council passed a Bill in 2017 to form an Algorithm Task Force, which is in charge of evaluating the algorithms being used by the government and making recommendations (The New York City Council, 2017). Meanwhile, GovEx, the city and county of San Francisco, Harvard Data-Smart, and Data Community DC have established an *Ethics and Algorithms Toolkit*, a risk management framework for government (Ethics Toolkit, n.d.). This toolkit guides the assessment of the algorithms which are already in use and those which are scheduled for future application, and suggests measures to manage threats and vulnerabilities. Meanwhile, Nesta has set out 10 questions which public bodies need to ask prior to using AI for making or augmenting decisions. The Nesta approach is framed in terms of questions rather than principles, because it assumes that general guiding principles might not be sufficient to make decisions over the use of AI in specific contexts (Copeland, 2019). The 10 questions are:

- **Objective**: why is AI needed and what outcome is it intended to enable?
- **Use**: in what processes and circumstances is AI appropriate to be used?
- **Impacts**: what impacts – good and bad – could the use of the AI have on people?
- **Assumptions**: what assumptions are AI solutions based on, and what are their limitations and potential biases?
- **Data**: what datasets are/were the AI trained on and calibrated by, and what are their limitations and potential biases?
- **Inputs**: what new data does AI use when making decisions?
- **Mitigation**: what actions have been taken to mitigate the negative impacts that could result from AI's limitations and potential biases?

- **Ethics**: what assessment has been made of the ethics of using AI?
- **Oversight**: what human judgement is needed before acting on AI's inputs and who is responsible for ensuring its proper use?
- **Evaluation**: how, and by what criteria, will the effectiveness of AI be assessed and by whom?

**Guiding the use of AI for public good: some examples from the United Kingdom**

***Office for Artificial Intelligence – a central government initiative***

This Office is responsible for overseeing the implementation of the AI and Data Grand Challenge (a key pillar of the UK Industrial Strategy). Its mission is to drive responsible and innovative uptake of AI technologies for the benefit of everyone in the UK, considering ethical implications, adoption across sectors, and general requirements (skills, investment, leadership, data). The Office for AI does this by engaging organisations, fostering growth, and delivering recommendations around data, skills, and public and private sector adoption (Government of the United Kingdom, 2019).

***The independent Ada Lovelace Institute***

The Ada Lovelace Institute represents a partnership between the Alan Turing Institute, the Royal Society, the British Academy, the Royal Statistical Society, the Wellcome Trust, Luminate, TechUK, and the Nuffield Council on Bioethics (ComputerWeekly, 2018). Independent of government, the Institute promotes informed public understanding of the impact of AI and data-driven technologies on different groups of people, guides ethical practice in the development and deployment of these technologies, and undertakes research and long-term thinking to lay the foundations for a data-driven society with wellbeing at its core (Ada Lovelace Institute, 2018).

**Data exchange with third parties**

Considering that data is held by different actors across the urban ecosystem, it is important to set in place certain mechanisms to help public administrations access those datasets with the purpose of using them to improve citizens' wellbeing. The principles mentioned before certainly serve to organise and guide activities, but more specific policies and models are required to underpin sustainable data exchange. Some examples of policies and strategies that help cities access third party data include buying or trading data, incentivising voluntary data sharing, e.g. through tax incentives, including data sharing clauses in public contracts and procurement, and creating data partnership agreements (Bradley & Tommis, 2017).

The city of Milan has assumed the role of a trusted broker of data from various sources within the city. Through its successful **Milan B2G data exchange policy**, the municipal authority has procured data from large corporations such as Airbnb, Uber, and Mastercard in exchange for data analytic support and insights. The sum has proven to be greater than the individual parts; by aggregating data from numerous sources, Milan is now able to provide valuable insights into consumer behaviour (e.g. tourist spending patterns), which in turn help donating companies to improve their own business. Meanwhile, the city has ensured that it is able to use the data provided to optimise its own services.

**Data Trusts**

According to the Open Data Institute, a data trust is 'a legal structure that provides independent stewardship of data,' (Open Data Institute, 2019). This stewardship determines who has access, under what conditions, and to whose benefit (Open Data Institute, 2019). But what distinguishes a data trust from other kinds of stewardship is its independent nature, which means that the organisation creating or collecting the data is not necessarily the steward, and that the steward itself could comprise of a group of organisations which are independent from data holders or users. Some of the potential benefits this approach might yield include helping to balance conflicting views and incentives about data sharing and access (as an independent institution), ensuring that decisions about data use are more transparent and participatory, and creating new opportunities to innovate with data (Open Data Institute, 2019).

**Example of a Data Trust in action: the Data Trust Pilot in the Greater London Authority and the Royal Borough of Greenwich**

With the aim of testing the concept of the Data Trust in a real-life setting, the Open Data Institute partnered with the Greater London Authority (GLA) and the Royal Borough of Greenwich (RBG) to develop a pilot project. This pilot examined the feasibility of creating a data trust in the context of the Sharing Cities Programme, enacted to help local authorities and industry collaborate to unlock the economic potential of data (Open Data Institute, 2019). In practice, the pilot explored the potential of a data trust in the context of a specific project, assessed technical aspects and created tools for this trust, evaluated decision making processes, and examined legal considerations. In the pilot's summary report, eight recommendations guiding future work around data trusts are discussed (Open Data Institute, 2019):

- Exhaust the options of other data-sharing arrangements
- Define a clear purpose
- Make sure the incentives to share data are understood
- Start small and prove the need
- Especially where personal data is involved, understand how citizens will need to be engaged from the beginning
- Technological solutions must be accompanied by organisational capacity
- Recognise that resources (including financial resources) and effort will be needed
- Recognise that new organisations impose overheads on existing ones.

## KEY ISSUE 6 – GOVERNING DATA ETHICALLY

The increasing technicity of cities as well as the interconnection of different data sources raises profound ethical issues, including but not limited to privacy, system opacity, and control of data. Despite these risks, many people do not fully grasp their consequences. Different initiatives – at cross-city level as well as urban programme level – have been introduced to tackle these challenges. Some of these initiatives include:

- **Cities Coalition for Digital Rights**: This is a joint initiative launched by Amsterdam, Barcelona, and New York City to protect, promote and monitor residents' and visitors' digital rights. They have signed a declaration which states five main principles to protect people's digital rights.
- **Barcelona Digital City**: The core principle underpinning all the city's digital policies is that technology should be placed at the service of the people. Ethical and responsible management through technology and data use will enable the city to reach a social compact with its stakeholder communities and citizens, a stable arrangement which constitutes nothing less than a critical data infrastructure.
- **Detroit Digital Justice Coalition**: This coalition of people and organisations believes that communication is a fundamental human right, and thus it mandates that all digital initiatives be grounded in the digital justice principles of access, participation, common ownership, and healthy communities.
- **Seattle Community Technology Advisory Board**: This Board is comprised of 10 members – six appointed by the Mayor, and four appointed by the Council. Among their responsibilities are making recommendations to the City Council on issues of community-wide interest relating to ICT, researching issues and collecting public input, promoting affordable access to and use of ICT, and advising on effective electronic civic engagement and e-government services.
- **Centre for Data Ethics and Innovation**: This Centre is an independent advisory body set up and tasked by the UK Government to investigate and advise on how to maximise the benefits of data-driven technologies. This year they are focused on targeting policy review, algorithmic bias review, the AI Barometer, and a responsive thematic project.
- **Smart Dubai AI Ethics Advisory Board**: This government body is comprised of representatives from leading government departments and private sector entities. It has been formed to shape the development and deployment of human-centred ethical AI to encourage fairness, transparency and accountability in AI systems in Dubai.

# Action Area 3

# TECHNICAL INFRASTRUCTURES AND CHALLENGES

## KEY ISSUE 7 – BUILDING OPEN DATA ECOSYSTEMS AND FOSTERING INTEROPERABILITY

At root, the principal objective of any data strategy is to increase access to data so as to unlock its potential in helping to tackle critical social, economic and environmental challenges whilst maintaining ethical standards, public trust and confidence, and democratic legitimacy. Here, 'opening data' and 'Open Data' are paramount aspirations; from this point, data sharing becomes easier. But in turn, these aspirations require attention to the central issue of 'interoperability', defined by European data standardisation projects as the 'ability of a system to exchange data with other systems of a different type and/or from other manufacturers,' (DIN CEN/CLC/ETSI/TR 50572 VDE 0418-0:2014-10, n.d.). To enhance interoperability it is necessary for municipal authorities to ensure the existence of:

(1) **An ICT Reference Architecture**
(2) **Open Systems**
(3) **Open Data standards**
(4) **Support to help organisations publish Open Data**.

Cities who toil with vendor lock-in and unclear integration processes and collaboration procedures will find it most difficult to open up their datasets. The avoidance of vendor lock-in is particularly important to prevent dependence on a sole data provider or vendor, and to enable various stakeholders (public bodies, local SMEs, Open Source initiatives, industry, and academia) to collaborate in the construction of a central data pool for shaping an urban data ecosystem that is available to and serves everyone.

**ICT Reference Architectures**
ICT reference architectures provide a basic template through which cities can begin to bring different datasets into a meaningful conversation. The main goals of urban ICT reference architectures are to:

- Provide a unified view and understanding on the ICT strategies of a city
- Identify interfaces for communication between the ICT components for building an integrative Smart City environment
- Enable the accommodation of existing systems into the ICT reference architecture
- Enable the exchange and interoperability of various components and/or software packages along the identified and standardised interfaces
- Define the ICT reference architecture and interfaces in a way that Open Source as well as components from different manufacturers can be used, to enable cities and communities to be independent from particular vendors
- Put Open Data at the heart of the ICT reference architecture as a concept for sharing data and information
- Follow the example of the extremely successful Internet/Telekom Reference Models – TCP/IP and ISO/OSI layered models
- Enable the re-use of Smart City components and/or solutions across different municipalities within the region.

The European Innovation Partnership on Smart Cities and Communities (EIP SCC) organised a work stream that defined such an ICT reference architecture based on the collaboration between researchers and IT architects from several European countries and a variety of stakeholders, such as industry, academia, SMEs, research institutes, and standardisation bodies (EIP SCC, 2019). Furthermore, the resulting document was adapted to the needs of the German market within a DIN[14] specification working group, denoted as *DIN SPEC 91357 Reference Architecture Model Open Urban Platform (OUP)* (DIN SPEC 91357, 2017). The resulting high-level reference architecture consists of a layered structuring of the ICT landscape in a city – starting from the field equipment layer, and continuing over the connectivity aspects up to the layer of data management and analytics, where data is evaluated and offered for applications and services of relevance for the citizens of an urban environment. Various aspects of the urban applications and services are presented in the higher layers in Figure 3, including facets such as *Stakeholder Engagement*, *Generic City/Community Capabilities*, and *Community Specific Capabilities*. In parallel, the vital topics of privacy, security and generic service capabilities in the form of infrastructure management span over the various layers of the template ICT reference model. It is important to note that the cited documents contain much more additional information regarding the properties of the different layers, the appropriate design principles, and the requirements which are correspondingly imposed on the ICT solutions and components in question.

As previously mentioned, the structuring of urban ICT according to the reference architecture of DIN OUP and EIP SCC would foster interoperability and a sustainable urban ecosystem as a whole, assuring that the basic principle of openness is followed. Hence, we focus in the following subsections on the increasing need to deploy Open Systems and design integrative urban solutions based on the key components of openness as presented in the following.

**Open Systems**
A concrete definition of an **Open System** is given by the Oxford Dictionary of Computer Science as '*any system in which the components conform to non-proprietary standards rather than to the standards of a specific supplier of hardware or software,*' (Oxford Dictionary of Computer Science, n.d.). Thereby, the concept of Open Interfaces plays a key role as an enabler for non-proprietary standards for communication protocols and data exchange formats.

14 DIN stands for Deutsches Institut für Normung e.V. (in English, German Institute for Standardisation).

**Figure 3**

## The Open Urban Platform as Reference Architecture defined within DIN OUP and EIP SCC


**Open Interfaces** are system formats which enable vendors and service providers to easily connect their datasets with the wider ecosystem and are essential enablers of effective data sharing.

**Open Data** is another vital pillar of openness and Open Systems within Smart Cities. DIN SPEC 91357 defines Open Data as '*datasets provided by public authorities and public enterprises to the general public*'. There are far more elaborate definitions of Open Data which touch on aspects such as timeliness, licences, machine readability and more; however, we hold that the above definition offers a sufficiently wide understanding of Open Data, which can be easily applied within an ICT reference architecture.

In addition, an urban environment might also utilise **Open Source** components. According to the Open Source Initiative (Open Source Initiative, 2007), Open Source software complies (with its basic code structure) with the following requirements: (1) free redistribution, (2) free source code, (3) free for modifications and derived works, (4) integrity of the author's source code, (5) no discrimination against persons or groups, (6) no discrimination against fields of endeavour, (7) unlimited distribution of licence (8) licence must not be specific to a product, (9) licence must not restrict other software, and (10) licence must be technology-neutral. Cities and communities should promote – where appropriate – the utilisation of Open Source software based on Open Interfaces and ideally Open Data in order to create a viable and interoperable ICT ecosystem involving various players and stakeholders such as SMEs, industry, academia, and so on.

Finally, it is important to refer to the concept of **Open Urban Platforms** (OUP), which constitute the cornerstone for enabling interoperability within urban ICT and avoiding vendor lock-in. According to DIN SPEC 91357, an OUP is a '*platform that uses Open Standards and interfaces to guarantee compatibility and interoperability with other systems and other urban platforms*'. Hence, such an Open Urban Platform can serve as reference architecture and as the 'natural environment' for fostering interoperability.

**Open Standards** constitute the last element of paramount importance because of their role within Open Urban Data Platforms as enablers of interoperability and vendor lock-in avoidance. In general, Open Standards for protocols, data formats and data models are understood as standards expressed clearly within publicly available documents, enabling multivendor interoperability. Open Standards must be formulated to properly engage a wide range of vendors, suppliers and service providers within an urban ecosystem. In many cities, Chief Digital Officers and their teams assume responsibility for testing interoperability between various datasets and technologies. Clear Open Standards enable a variety of data vendors to collect, collate and provide data which can be easily plugged into an open portal.

**Open Data platforms/portals: architectures, solutions and components**

A major source of data in European cities and municipalities is the large number of established and operating Open Data portals, which offer a range of administrative data openly and freely according to the rules of the Public Service Information Directive (PSI Directive 2003/98/EC). Open Data platforms for the public sector have been proposed by programmes such as H2020 Triangulum (Triangulum Project, 2019), Open Cities (Open Cities, n.d.), Theseus (Wolfgang, et al., 2014), Trusted Cloud (Trusted Cloud, 2019), H2020 Espresso (Espresso Project, 2017), Smart Data (Smart Data Forum, 2019), and Smart Services (Smart Services, 2019). In the context of digitised public infrastructures, the Open Urban Data Platforms (DIN SPEC 91357, 2017) – mostly based on DIN SPEC 91357 and the EIP SCC reference architecture model – are increasingly being adopted and promoted. Numerous platforms have been established at national and European level which aggregate the data of individual municipalities, cities and states and present them in a summarised form. CKAN (CKAN, n.d.), Socrata (Socrata, 2019) and OpenDataSoft (OpenDataSoft, 2019) are prominent technologies in the field of Open Data. The associated metadata is captured and managed using standards such as DCAT (DCAT, 2019) and DCAT-AP (DCAT-AP, 2019).

In addition, the International Data Space (International Data Spaces, n.d.) warrants consideration. It was created with the aim of enabling data exchange within the framework of industry and commerce. The concept of the Urban Data Space (Schieferdecker, et al., 2018) (Cuno, et al., 2019) was developed in a German BMBF-funded study and forms the basis for the efficient, legal, and rule-compliant exchange of various data types in the municipal and public context. On the basis of the International Data Space and its associated connector components, data is obtained and exchanged for analysis within the framework of the Smart City.

Open Data platforms must also offer a number of interfaces through which public and private services can easily access and utilise data. In fact, service-orientated architectures (SOA) and microservices[15] offer advanced and powerful data sharing capacities to small and loosely coupled services. Different communication and transport protocols as well as standards are used – prominent examples are given by SOAP, REST/http(S), and WS* (Web Services Activity, n.d.). In the microservices context, the use of container technologies (Techradar, 2018) such as Docker (Boettiger, 2015) and Kubernetes (Bernstein, 2014) has also proven to be advantageous for developing dynamic, highly scalable, high-performance service architectures based on larger amounts of data. In addition, standards such as BPEL (Business Process Execution Language) (BPEL, 2019) and Business Process Model and Notation (BPMN, 2019) are established and further developed, with the purpose of modelling and controlling business processes on the basis of the available service architectures. Moreover, the scalable use of cloud infrastructures as a means for cost–benefit optimisation relating to the utilisation of data-based infrastructures has also gained attention in recent years. Various commercial providers such as Amazon (Amazon AWS, 2019) and Google (Google Compute, 2019) have suitable products on the market, which are also supplemented by the existence and broad usage of Open Source solutions such as OpenStack (OpenStack, n.d.) and Apache CloudStack (Apache CloudStack, 2019).

The above aspects enable scalable provisioning from individual software solutions to complex platforms and Smart City services. Furthermore, event processing systems such as Kafka (Apache Kafka, n.d.) and Flink (Apache Flink, n.d.) are state-of-the-art in the field of data platforms, and offer the capability to process data streams efficiently. The storage and administration of the resulting data can be achieved by using different database technologies, such as SQL databases, e.g. PostgreSQL (PostgreSQL, n.d.) and Maria DB (Maria DB, n.d.), NoSQL databases, e.g. MongoDB (MongoDB, n.d.) (Han, et al., 2011), and Cassandra (Apache Cassandra, n.d.).

The tools offered by Apache Hadoop (Apache Hadoop, n.d.) are particularly suitable for the distributed processing and efficient storage of large amounts of data (big data) in the form of data blocks. The processing is based on the MapReduce programming model (Dean & Ghemawat, 2008), which was developed especially for distributed datasets. Furthermore, it is possible to easily integrate the standard CKAN software for (Open) Data Catalogues with Hadoop (Scholz, et al., 2017) and achieve effective embedding of the Hadoop Big Data framework within an urban environment.

Open Data platforms utilise software systems which are based on Open Standards, such as published and fully documented external application programming interfaces (APIs) which allow use of the software in ways other than originally intended by the programmer, without requiring modification of the source code. API software provides another system or user with direct access to data, and the majority of Open Data portals provide an API that facilitates the easy retrieval of information and data by a variety of users. The API may also enable access to data catalogues and other functionalities, further expanding its practical value. Most modern Open Data portals such as CKAN, DKAN and OpenDataSoft provide APIs out-of-the-box, and APIs should always be available to end users and other systems when feasible.

In recent years, the trend towards decentralised processing of data volumes has been increasingly observed away from the cloud, which is reached OTT (over-the-top) via the transport network (e.g. the internet or telecom network), in favour of distributed processing directly at or close to the data sources (in the technical network sense). These approaches are called Edge and Fog computing, the precise definition of which varies widely in the literature but generally refers to the processing of massive data in the network vicinity of the data sources, e.g. at the access router or directly in the 5G access network.

With regard to the distributed storage and processing of data on the internet, the development and deployment of peer-to-peer (P2P) technologies (Kamvar, et al., 2003) has been a major topic in recent years. These technologies scale with the number of participants in the P2P overlay and enable efficient decentralised

15 Information on microservices: https://microservices.io/

data exchange. Developments in the blockchain (Swan, 2015) domain have come to play a significant role, by far exceeding the use of popular cryptocurrencies such as Bitcoin (Bitcoin, n.d.) and Ethereum (Ethereum, n.d.). The blockchain concept enables the decentralised, verified, authorised and unchangeable storage of transactions and associated data. Based on these properties, the general requirement for a central trust-building instance in communication and service architectures can be circumvented, and data can be securely and trustworthily stored and retrieved.

**Helping organisations publish Open Data**

The European Commission has published an extensive Goldbook for Publishing Open Data, which is of significant value to municipal authorities when helping organisations, businesses and institutions to share data (European Data Portal, 2018). The Goldbook targets organisations that want to publish Open Data; however, the provided insights are not limited to Open Data and can be applied to other types of data as well. It identifies three stages that an institution should pass through in order to share data appropriately: (1) creation of a data strategy, (2) technical preparation and implementation, and (3) monitoring.

Opportunistic data sharing is rarely beneficial. In order to share data appropriately, organisations need to reflect upon the strategic value of sharing data and opening access to data. Ideally they should have a clear data strategy to guide their choices, which includes formulating answers to questions such as 'What kind of data do we have?' and 'What kind of data do we want to share, and with whom?'. The Goldbook further proposes nine key topics that every organisation crafting a data strategy should cover (see Figure 4).

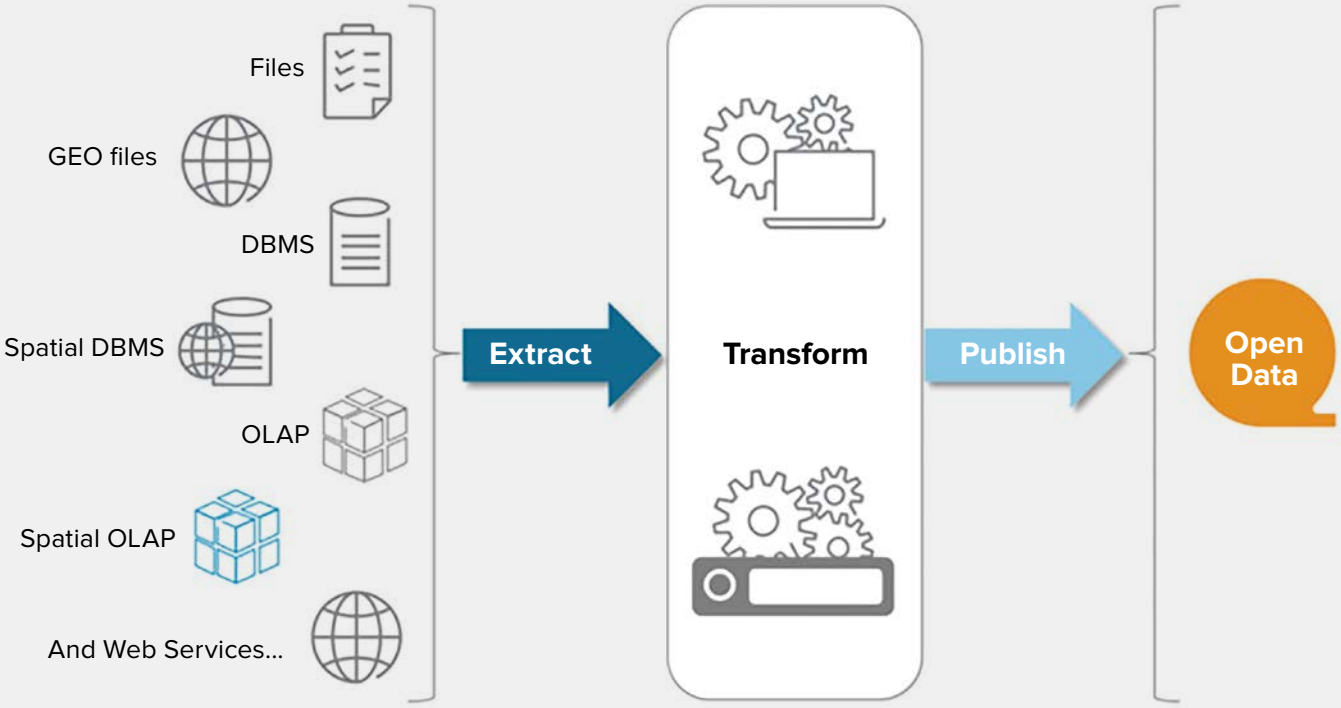
In the technical preparation and implementation stage, issues such as data management, how to publish data, and how to access data should be further explored, based on insights and limitations identified in the wider data strategy. Good practices include the ETP (Extract, Transform, Publish) process, inspired by the ETL (Extract, Transform, Load) data warehouse process (see Figure 5). Data will be extracted from different data sources, transformed according to different purposes and application areas, and finally published. Publishing is not limited to sharing data as Open Data; it also includes sharing data as private data, and sharing data with users who have specific access rights.

**Figure 4**

## The 9 key topics every organisation level data strategy should cover

**Figure 5**

## A visualisation of the Extract, Transform, Publish process




**Source:** DCAT-AP, 2019

Lastly, during the monitoring stage, the overall performance of Open Data systems and the nature of the usage of specific datasets (such as which are the most popular, useful, or interesting) should be analysed and monitored, in collaboration with user groups. The results and lessons learned from user engagement can influence monitoring goals and techniques, and vice versa.

### KEY ISSUE 8 – INVESTING IN INFRASTRUCTURE: HARDWARE AND SOFTWARE

Smart City strategies rely on base infrastructure that often falls beyond their purview. The existence, for example, of an extensive network of sensors, fibre optic cables, 5G, IoT technologies, AI, and data analytic tools all underpin the capacity of cities to 'go smart'. But municipal authorities have the power to accelerate the adoption of these technologies, and the capacity to invest in technical infrastructure, including hardware and software.

Because each city is endowed with different antecedent assets, it is difficult to readily identify infrastructure investments that present as immediate priorities. More importantly, the participatory and integrated approach to design principles advocated by EIP SCC and DIN OUP points to the need to gradually acquire urban ICT capacity in a stepwise manner, prioritising the particular needs of a specific municipality and its citizens (e.g. needs identified through citizen participation and urban design planning). However, in building a tailored ICT-based Smart City, the gradual implementation of technology which enhances interoperability and openness is of principal importance.

In order to provide a flavour of the potential infrastructure investments cities might make, Figure 6 offers examples of deployment scenarios that have been observed or are currently being implemented or planned in various cities across Europe (Triangulum Project, 2019).

### KEY ISSUE 9 – DATA SECURITY

A central ethical challenge confronting Smart Cities is data security; hacking, security breaches, and misuses of data constitute existential risks to the ongoing legitimacy of data ecosystems. The concept of the CIA triad, which stands for *confidentiality, integrity and availability*, provides a useful starting point for tackling this issue. This triad (TechRepublic, 2008) clarifies the most important and acute risks to information security and offers guidance on policies which help to enhance information security within organisations.

**Figure 6**

## Examples of data infrastructure investments by Municipal Authorities

| Use Case | Description | City in which the solution was implemented | ROI, years | Initial investment |
|---|---|---|---|---|
| **Open Data Portal** | A data portal for the City of Eindhoven to upload, share, use, analyse and visualise public datasets. | Eindhoven (Netherlands) | 0.5–2 years | <50K Euro |
| **Data Curation** | A service that allows people (e.g. citizens or the city as a whole) to access real-time and historic datasets (mainly numeric datasets) and make informed choices. The data curation service improves and enhances data and gives benefits back to the data provider. It gives an opportunity to create innovation (the service is already used for research). | Manchester (United Kingdom) | 0.5–2 years | 50K–250K Euro |
| **Data Visualisation Platform** | A collection of tools to visualise data from a range of sources in different ways (e.g. VR, AR, 2D maps). The data visualisation platform enables users to engage with data in a user-friendly way. | Manchester (United Kingdom) | 0.5–2 years | <50K Euro |
| **Cloud Data Platform** | An ICT platform which facilitates collection, storage and processing of Smart City Data. It provides data access. | Stavanger (Norway) | 0.5–2.5 years | 50K–250K Euro |
| **Computing Platform** | An ICT platform that delivers on-demand access to a shared pool of computing, storage and networking resources. | Stavanger (Norway) | | 50K–250K Euro |
| **Smart City Data Platform of Platforms** | A central data hosting and distribution platform for real-time data. Private persons, businesses and municipalities can add data to the platform, use the API generation service and market their data in a platform approach. | Eindhoven (Netherlands) | 0–1 years | <50K Euro |

***Confidentiality*** identifies the technical interventions required to safeguard against unauthorised personnel or systems accessing, disclosing or stealing data. Good practices to ensure confidentiality include:

- Data encryption, with the help of standards such as AES (Advanced Encryption Standard – symmetric) or RSA (the Rivest-Shamir-Adleman algorithm – asymmetric)
- Usage of transport-layer security during transmission (e.g. SSL/TLS).

***Integrity*** describes the ability of a system to maintain the consistency, accuracy, and trustworthiness of data over its entire life cycle. This stipulates that data should not be altered during transmission, and should never be changed by unauthorised personnel or systems. Typical good practices to safeguard integrity are:

- Provision of checksums for integrity verification
- Regular backups of data and recovery mechanisms
- Usage of file permissions
- Physical as well as digital access control (for both users and systems).

***Availability*** refers to the modality or system used to access or utilise data and/or services with acceptable timeliness, and reliably ensuring that data is available for example 99% of the time in any given day. Good practices to ensure availability are:

- Proper maintenance of hardware
- Usage of up-to-date software

- Maintaining recovery mechanisms
- Deploying redundancy strategies (e.g. by using RAID)
- Usage of high-availability clusters to mitigate the risks.

Techniques such as *l-diversity* or *t-closeness* can also be used to ensure a high degree of anonymisation and thereby increase the availability of properly anonymised data. Finally, it is important to ensure *compliance with GDPR* as well as local policies.

In 2002, the OECD published revised *Guidelines for the Security of Information Systems and Networks,* in which nine principles were proposed: (1) awareness, (2) responsibility, (3) response, (4) ethics, (5) democracy, (6) risk assessment, (7) security design and implementation, (8) security management, and (9) reassessment (OECD, 2002). These principles were extended by the National Institute of Standards and Technology (NIST) in their document *Systems Security Engineering: Considerations for a Multidisciplinary Approach in the Engineering of Trustworthy Secure Systems*, which was initially published in 2016 and updated in 2018 (Ross, et al., 2016). In this document, a **taxonomy of security design principles** is developed to act as a foundation for engineering trustworthy, reliable and secure systems (see Figure 7).

Other **standards** that should be considered include ISO/IEC 27001 and ISO/IEC 27002. ISO/IEC 27001 specifies a management system intended to keep information security under control and provides specific requirements that should be fulfilled, while ISO/IEC 27002 offers a guideline for organisational information security standards.

**Figure 7**

## The National Institute of Standards and Technology (NIST) taxonomy of security design principles

| Security Design Principles | |
|---|---|
| Security Architecture and Design | |
| Clear Abstractions | Hierarchical Trust |
| Least Common Mechanism | Inverse Modification Threshold |
| Modularity and Layering | Hierarchical Protection |
| Partially Ordered Dependencies | Minimised Security Elements |
| Efficiently Mediated Access | Least Privilege |
| Minimised Sharing | Predicate Permission |
| Reduced Complexity | Self-Reliant Trustworthiness |
| Secure Evolvability | Secure Distributed Composition |
| Trusted Components | Trusted Communication Channels |
| Security Capability and Intrinsic Behaviours | |
| Continuous Protection | Secure Failure and Recovery |
| Secure Metadata Management | Economic Security |
| Self-Analysis | Performance Security |
| Accountability and Traceability | Human Factored Security |
| Secure Defaults | Acceptable Security |
| Life Cycle Security | |
| Repeatable and Documented Procedures | Secure System Modification |
| Procedural Rigor | Sufficient Documentation |

**Source:** European Data Portal, 2018

## KEY ISSUE 10 – DATA VISUALISATION

**The need for data visualisation**

Data is of no consequence without the capability to analyse and understand it. The best way to represent data is through visualisation methods, such as bar diagrams, quantile visualisations, distribution curves, box plots, scatter plots and other outputs which are traditionally offered by statistical and data analytics software. One of the challenges in this context is efficient integration of the Content Management Systems (CMS) of the relevant city data hubs and platforms with the corresponding visualisation frameworks, to allow citizens and users to understand the data based on different online/web-based representations. This relates to both static or slowly changing data, as well as IoT-based data streams. Furthermore, data needs to be comprehensively presented on maps in order to increase its accessibility for citizens.

**Visualisation frameworks**

There are a large number of visualisation frameworks available which can be easily integrated with web-based platforms and CMS. Typical examples are JavaScript-based frameworks such as D3 (D3, n.d.), React-vis (React-vis, n.d.), Chart.js (Chart.js, n.d.), Processing.js (Processing.js, n.d.), and Raphael.js (Raphael.js, n.d.). Given the array of available visualisation frameworks, we focus on some of the most widespread ones in order to highlight some success stories and characteristic properties.

D3 is a prominent web-based framework that can be easily utilised for the visualisation of Open Data and data on urban platforms in general. The flexible D3 JavaScript tool is used within the data portal of New York City to display various views of the provided Open Datasets (DATA.NY.GOV, n.d.). A similar D3-based framework was used to visualise the tax budget of Brazil in 2014 (NGO INESC, n.d.), and the public portal was developed in close cooperation between the Open Knowledge Foundation and the Brazilian NGO INESC (Institute of Socio-Economic Studies).

Another example is the digital print brochure 'Berlin – A Success Story' (BerlinOnline, n.d.), which was designed in 2014 by BerlinOnline on behalf of the Berlin Senate Chancellery, and later converted into a website at www.berlin.de using the JavaScript framework Flotr2 (Flotr2, n.d.) to visualise statistical data about the city.

In general, various different programming languages can be used in the implementation of web applications. Accordingly, an evaluation of visualisation frameworks – based on server-side scripting languages such as PHP – is required. In this context, the JpGraph framework (JpGraph, n.d.) provides an interesting example, which is easy to integrate into existing web portals and CMS platforms. JpGraph is a PHP-based framework which can interplay with the Drupal PHP frontend.

Other tools that have been noted in different good practice examples are provided by Google Chart (Google Chart, n.d.) and JavaScript InfoVis Toolkit (JavaScript InfoVis Toolkit, n.d.). These are among the best-known tools in the field of freely usable frameworks for the visual representation of data, together with the BIRT software, which in addition to visualisation methods also offers further functionalities for business intelligence and reporting. BIRT is designed as an 'Open Source technology platform and is used to create data visualisations and reports that can be embedded into rich client and web applications,' (BIRT, n.d.). It is especially interesting to see the integration of BIRT within the widely utilised Eclipse software developing platform, and its potential for deployment as a web service/portal based on the underlying software stack.

Finally, it should be mentioned that even though the above frameworks differ in how the data is processed, the programming language and resulting styles offer a wide range of data visualisation techniques such as line plots, filled line plots, step line plots, line plots with markers, line plots with inverted Y-axes, line plots with values, standard bar plots, horizontal bar plots, combined line and bar plots, pie plots, 3D pie plots, exploding pie plots, scatter plots, impulse plots, field plots, splines, geomaps, and more.

**Map-based visualisation**

Maps often offer the most valuable visualisations. The modern technological aspects of interactive/reactive and responsive design play a particular role in this context by enabling lively and user-engaging representations of the data on maps. Typical map data providers are GoogleMaps and OpenStreetMap, whilst a good example of a map visualisation library is Leaflet (Leaflet Library, 2017). Leaflet and similar libraries are often JavaScript-based, and can be easily integrated with CMS, serving as an interface to interact with the datasets from the relevant platforms. Another commercial product worth mentioning is the ArcGIS platform (Esri, n.d.) from Esri, which allows for high quality data analytics and visualisations and can be integrated with Open Data portals based on the pre-processing of data to corresponding input formats.

In May 2019, the city of London announced its intention to create a digital map of underground pipes and cables, known as the Underground Asset Register. The Register will show the below-ground locations of electricity and phone cables, and gas and water pipes. The goal of developing and using this map is to prevent accidents and to allow for better planning (Government of London, 2019). This is a functional example of the worth of map-based visualisation in practice.

**Urban 3D models**

Cities can use 3D models to create a digital representation of the overall urban environment and illustrate a variety of scenarios based on 3D models and their associated data. Naturally, it is expected that a Smart City 3D model should be enhanced by different types of data from sources within the urban environment in question. The data would normally be stored in a logically centralised system and made available over corresponding APIs, such that it can be further processed for various scenarios and urban optimisation processes. An important aspect of the near real-time utilisation is the timely availability of the data attached to the 3D model, which enables a viable and sustainable use of this valuable tool.

A 3D model in combination with timely quantitative and qualitative data offers impressive potential for city administrations and corresponding services and institutions. For example, a 3D model can enable the 'inventory' of a city to be taken in terms of infrastructure, such as tunnels, bridges, pavements, traffic/road signs, and so on. It can also be used as a control tool to assess the implementation of different real-world measures by city planning departments (e.g. new walkways and bicycle lanes), and has the potential to assist with accelerating various processes such as road planning, traffic predictions, and permission/approval-issuing processes for parking, buildings, pavement, and public space utilisation. Additionally, it is possible to proactively predict future problems within a Smart City (e.g. with respect to roads or water facilities/infrastructure) and identify reasonable pre-emptive countermeasures. The data which can be merged with a 3D model can originate from multiple sources, and can include static data (such as public Open Data) as well as IoT data streams based on integration with IoT sensor data platforms.

Various cities across the world already possess such models, including Berlin (3D Model of Berlin, n.d.) and Hamburg (3D Model of Hamburg, n.d.). It is worth noting that 3D models are quite large and require a significant amount of storage space as well as computer processing power for their rendering. The 3D model files are stored in different formats which are known from the CAD or from the open formats' domain, such as DXF, DWG, CityGML, 3DS, and C4D.

**Data input formats**

All of these data visualisation technologies require the data to be provided in particular formats, most commonly CSV, XML, JSON, KLM, CityGML, XLS, XLSX, JSON, XML, CSV and TXT, which pose an additional requirement for data providers that must be borne in mind.

**Urban development strategies and data visualisation: the example of Ludwigsburg's control and information system**

The city administration of Ludwigsburg uses a newly developed 'control and information system', which helps to structure and visualise data. The system compares the targets set in Ludwigsburg's Urban Development Strategy with current city indicators, providing an overview of how the city is performing and increasing policy transparency. It provides comprehensive information for citizens and visible guidelines for sustainable urban development. Through the topic-related view and a search function, all users are able to obtain a comprehensive insight into all the subject areas and associated projects. It serves as an assessment tool for the municipal administration to see individual projects in the overall city and policy context, and allows them to recognise the effects of one policy on other sectors at an early stage. The goal of using this tool is to make urban development more structured, coherent, and ultimately resource-efficient (Ludwigsburg Stadt, 2019).

Action Area 4

# RESOURCES, FINANCE, AND ECONOMICS

## KEY ISSUE 11 – FINANCING MODELS AND PROCUREMENT

**Financing**

Financing Smart City projects, and innovation in urban areas in general, can be challenging. Innovation means higher risks, and the high complexity of these projects means high transaction costs. Incentive structures are not always inviting enough for the investor. There are five categories of financing options normally deployed when investing in Smart City projects, data platforms, and associated data ecosystems (von Radecki, et al., 2017).

- **Government-based finance options**. Governments issue debt instruments with an agreement that the investor will pay back the debt over time. This option is the most commonly used in Smart City investments involving a high risk. Examples of this mechanism include green bonds, social impact bonds, and energy efficiency loans (von Radecki, et al., 2017).
- **Development extractions**. In this case, governments force developers to pay for the infrastructure services that their developments will utilise. Examples include tap fees, linkage fees, and impact fees (von Radecki, et al., 2017).
- **Public–Private Partnerships (PPP)**. In some cases, a public authority contracts a private service company to invest in a Smart City solution which is more efficient – and therefore cost-saving – than the existing infrastructure. A long-term contract makes sure that the investor harnesses a sufficient ROI (return of investment) and the city saves costs overall. Alternatively, a pay-for-performance arrangement means that an investor into a particular technology begins generating return on that investment once the technology delivers the agreed financial and operational performance results (von Radecki, et al., 2017).
- **Mechanisms to leverage the private sector**. These usually take the form of loans, taxes or fees that are managed for the government and which aim to promote the investment in innovative solutions. Examples of these mechanisms are Loan Loss Reserve Funds (LLRFs), Loan Guarantees, On-Bill Financing, Pool Bond Financing, Value Capture, and Tax Increment Financing (von Radecki, et al., 2017).
- **New funding alternatives**. These include a variety of alternative resources that could be considered for financing innovative urban projects as well as local start-ups and SMEs. Examples include crowdsourcing, microlending, venture capital, and philanthropic funding (von Radecki, et al., 2017).

**Financing Smart City projects: examples of finance methods adopted**

*Amsterdam Smart City Unit*

The example of the Amsterdam Smart City Unit[16] shows how joint ventures between municipalities and private companies help to foster digital innovation in a local ecosystem. Eight (public and private) partners co-invested in a newly founded entity that is responsible for driving the overarching agenda of Smart City Amsterdam. It organises innovative project ideas, acts as a network broker to all interested parties, strengthens and fosters city branding, and is a trusted process facilitator and moderator for coordinating local and regional innovation projects. Amsterdam Smart City is funded by annual fees from its members.

*Dark Fibre in the Dublin Docklands*

Dublin City Council (DCC) used a competitive dialogue tendering procedure in 2016 to source a company to manage the fibre optic network in the Docklands. Through the dialogue process it emerged that selecting an Open Access fibre network, where DCC would remain owners of the asset, and offering access to the network to all operators on an equal basis was the best option. Following this, DCC discovered from the proposals that an initial investment by the city would be paid back in three years from revenue generated, and the operation would continue to yield an annual profit from then on (von Radecki, et al., 2017).

*Local Digital Fund – UK Ministry of Housing, Communities and Local Government*

The Local Digital Fund was announced in 2018 by the UK Ministry of Housing, Communities and Local Government (MHCLG). It aims to help local authorities implement the Local Digital Declaration by funding digital skills training and projects to address local service challenges in common, reusable ways. The Fund agreed to invest up to £7.5 million during financial years 2018/19 and 2019/20 (Ministry of Housing, Communities and Local Government, 2019). In the first round, MHCLG funded a project to automate development data and address the shortage of delivery data, proposed by the Greater London Authority and four other councils, and another project to develop and test a digital data protection impact assessment tool that could be used by other public organisations, proposed by Greater Manchester Combined Authority and 10 other partners.

16 Amsterdam Smart City consists of eight core partners: City of Amsterdam, the Amsterdam Economic Board, Alliander (energy grid company), KPN (telecom/ICT), Arcadis (natural and built asset design and consultancy firm), PostNL (logistics), Amsterdam ArenA (stadium), and Amsterdam University of Applied Sciences.

**Financing Smart City projects: examples of finance methods adopted (continued)**

*Nord-Pas de Calais Regional Fund*
The Nord-Pas de Calais Regional Council and CCI Nord de France created a dedicated investment fund with an initial financing capacity of EUR €50 million (circa £44 million). The fund serves to finance businesses in the region that have projects linked with any of the following areas: energy efficiency, the transition to renewable energy, energy-producing buildings, energy storage, internet, sustainable mobility of people and goods, the circular economy, and the economy of functionality (European Investment Bank, 2015).

*Smart Cities and Sustainable Development – European Investment Bank and Belfius Bank*
Belfius Bank and Insurance, in cooperation with the European Investment Bank, have created the Smart Belgium initiative which has financed more than 100 projects for over EUR €1 billion, with extra funding of EUR €400 million available. The programme is focused on Smart Cities and sustainable development, and supports cities in communal projects that are 'sustainable and intelligent' in three key areas: mobility, urban regeneration, and energy efficiency/ renewable energies (Gyselinck & Raisière, 2018).

*Badenova Innovation Fund*
The energy utility company Badenova in south-west Germany has been administering an Innovation Fund for 19 years. The Innovation Fund for Climate and Water Protection is unique in its type: each year, it provides around EUR €1.5 million from the company's profits for exemplary climate and water conservation projects in the region. Since its launch in 2001, this has amounted to around EUR €30 million in subsidies for 272 environmental projects (Badenova, n.d.).

**Procurement**
Public procurement can serve as a powerful tool to shape and mould innovation processes in urban areas. Public procurement can not only serve the local ecosystem, but can also provide governments with access to innovative technologies which can positively impact cities and city regions.

The *Procure Network* – formed by 11 European cities – has identified six areas where value can be added to public procurement (Baqueriza-Jackson, 2018). Recommendations for the procurement cycle include:

1. **Identifying needs**: Including citizens and suppliers in the supplier-identification process, analysing spend, reviewing policies, challenges and issues for the city, building a supplier database, and communicating effectively about the supply chain needs of the city
2. **Developing a strategy**: Linking the procurement strategy to identified challenges and wider policy, implementing strategy by capacity building across all stakeholders, and engaging with citizens through participatory budget allocation
3. **Designing procurement**: Innovate for outcomes, link design to wider issues, engage early with suppliers, co-design procurement with citizens, support and build capacity for suppliers, encourage SMEs with 'joint bids and buyers' joint tenders, and aim to divide tender requests into smaller lots
4. **Tendering**: Embedding wider social, environmental and economic objectives and expectations in the contract, and weighing criteria so as to reward bids that prioritise wider outcomes
5. **Awarding**: Clear choice of scoring methodology (quantitative, qualitative, pass/fail), clarification of mechanisms for scoring of innovative criteria, and ensuring effective communication with peer cities to increase awareness of good practices
6. **Monitoring**: Build capacity of procurers, contract managers and technical officers, provide support to help suppliers deliver wider outcomes, and choose a methodology to manage and monitor wider outcomes (on a contract-by-contract/collective basis).

**Innovation procurement** is an approach that could be followed to purchase and deploy new and innovative technologies, since its focus is on facilitating the development of solutions and testing them in real environments. Innovation procurement can take two forms (sometimes seen as a continuum):

- **Pre-Commercial Procurement** (PCP) is used to steer the development of solutions towards concrete public sector needs, whilst comparing or validating alternative solution approaches from various vendors (Bos, 2016)
- **Public Procurement of Innovative Solutions** (PPI) helps a public procurer to act as launching customer/early adopter/first buyer of innovative commercial end-solutions newly arriving on the market (Bos, 2016).

**Dublin's procurement of innovation projects**

Dublin started a Small Business Innovation Research (SBIR) programme, which falls under the category of pre-commercial procurement. SBIR competitions are open to all organisations which can demonstrate a route to market for their solution. The SBIR programme is particularly suited to small and medium-sized business, as the contracts are of relatively low value and operate in short timescales. Developments are 100% funded and focused on specific identified needs, increasing the likelihood of subsequent adoption and application. Suppliers for each project are selected by an open competition process and retain the intellectual property generated from the project, with certain rights of use retained by the contracting department. In 2016, Smart Dublin partnered with Enterprise Ireland to launch the cycling SBIR. It made EUR €100,000 seed funding available to pilot data-driven cycling solutions. The competition received 96 expressions of interest and 23 actual proposals; 14 companies were selected to pitch their ideas, and five received Phase 1 funding. Four companies received Phase 2 funding in January 2017 (von Radecki, et al., 2017).

## KEY ISSUE 12 – COST–BENEFIT ANALYSIS

A **clear business case** is difficult to formulate when trying to make an investment in digitally-driven solutions. Usually, data contributes to creating both public value and private return on investments. The actual distribution of benefits depends on a variety of context-specific factors, e.g. *How many people stop using their car in Eindhoven as opposed to Taipei when a bike-sharing scheme is introduced? How much solar potential is there in London as opposed to Zagreb – and how do energy consumption rates relate to this? How many people benefit from better distribution of water in the city, and would they pay for it, or would return of investment be intangible?*

The difficulties faced when trying to assemble a compelling business case for smart investments in data infrastructure and data-driven solutions are significantly problematic, and many high-potential projects simply do not get off the ground as a result. Put simply, traditional business models fail in the face of complex urban systems solutions. Three particular difficulties recur:

- **Shared value**: Sustainable technologies in cities create private and social returns on investment at the same time, with the latter often representing the larger benefit. However, private companies are needed as innovators and operators of connected systems, and private investment is needed to cover higher upfront costs. The shared public and private value stemming from Smart City investments needs to be reflected within new forms of public–private partnerships that link policy making, government incentives and public spending to fair business models and private stakeholders in the Smart City ecosystem.
- **Transaction costs**: As the complexity of solutions rises, more stakeholders are needed to develop, implement, operate and maintain Smart City solutions, which reduces the likelihood of an even distribution of benefits across all stakeholders, leading to unbalanced cost–benefit models and therefore to uneven investment incentives. Here, simple agreements and smart contracts[17] are required to drive down transaction outlays and to account for individual costs and benefits accruing to Smart City stakeholders.
- **Risk**: The risks of distributed benefits and shared investments are still high due to a lack of standardised and reproducible evidence. Prospective benefits of data-driven investments in cities need to be proven under reproducible circumstances in order to convince future beneficiaries to become Smart City investors. The risk in urban investments is that short-term commercialisation and extraction of value can result in longer-term cost to the public budget. Therefore, ensuring fair and responsible valuation and monetisation of the content of urban data is necessarily more complex; it presents real economic development opportunities (as well as city value benefits), but requires more sophisticated approaches and tools to deal with this complexity.

**Contingent valuation and the total economic value model**

The essence of an economic analysis is to compare all the benefits of the proposed action with all the costs, with a project said to pass a benefit–cost test if the sum of all the benefits is greater than the sum of all the costs. Such an analysis is seriously defective without monetary values for the urban amenities and services (hereafter 'goods') affected by a proposed action (Carson, 2000). The central problem in the application of standard economic tools to the provision of urban goods, whether indirectly through regulation or directly through public provision, is placing a monetary value on these goods. Because such goods are not routinely bought and sold in the market, actual cost/sales information is seldom available (Carson, 1985). To that end, economists have developed a variety of techniques to value non-market amenities consistent with the valuation of marketed goods. These techniques are based upon either observed behaviour (revealed preferences) toward some marketed goods with a connection to the non-marketed goods of interest, or stated preferences in surveys with respect to the non-market goods. The stated preference approach is frequently referred to as contingent valuation, or total economic valuation when used in the context of environmental amenities (Cummings, et al., 1986). Where individual preferences are indifferent, the wider impact of an investment in public goods or a common pool of social resources needs to be measured in terms of quantifiable effects within the environment, the economy, or the society.

A good example of this is the Stockholm congestion charging system (see Figure 8).

The net sum of all the relevant WTPs (Willingness to Pay), WTAs (Willingness to Accept) and/or the Net Present Values for a project outcome or policy change defines the total economic value (TEV) of any change in wellbeing due to a project or policy. TEV can be characterised differently according to the type of economic value arising, but in general provides an overall measure of the economic value of any asset, such as the environment, urban data, infrastructure, and so on. It decomposes into use and non-use (or passive use) values, and further sub-classifications can be provided if needed (Amrusch & Feilmayr, 2009).

17 In essence, it is about simple one-click sign-on contracts that contain all provisions for trusted and secure data sharing and make sure revenues are shared fairly.

**Figure 8**

## Cost–Benefit Analysis of the Stockholm congestion charging system

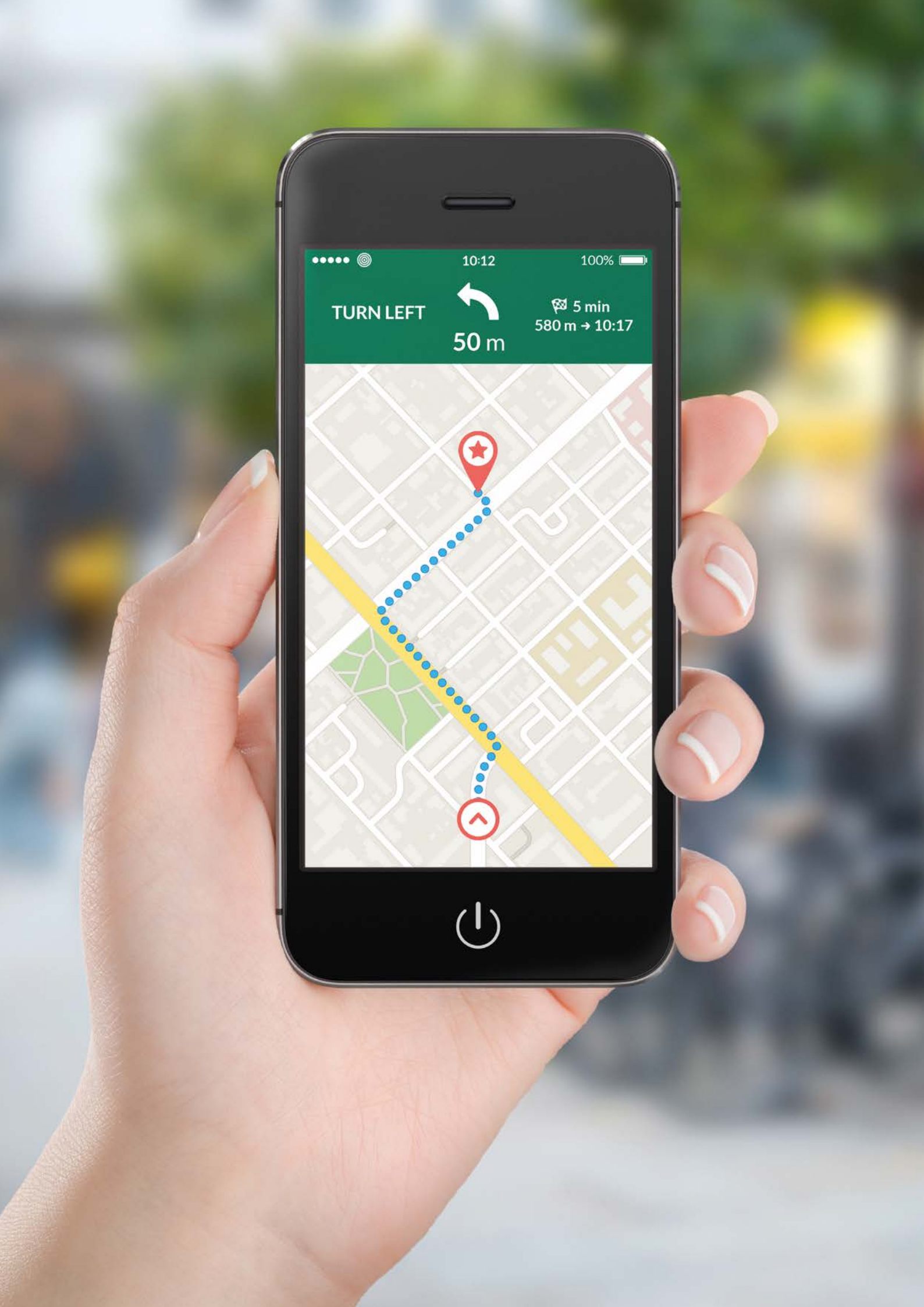
A Cost–Benefit Analysis (CBA) of the Stockholm congestion charging system undertaken from its inception in 2006 provides the following results:

- The figure shows that the congestion charges produce a net social benefit of a little less than SEK 700 million/year (EUR €74 million/year)
- Consumer surplus is negative, as expected, but the value of the time gain is high in comparison to the paid charges, at around 70% of the paid charges. This is high compared to most theoretical or model-based studies
- This is mainly due to 'network effects', i.e. significant amounts of traffic that do not cross the cordon and hence do not pay any charge, but still gain from the congestion reduction
- 'Other' effects – environmental effects and improved traffic safety – are valued at EUR €22 million/year
- The total public financial surplus is EUR €65 million/year, of which EUR €57 million is net revenue from the charges and EUR €19 million is increased revenue from public transport fares
- The yearly cost of the system (EUR €23 million) includes reinvestment and maintenance, such as replacement of cameras and other hardware, and additional costs such as moving charging portals when the building of a northern bypass began in 2007
- The annual socioeconomic surplus of EUR €72 million has to be compared to the investment cost. To clarify the investment cost, it is assumed that this is the entire start-up cost, i.e. not only the costs prior to the start of the system, but also the operating costs in 2006 plus other additional minor costs such as traffic signals, and the services of the Swedish Enforcement Agency and Swedish Tax Agency. This includes system development in the widest sense, educating and training staff, testing, public information, and the Swedish Road Administration's costs for closing down the system and evaluating the results during the second half of 2006. This is budgeted at approximately SEK 1.9 billion (EUR €200 million). A significant portion of the costs prior to the start in early 2006 were for extensive testing, as it was absolutely necessary that everything worked from the start
- Not all costs incurred during 2006 were running costs; the system was improved in several ways during the spring of 2006. Actual running costs decreased significantly each month, and it was quickly evident that progress was good: the number of complaints and legal actions were lower than anticipated, reducing costs for legal and tax administration. The number of calls to the call centre (the single biggest item in running costs) were down to 1,500 calls instead of 30,000 per day
- This enabled the call centre to be downsized, and a reduction of running costs was achieved.

With an investment cost of SEK 1,900 million (EUR €200 million), the investment could be recovered in financial terms in around 3.5 years. The net financial surplus is around SEK 540 million/year – approximately EUR €57 million/year, excluding the increased net revenue of the transit operator. In socio-economic terms, the investment is 'recovered' in a little more than 4 years.

To calculate the net present value of the investment, it is necessary to define a lifespan for the system. As reinvestment and maintenance costs are included in the running costs of SEK 220 million/year (EUR €23 million/year), a possible lifespan of 20 years is a tentative estimate. The Norwegian systems, for example, have been running for around 15–20 years, and there seem to be no technical reasons to prevent them from continuing to function. A lifespan of 20 years would give a net present value of around SEK 8 billion (EUR €843 million), assuming the Swedish recommended discount rate of 4% per year and assuming that all benefits and costs remain constant, and a net present value ratio of 4:3.

**Source:** Department of Environment and Health, City of Stockholm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5 min
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# 3: TOWARDS A SMARTER LIVERPOOL CITY REGION: FOOD FOR THOUGHT

Based upon our extensive body of previous work with European (and other) cities and a limited number of key interviews (details included at the end of the Guide) with local actors, we conclude by offering what we label *food for thought.* This closing section of the review is by necessity exploratory and designed to be thought-provoking. A more comprehensive and nuanced understanding of the local context than has been possible to acquire in this largely desk-based project would be needed to offer firmer and more directive prescriptions. In any case, only through local dialogue with stakeholders and citizens can a sustainable direction of travel be agreed. Whilst some of our comments might resonate with stakeholders and prompt specific responses and actions, our aim is modest: we hope only to excite interest in capitalising on learning from the experiences of other city regions, and to provoke and enrich local conversation.

**Cause for optimism: existing energy, strengths and assets**

The energy and impetus so necessary to build a Smart Liverpool City Region and an effective LCR data ecosystem is already flourishing. A real moment of opportunity exists for LCR to accelerate its digital transition, build, enhance and scale its data ecosystem, and adopt smart and data-driven solutions to pressing economic, social and environmental problems.

The Liverpool City Region Combined Authority (LCRCA) expressed its ambition to promote and develop its innovation assets from its outset, and explicitly in its devolution agreement with central government in 2015 (Liverpool City Region, 2015). In 2016, with its focus on productivity, people and place, the LCR Growth Strategy (Liverpool City Region Local Enterprise Partnership, 2016) set as a specific goal the development of a digital industry and infrastructure, including ultra-fast broadband infrastructure and freely available public Wi-Fi networks. The LCRCA's emerging Local Industrial Strategy (LIS) also underscores the importance of leveraging LCR's digital expertise and assets through improved data archiving and the development of AI solutions capabilities. Moreover, the Metro Mayor and Senior Managers have articulated their intention of making the Combined Authority a data-driven organisation that utilises data to inform and improve public policies and services. Local authorities are also making significant efforts to conceptualise, audit and improve their data infrastructures, and Liverpool City Council in particular is taking stock of the values it wishes to use to calibrate its data management activities, and how it might scale its use of smart technology to support further inclusive and clean regeneration and renewal. The region hosts major tech companies such as Atos, EPAM, Unilever and Shop Direct, and has the UK's largest SME-led e-health cluster, a nascent IoT cluster, and a growing number of tech enterprises and SMEs in the digital and creative sectors.

More specifically, LCRCA, local authorities, the LEP and other organisations such as universities, local authorities and private companies are actively implementing a number of smart projects, including:

- **Deployment of 5G networks**: a consortium of public sector health suppliers, the NHS, university researchers, local SMEs, and a UK 5G technology vendor are testing the use of 5G in the city region, along with Artificial Intelligence, virtual reality and IoT, with the aim of reducing the digital divide and enabling better health and social care in communities (UK 5G Innovation Network, 2018)
- **A 'supercomputer' dedicated to industrial R&D**: the Hartree Centre/Daresbury hosts one of the most powerful supercomputers in the UK, and works in cooperation with IBM's UK research and development centre to enhance the data analytic capacities of local actors, including SMEs
- **Digital skills**: LCRCA, the LEP, local government and industry-led initiatives are addressing some of the basic and advanced skills gaps that exist in the city region (Liverpool City Region Combined Authority, 2018). For example, the NHS has several programmes aimed at training its staff and patients to use digital tools
- **Sensor City**: this innovation hub is the result of a collaboration between the University of Liverpool and Liverpool John Moores University, and offers technical expertise and business support to promote sensor solutions to academic and industry actors
- **LCR Activate**: this support and funding programme is designed exclusively for helping digital and creative businesses in the city region to grow. It provides practical, hands-on support and funding to help digital and creative businesses flourish using emerging technologies, such as AI, machine learning, virtual and augmented realities, big and Open Data, high-performance computing, and cloud and cognitive computing (Liverpool City Region Combined Authority, 2018)
- **Transport data**: the LCRCA works alongside Merseytravel to improve the delivery of transport services. For instance, real-time information about bus routes and service operation is now offered to users in the city region, and via the use of sensors, traffic lights give priority to buses when roads are congested to improve punctuality
- **Consumer Data Research Centre (CDRC)**: led by the University of Liverpool, the Centre functions as a consumer data access broker for other academic groups.

Meanwhile, signature planned projects include:

- **The Digital Spine**: the investment in a 260km fibre optic network will connect the whole city region across all six local authority areas and its most important assets – the Hartree Supercomputer, and the GTT fibre optic cable (Liverpool City Region Combined Authority, 2018)

- **A Civic Data Trust/Cooperative**: this SIF-funded project aims to develop an integrated data and digital innovation facility that supports collaboration between health tech partners and provides secure access to relevant data, while gaining trust from the public in how data is used
- **AI Solutions Hub**: the Alan Turing Institute, the STFC Hartree Centre and IBM Research intend to expand their existing partnership, which applies world-leading AI and high-performance computing to industrial challenges as part of the UK's Industrial Strategy
- **Transport for the North**: in their efforts to improve public transportation in the Northern region, the Combined Authority and Merseytravel are planning to implement a single travel card which will allow users to traverse the whole region. To this end, they will share data about timelines, timetables and planning with all the Northern regional authorities.

**Challenges and barriers to enhanced data sharing**

Despite the promising foundations upon which a high-performing LCR data ecosystem might be built, LCR still faces some challenges and barriers which will need to be confronted and overcome if progress is to be made. Some of these challenges are already recognised by LCRCA, the LEP, and local authorities, and include: the wealth gap (with below average GVA per head), the business gap (with low business density rates and too few private sector jobs), and the skills gap (with more skilled workers required for the growing business sector). Building a Smart City Region in this political-economical-institutional context presents its own unique challenges; whilst not inevitably the case, it is likely that the task will be especially difficult and complex.

Furthermore, there are specific challenges related to the institutional landscape and the articulation of a clear digital and data agenda:

- **Lack of a data strategy**: although important projects and initiatives exist, there is no overarching and commonly agreed strategy, plan or sense of mission to orientate, galvanise and align local stakeholders
- **Limited data sharing**: although several organisations across the LCR (such as SMEs, public bodies, universities, LCRCA, and local authorities) could benefit from sharing data, the existence of this practice is limited. Where data is shared between organisations, sharing is usually precipitated by a specific project
- **Absence of standards**: local authorities are fully aware of the importance of using data standards, but in practice the application of common standards is limited. Moreover, data is held according to different protocols, in different technical systems and in different formats, making interfacing and reconciliation difficult
- **Limited understanding of existing datasets and diversity of owners**: stakeholders in the LCR are aware of some fields in which data is collected, but they have insufficient knowledge of which other organisations are collecting and holding data and of what nature
- **Low collaboration between institutions**: though there are projects beginning to address this issue, such as the proposed and highly promising Civic Data Trust/Cooperative, collaboration between different organisations is limited and this hampers fostering data relations and data sharing
- **Limited analytical capacity in local governments and the LCRCA**: though efforts are being made by the local authorities to integrate data in their policy making cycle, austerity and severe budget cuts have placed limitations on available resources for data analytics and technical capacity. In addition, since the LCRCA is still a relatively new organisation, it too is still at an early stage in building its data infrastructure, analytic resources and capacities
- **Difficulty of measuring policy impacts**: limited access to local data hinders any attempt to develop a more evidence-based approach to policy making and evaluation, and this limitation restricts understanding and prioritisation of rapidly developing policy concerns and prevents anticipatory and timely intervention
- **Digital divide and low skills**: poverty and relatively low education and skill levels reinforce inequalities in the online activities of certain social groups, and there is concern that an existing gap in intermediate level digital skills – middle level analytics and data management abilities – is not being effectively remediated.

**Unlocking the value of big data and increasing the efficacy and ethics of critical LCR economic, social, and environmental policy interventions**

We conclude by offering some thoughts on priority actions which might be helpful in advancing the work of building a high-performing data ecosystem in LCR. Our suggestions are offered principally as thought experiments, designed only to stimulate local conversation and promote further debate on questions which are of pivotal significance. To the extent that they gain traction locally, they may prove to be of practical use. Those which fail to resonate with local stakeholders may also provide valuable insight, clarifying why some suggestions and options might be unworkable and perhaps provoking consideration of alternative ideas.

1. **It would seem most appropriate to build a data ecosystem at the scale of the city region, and to this end, LCRCA would seem best placed to lead, coordinate or at the very least incubate the building of such a data ecosystem**. Given the scale at which many socio-economic processes work, the ever wider expansion of urbanisation processes into hinterlands, and the ongoing ambition of English devolution to birth and scale city region authorities led by elected Metro Mayors, it would seem imperative that a data ecosystem be developed at the LCR scale. Given that it is very well placed to do so, the LCRCA could play a strategic role in building this data ecosystem, proactively driving forward the data agenda and providing leadership and a common framework for local authorities and sub-city region-scale data strategies to align with. No one can 'own' a Smart City, but every Smart City needs to have a recognised body with intensity of focus and convening power.

2. **A Future Innovation Office or the like could coordinate and guide the development of an innovative regional data**

**ecosystem**. A decade of austerity has taken its toll. Public finances are severely limited. No institution, including the LCRCA, currently has adequate resources and capacity to champion a local digital and data transformation. Further investment and capacity building will be essential. To operationalise the strategic role of the LCRCA in this transition, the creation of a Future Innovation Office or FIO (similar to New York City's OLTPS and London's LOTI) by, within or alongside the LCRCA could prove useful. An FIO would be responsible for the development of an LCRCA data strategy predicated upon a long-term vision. Among other tasks, it could be in charge of developing a strategic plan for the long-term development of smart technology in the city region, driving innovation in collaboration with the private sector and other regional stakeholders, supporting local authorities in procurement of innovation, working collaboratively with the evidence, research and intelligence units of LCRCA and local authorities to foster enhanced data analysis for evidence-based policy, and enabling the sustainable development of a technical data-driven ecosystem involving local SMEs, large scale industry, academia, and Open Source project initiatives.

3. **A layered data hub for the Liverpool City Region could allow structured and secure access to data, increasing transparency and creating business opportunities**. A common strategy adopted by other cities is the development of a city regional data repository. It remains to be seen if the proposed high potential and innovative Civic Data Trust/Cooperative will grow beyond health and social care and serve as a data platform for other domains of data, or whether similar Civic Data Trusts/Cooperatives will be established for (say) transport, skills, housing, the environment and so on. If the latter, a wider 'umbrella' city region data platform might be required. Such a data repository could take the form of a layered data hub with access control and various levels of openness. A first layer might include data produced by and for LCRCA and local authorities; a second layer could serve as a data marketplace, where data could be exchanged with private companies and citizens on defined terms; a third layer could function as the connection with other existing and future data sharing projects (e.g. the Civic Data Trust/Cooperative); and a fourth layer might operate as a regional Open Data portal with APIs, providing access to, for example, transportation, environmental and tourism data, and general statistics. Mechanisms for governing such a data hub would need to be decided upon, along with specific policies regulating data standards and formats and the secure exchange of data. Throughout all of this, the learning being accrued by the establishment of the Civic Data Trust/Cooperative will be of pivotal importance.

4. **A Joint Taskforce could enhance collaboration over data governance within and between LCRCA and local authorities**. The cornerstone of a digital and smart transition is the ability to connect resources, data and capabilities, and use them to maximum effect. LCRCA and the six constituent local authorities each own large volumes of data. Creating a Joint Taskforce to bring together LCRCA, the FIO and all the local authorities could serve as a starting point to initiate coordination of agreed data sharing strategies, prioritisation, and digital services development. Such a Taskforce would play a leading role in the shaping of any local data strategy.

5. **A City Regional Innovation Think Tank and training programs could improve stakeholder engagement, private sector employment, and digital skills development to make the region future-ready**. Working alongside LCR stakeholders is fundamental to guaranteeing that the whole city region moves towards digitalisation together and that the data ecosystem serves and benefits LCR public bodies, private businesses, third sector actors, and citizens. A City Regional Innovation Think Tank, working in an advisory capacity – drawing members from public bodies, the private sector, social enterprises, research institutes, and civil society – could facilitate wider input into the design, implementation and governance of any proposed data ecosystem. It could assist the Future Innovation Office and Joint Taskforce with setting an agenda and planning new projects, and could organise intelligence challenges to define potential uses of the data gathered, including hackathons, makeathons, and other events focused on shaping the data agenda and creating new opportunities for companies and social enterprises. It could also champion Open Access and local solutions regarding ethics, privacy, security, and digital inclusion.

6. **Through participation in peer-to-peer networks, continuous learning, connectivity and knowledge exchange could be ensured**. Across Europe, and especially thanks to European-funded projects testing technologies and sharing experiences in a network of cities (such as the Lighthouse Cities examined here, but also with follower and observer cities), there are a number of initiatives through which local governments are currently sharing good practices and lessons learned from failed and faltering interventions. Examples of these networks include: Open and Agile Smart Cities – a non-profit, international Smart City network with the goal of creating and shaping the nascent global Smart City data and services market (OASC, 2019) – and the Morgenstadt network, where research, industry and municipalities are working together to identify and nourish new markets and development potential within urban systems (Morgenstadt, 2019). LCRCA is already a member of the excellent MetroLab Network, and ongoing learning from this network will be invaluable. But LCR could also embed itself more centrally in other networks to gain and share further knowledge and experiences. It is only through continuous exposure to good practices that any city region will be able to build a data ecosystem capable of rivalling international competitors.

# CASE STUDIES PROFILED

Given the relevance of particular cities and projects (see Figure 9), alongside e-copies of this Good Practices Reference Guide, extended deep dive 'Use Cases' for a number of cities will be made available on the Heseltine Institute website: **www.liverpool.ac.uk/heseltine-institute/reports.**

**Figure 9**

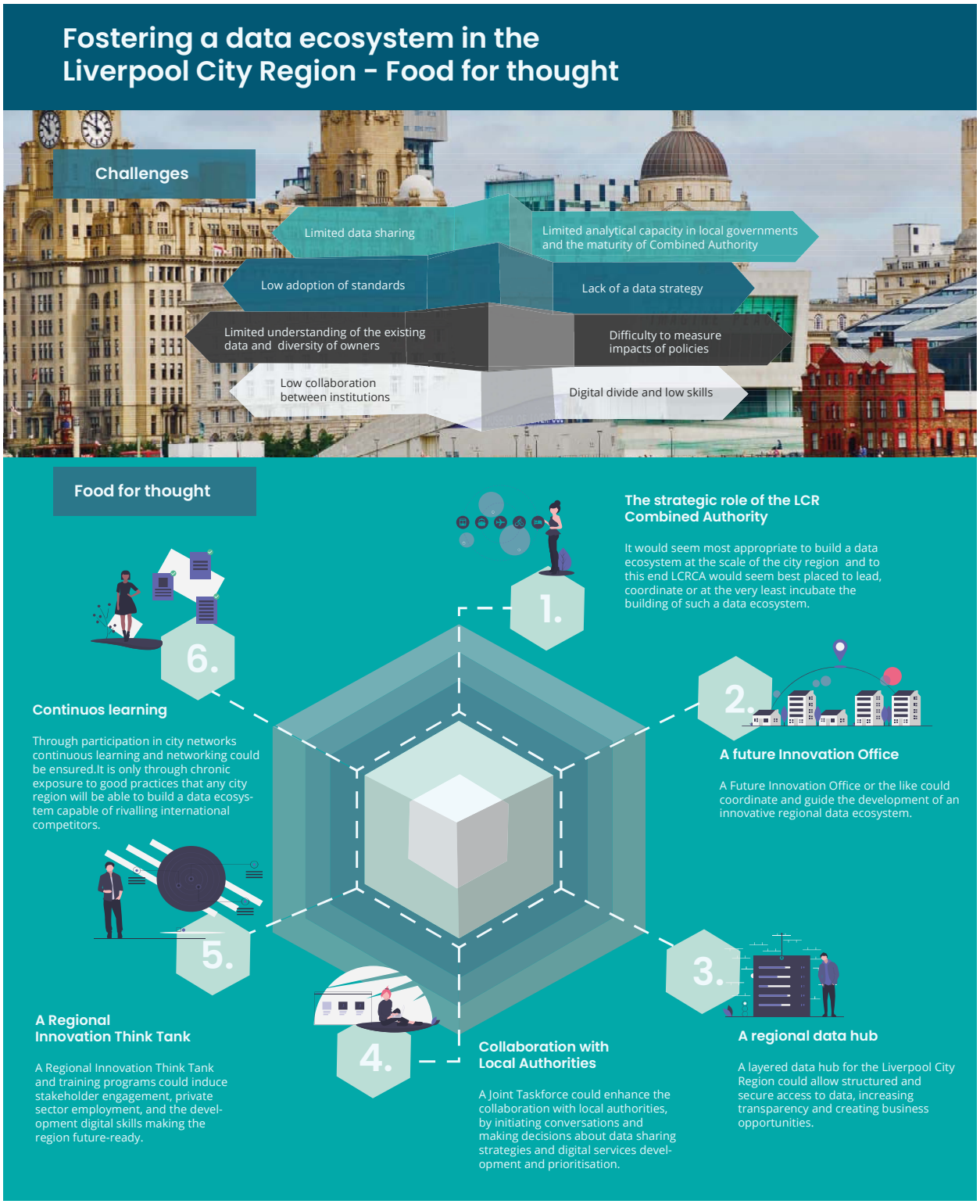
## Table of the good practice case studies profiled in this review

| Name | Location | Solution |
|---|---|---|
| **1. Open Source Database** | Vienna, Austria | The Use Case provided a technical ICT framework for monitoring the project data, a testbed for wider use in the city of Vienna, and a framework for ICT applications. |
| **2. Big Data Visualisation** | Cologne, Germany | The Urban Cockpit Solution provides a fast and easy overview of the current situation in the city concerning traffic, energy and environment. The tool is publicly available online for the citizens. |
| **3. Sharing Cities Urban Sharing Platform** | Milan, Italy | The Sharing Cities Urban Sharing Platform (USP) is a logical collection of technical components, capabilities and processes which provides information from a wide variety of devices and sensors to improve use of city resources and inform better choices. |
| **4. Smart City Data Platform** | Eindhoven, Netherlands | The living lab in Strijp-S is connected via this platform. The platform is designed to be open and transparent without compromising privacy or security and while respecting data ownership. Integration can occur in matters of minutes and the platform is set up to be limitlessly scalable. |
| **5. Big Data Integration Solution** | Barcelona, Spain | This semantic model reflects and connects three domains of interest: mobility, energy, and integrated infrastructures. Users can browse and query the ontology. The goal is to provide a solution that is easier to evolve, maintain, and export to new cities with different data and use patterns. |
| **6. Data-Enabled Innovation Challenges** | Manchester, United Kingdom | The innovation challenges run twice a year from 2018–2020. The process will adapt and evolve. The first challenge focused upon the exemplar apps and encouraged participants to identify ways to improve these ideas. |
| **7. X-Road Data Exchange Platform** | Tallinnn, Estonia | X-Road connects all e-governance applications in Estonia. It is a secure internet-based data exchange layer that enables the state's different information systems to communicate and exchange data. |
| **8. Citizen Science & IoT Data Governance** | Barcelona, Spain | This uses the DECODE wallet to connect to the SmartCitizen infrastructure and link the sensors with their accounts. Using the wallet, the users can select from a range of data sharing policies from predefined groups that have been previously discussed and agreed within their communities. |
| **9. Dublinked Data Portal** | Dublin Region, Ireland | Development and permanent update of an Open Data repository on Greater Dublin's urban provisions and built environment. Dublinked collects, curates, standardises, and shares data with the wider public on local services and provisions such as energy, environment, waste collection, water, traffic, and planning. |

# LIST OF INTERVIEWEES ENGAGED IN LIVERPOOL CITY REGION

1. Iain Buchan – Chair in Public Health and Clinical Informatics, Population Health Sciences
2. John Murray – Technical Innovator (Data Fusion Science) and Visiting Researcher (University of Liverpool). Topics: Data Science, Geodemographics, Small Area Estimation, Zone Design
3. Simeon Yates – Associate Pro Vice-Chancellor, Research Environment and Postgraduate Research (University of Liverpool)
4. Aileen Jones – Head of Research and Intelligence (Liverpool City Region Combined Authority)
5. John Whaling – Lead Officer, Digital and Innovation (Liverpool City Region Combined Authority)
6. Simon Maskell – Professor of Autonomous Systems, Electrical Engineering and Electronics (University of Liverpool)
7. Benjamin Barr – Senior Clinical Lecturer in Applied Public Health Research, Public Health and Policy (University of Liverpool)
8. Kelly Montana-Williams – Strategic Projects Manager, Research Partnerships and Innovation (University of Liverpool)
9. Paula Williamson – Professor of Medical Statistics, Biostatistics (University of Liverpool)
10. Alex Singleton – Professor of Geographic Information Science, Geography and Planning (University of Liverpool)
11. Paul Fergus – Associate Professor in Machine Learning (Liverpool John Moores University)
12. Carl Chalmers – Senior Lecturer in Computing and Mathematical Sciences (Liverpool John Moores University)
13. Alan Southern – PI on Social Economy Pillar at Heseltine Institute (Management School, University of Liverpool)
14. Huw Jenkins – Lead Officer for Transport, Policy and Strategic Commissioning Directorate (Liverpool City Region Combined Authority)
15. Robin Pinning – Chief Technology Officer (Hartree Centre)
16. Dave Meredith – Software Engineer (Hartree Centre)
17. Tom Collingwood – Blockchain Technical Specialist (Hartree Centre)
18. Sue Jarvis – Deputy Director of Heseltine Institute (University of Liverpool)
19. Lisa Ahmed – Senior Impact and Business Development Manager, Faculty of Science and Engineering (University of Liverpool)
20. Lisa Smith – Divisional Manager Policy, Intelligence and Performance, Office of the Chief Executive (Liverpool City Council)
21. Andy Garden – Head of Information Technology (Knowsley Council)
22. Ian Hawkins – Head of Information Technology (Liverpool City Region Combined Authority)

# FOOD FOR THOUGHT FOR LCR STAKEHOLDERS: A VISUALISATION



# REFERENCES (AND RESOURCES CONSULTED)


3D Model of Berlin, n.d. *City Models – Digital Inner City*. [online] Available at: <https://www.stadtentwicklung.berlin.de/planen/stadtmodelle/de/digitale_innenstadt/3d/download/index.shtml> [Accessed: 4 June 2019].

3D Model of Hamburg, n.d. *3D Building Models.* [online] Available at: <https://www.hamburg.de/bsw/geodaten/7615476/3d-gebaeudemodelle> [Accessed: 4 June 2019].

Ada Lovelace Institute, 2018. *Our Prospectus.* [online] *3D Building Models.* Available at: <https://www.adalovelaceinstitute.org/our-prospectus> [Accessed: 8 July 2019].

Agile Alliance, 2019. *12 Principles Behind the Agile Manifesto.* [online] Available at: <https://www.agilealliance.org/agile101/12-principles-behind-the-agile-manifesto> [Accessed: 14 June 2019].

Agile Alliance, 2019. *Agile 101.* [online] Available at: <https://www.agilealliance.org/agile101> [Accessed: 14 June 2019].

Agile Alliance, 2019. *The Agile Manifesto.* [online] Available at: <https://www.agilealliance.org/agile101/the-agile-manifesto> [Accessed: 14 June 2019].

Ajuntament de Barcelona, 2016. *Transició cap a la Sobirania Tecnològica: Pla 'Barcelona Ciutat Digital': Mesura de Govern.* Barcelona: s.n.

Amazon AWS, 2019. [online] Available at: <https://aws.amazon.com/de> [Accessed: 31 May 2019].

Amrusch, P. & Feilmayr, W., 2009. Nonmarket Valuation of Inner-City Ecological Values. *WIT Transactions on Ecology and the Environment*, 122, pp. 415–424.

Apache Cassandra, n.d. [online] Available at: <http://cassandra.apache.org> [Accessed: 31 May 2019].

Apache CloudStack, 2019. [online] Available at: <https://cloudstack.apache.org> [Accessed: 31 May 2019].

Apache Flink, n.d. [online] Available at: <https://flink.apache.org> [Accessed: 31 May 2019].

Apache Hadoop, n.d. [online] Available at: <https://hadoop.apache.org> [Accessed: 31 May 2019].

Apache Kafka, n.d. [online] Available at: <https://kafka.apache.org> [Accessed: 31 May 2019].

Associação Porto Digital, n.d. *Desafios Porto.* [online] Available at: <https://www.portodigital.pt/initiatives/cat/ongoing-2> [Accessed: 26 June 2019].

BABLE, 2019. *Use Cases.* [online] Available at: <https://www.bable-smartcities.eu/explore/use-cases.html> [Accessed: 9 July 2019].

Badenova, n.d. *Innovationsfonds für Klima- und Wasserschutz.* [online] Available at: <https://www.badenova.de/web/%C3%9Cber-uns/Engagement/Innovativ/index.jsp> [Accessed: 22 May 2019].

Baqueriza-Jackson, M., 2018. *Creating a Good Local Economy Through Procurement.* s.l.: Procure Network.

BerlinOnline, n.d. *Berlin Eine Erfolgsgeschichte.* [online] Available at: <https://www.berlinonline.net/beratung-entwicklung/referenzen/digitale-broschuere-berlin-eine-erfolgsgeschichte> [Accessed: 4 June 2019].

Bernstein, D., 2014. Containers and Cloud: From LXC to Docker to Kubernetes. *IEEE Cloud Computing,* 1(3), pp. 81–84.

BIRT, n.d. [online] Available at: <https://www.eclipse.org/birt> [Accessed: 4 June 2019].

Bitcoin, n.d. [online] Available at: <https://bitcoin.org> [Accessed: 31 May 2019].

Boettiger, C., 2015. An Introduction to Docker for Reproducible Research. *ACM SIGOPS Operating Systems Review,* 49(1), pp. 71–79.

Bos, L., 2016. *Horizon 2020 Funding for Innovation Procurement (PCP and PPI).* s.l.: s.n.

BPEL, 2019. *OASIS Web Services Business Process Execution Language (WSBPEL) TC*. [online] Available at: <https://www.oasis-open.org/committees/wsbpel> [Accessed: 31 May 2019].

BPMN, 2019. [online] Available at: <http://www.bpmn.org> [Accessed: 6 June 2019].

Bradley, G. & Tommis, M., 2017. *SmartImpact Meeting Report – Data Integration.* s.l.: SmartImpact.

Brown University, 2019. *Data Governance Roles.* [online] Available at: <https://www.brown.edu/about/administration/data-governance/data-governance-roles> [Accessed: 6 June 2019].

Business Application Research Center, 2017. *Data Governance: Definition, Challenges & Best Practices.* [online] Available at: <https://bi-survey.com/data-governance> [Accessed: 7 June 2019].

Carrara, W., Engbers, W., Nieuwenhuis, M. & Steenbergen, E., 2016. *Analytical Report 4: Open Data in Cities.* s.l.: European Data Portal.

Carson, R., 1985. *Three Essays on Contingent Valuation (Welfare Economics, Non-Market Goods, Water Quality)*. PhD. University of California.

Carson, R., 2000. Contingent Valuation: A User's Guide. *Environmental Science & Technology*, 34, pp. 1413–1418.

Chart.js, n.d. [online] Available at: <https://www.chartjs.org> [Accessed: 6 June 2019].

CKAN, n.d. [online] Available at: <https://ckan.org> [Accessed: 31 May 2019].

ComputerWeekly, 2018. *Ada Lovelace Institute Gets Board to Drive AI Research for Social Good*. [online] Available at: <https://www.computerweekly.com/news/252453699/Ada-Lovelace-Institute-gets-board-to-drive-AI-research-for-social-good> [Accessed: 8 July 2019].

Copeland, E., 2019. *What Would it Take to Help Cities Innovate Responsibly with AI?* [online] Available at: <https://www.nesta.org.uk/blog/helping-cities-innovate-responsibly-ai> [Accessed: 17 June 2019].

Cummings, R., Brookshire, D. & Schulze, W., 1986. *Valuing Environmental Goods: An Assessment of the Contingent Valuation Method.* Lanham: Rowman & Littlefield.

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

D3, n.d. *Data-Driven Documents*. [online] Available at: <https://d3js.org> [Accessed: 21 February 2020].

DATA.NY.GOV, n.d. *Developers Resources Page*. [online] Available at: <https://data.ny.gov/developers> [Accessed: 4 June 2019].

DCAT, 2019. *Data Catalog Vocabulary (DCAT)*. [online] Available at: <https://www.w3.org/TR/vocab-dcat> [Accessed: 31 May 2019].

DCAT-AP, 2019. *DCAT Application Profile for Data Portals in Europe*. [online] Available at: <https://joinup.ec.europa.eu/solution/dcat-application-profile-data-portals-europe> [Accessed: 31 May 2019].

Dean, J. & Ghemawat, C., 2008. MapReduce: Simplified Data Processing on Large Clusters. *Communications of the ACM*, 51(1), pp. 107–113.

Digital Dublin, 2013. *A Digital Masterplan for Dublin: Shaping our Digital Future – a Roadmap Summary*. Dublin: Dublin City Council.

DIN CEN/CLC/ETSI/TR 50572 VDE 0418-0:2014-10, 2014. *Functional Reference Architecture for Communications in Smart Metering Systems*. Berlin: Beuth Verlag.

DIN SPEC 91357, 2017. *Reference Architecture Model Open Urban Platform (OUP)*. Berlin: Beuth Verlag.

Eaton, M. & Bertoncin, C., 2018. *State of Offices of Data Analytics (ODA) in the UK*. London: Nesta.

EIP SCC, 2019. *Homepage.* [online] Available at: <https://eu-smartcities.eu> [Accessed: 27 May 2019].

Espresso Project, 2017. *Citizen Focus Ambassador Cities Initiative Relaunch.* [online] Available at: <http://espresso-project.eu> [Accessed: 31 May 2019].

Esri, n.d. *ArcGIS: The Mapping and Analytics Platform*. [online] Available at: <https://www.esri.com/de-de/arcgis/about-arcgis/overview> [Accessed: 6 June 2019].

Ethereum, n.d. [online] Available at: <https://www.ethereum.org> [Accessed: 21 May 2019].

Ethics Toolkit, n.d. *Ethics & Algorithms Toolkit.* [online] Available at: <https://ethicstoolkit.ai> [Accessed: 17 June 2019].

EUROCITIES, 2019. *EUROCITIES Principles on Citizen Data.* [online] Available at: <http://nws.eurocities.eu/MediaShell/media/Citizen_data_principles_final_draft.pdf> [Accessed: 23 February 2020].

European Data Portal, 2018. *Open Data Goldbook for Data Managers and Data Holders: Practical Guidebook for Organisations Wanting to Publish Open Data*. Paris: Capgemini.

European Investment Bank, 2015. *France: Nord-Pas de Calais Region Set to Support the Third Industrial Revolution.* [online] Available at: <https://www.eib.org/en/press/all/2015-237-nord-pas-de-calais-15-meur-dans-un-fonds-dinvestissement-dedie-a-la-troisieme-revolution-industrielle> [Accessed: 22 May 2019].

Financial Times, 2019. *How China's Smart-City Tech Focuses on its Own Citizens.* [online] Available at: <https://www.ft.com/content/46bc137a-5d27-11e9-840c-530737425559> [Accessed: 8 July 2019].

Flotr2, n.d. *The Canvas Graphing Library*. [online] Available at: <https://github.com/HumbleSoftware/Flotr2> [Accessed: 4 June 2019].

Fraunhofer IAO, 2018. *Data Governance Roles – Hierarchical Framework*. Stuttgart: Fraunhofer IAO.

Fraunhofer IAO, 2019. *Digitale Transformation – eine neue Perspektive für München. Anforderungen an die Fortschreibung der Perspektive München*. Stuttgart: Fraunhofer IAO.

Fraunhofer IAO, 2019. *Stakeholder Mapping – Data Ecosystem*. Stuttgart: Fraunhofer IAO.

G8, 2013. *G8 Open Data Charter and Technical Annex*. [online] Available at: <https://www.gov.uk/government/publications/open-data-charter/g8-open-data-charter-and-technical-annex> [Accessed: 23 February 2020].

Google Chart, n.d. *Display Live Data on Your Site*. [online] Available at: <https://developers.google.com/chart> [Accessed: 4 June 2019].

Google Compute, 2019. *Compute Engine*. [online] Available at: <https://cloud.google.com/compute> [Accessed: 31 May 2019].

Government of London, 2018. *Smarter London Together.* [online] Available at: <https://www.london.gov.uk/what-we-do/business-and-economy/supporting-londons-sectors/smart-london/smarter-london-together> [Accessed: 18 April 2019].

Government of London, 2019. *London to Create Digital Map of Underground Pipes and Cables.* [online] Available at: <https://www.london.gov.uk/press-releases/mayoral/london-to-create-digital-map-of-underground-pipes> [Accessed: 31 May 2019].

Greater Manchester Combined Authority, 2017. *The Greater Manchester Digital Strategy 2018–2020.* Greater Manchester: s.n.

Gyselinck, D. & Raisière, M., 2018. *Building the Solutions of Tomorrow Together.* [online] Available at: <https://smartbelgium.belfius.be/wat-is-smart-belgium> [Accessed: 22 May 2019].

International Data Spaces, 2019. [online] Available at: <https://www.internationaldataspaces.org> [Accessed: 31 May 2019].

JavaScript InfoVis Toolkit, n.d. *Creative Interactive Data Visualizations for the Web*. [online] Available at: <https://philogb.github.io/jit> [Accessed: 4 June 2019].

Jayasena, N. S., Mallawarachchi, H. & Waidyasekara, K., 2019. *Stakeholder Analysis For Smart City Development Project: An Extensive Literature Review.* Les Ulis: MATEC Web of Conferences/EDP Sciences.

Han, J., Haihong, E., Guan, L. & Du., J., 2011. Survey on NoSQL Database. In: *6th International Conference on Pervasive Computing and Applications*. Piscataway: Institute of Electrical and Electronics Engineers, pp. 363–366.

JpGraph, n.d. *Chart Gallery*. [online] Available at: <https://jpgraph.net> [Accessed: 4 June 2019].

Kamvar, S. D., Schlosser, M. T. & Garcia-Molina, H., 2003. The Eigentrust Algorithm for Reputation Management in P2P Networks. In: *WWW '03: Proceedings of the 12th International Conference on World Wide Web*. New York City: Association for Computing Machinery, pp. 640–651.

KPMG, 2017. *Data Driven Government*. [online] Available at: <https://assets.kpmg/content/dam/kpmg/be/pdf/Markets/at-gov-brochure.pdf> [Accessed: 23 February 2020].

Leaflet Library, 2017. *Overview.* [online] Available at: <https://leafletjs.com> [Accessed: 4 June 2019].

Liverpool City Region Local Enterprise Partnership, 2016. *Building Our Future: Liverpool City Region Growth Strategy*. Liverpool: Liverpool City Region Local Enterprise Partnership.

Liverpool City Region Combined Authority, 2018. *Digital Spine to Connect City Region to Ultra-Fast Fibre Broadband.* [online] Available at: <https://www.liverpoolcityregion-ca.gov.uk/digital-spine-to-connect-ultra-fast-fibre-broadband-across-liverpool-city-region> [Accessed: 16 May 2019].

Liverpool City Region Combined Authority, 2018. *Skills for Growth Action Plan: Digital and Creative 2018–2020*. Liverpool: Liverpool City Region Combined Authority.

Liverpool City Region, 2015. *Liverpool City Region Devolution Agreement*. London: HM Treasury.

Ludwigsburg Stadt, 2019. *KSIS: Kommunales Steuerungs- und Informationssystem.* [online] Available at: <https://www.ludwigsburg.de/start/stadt_buerger/ksis.html> [Accessed: 23 May 2019].

Maria DB, n.d. *The Open Source Relational Database.* [online] Available at: <https://mariadb.org> [Accessed: 31 May 2019].

Ministry of Housing, Communities and Local Government, 2019. *Local Digital Fund.* [online] Available at: <https://localdigital.gov.uk/fund> [Accessed: 22 May 2019].

MongoDB, n.d. [online] *The Database for Modern Applications*. Available at: <https://www.mongodb.com> [Accessed: 31 May 2019].

Morgenstadt, City of the Future, 2013. *Innovation Network, 'Morgenstadt: City Insights' – New York City*. Stuttgart: Fraunhofer.

Morgenstadt, 2019. *About Us.* [online] Available at: <https://www.morgenstadt.de/en/about_us.html> [Accessed: 18 June 2019].

NGO INESC, n.d. *Public Portal for Tax Budgeted Visualization.* [online] Available at: <http://orcamento.inesc.org.br> [Accessed: 4 June 2019].

OASC, 2019. *About.* [online] Available at: <https://oascities.org/about-oasc> [Accessed: 18 June 2019].

OECD, 2002. *OECD Guidelines for the Security of Information Systems and Networks: Towards a Culture of Security.* Paris: OECD Publications.

Open Cities, 2010. [online] Available at: <https://www.fokus.fraunhofer.de/go/OpenCities> [Accessed: 31 May 2019].

Open Data Institute, 2019. *Data Trusts: Lessons From Three Pilots*. London: ODI.

Open Data Institute, 2019. *Greater London Authority and Royal Borough of Greenwich – Data Trust Pilot: Summary Report.* London: Open Data Institute.

Open Source Initiative, 2007. *The Open Source Definition.* [online] Available at: <https://opensource.org/osd> [Accessed: 27 May 2019].

OpenDataSoft, 2019. *Leading Solution for Data Sharing.* [online] Available at: <https://www.opendatasoft.com> [Accessed: 31 May 2019].

OpenStack, n.d. *Open Source Software for Creating Private and Public Clouds*. [online] Available at: <https://www.openstack.org> [Accessed: 31 May 2019].

Oxford Dictionary of Computer Science, n.d. *Open System definition*. Oxford: Oxford University Press.

PostgreSQL, n.d. *The World's Most Advanced Open Source Relational Database.* [online] Available at: <https://www.postgresql.org> [Accessed: 31 May 2019].

Processing.js, n.d. *A Port of the Processing Visualisation Language*. [online] Available at: <http://processingjs.org> [Accessed: 4 June 2019].

Raphael.js, n.d. *JavaScript Library*. [online] Available at: <https://dmitrybaranovskiy.github.io/raphael> [Accessed: 31 May 2019].

React-vis, n.d. *A Composable Charting Library*. [online] Available at: <https://uber.github.io/react-vis> [Accessed: 31 May 2019].

Robertson, J., 2017. *Toward Treating 'Data as Infrastructure'.* [online] Available at: <https://medium.com/@JonSRobertson/toward-treating-data-as-infrastructure-8cd68c692f6d> [Accessed: 18 April 2019].

Ross, R., McEvilley, M. & Oren, J. C., 2016. *Systems Security Engineering: Considerations for a Multidisciplinary Approach in the Engineering of Trustworthy Secure Systems*. Gaithersburg: NIST Publications, U.S. Department of Commerce, Special Publication (NIST SP), Report Number 800–160.

Sautter, J., Litauer, R., Fischer, R., Klages, T., Wuchner, A., Müller, E., Schaj, G., Dobrokhotova, E., Drews, P. & Reiss, S., 2018. Beyond Data Quality: Data Excellence Challenges from an Enterprise, Research and City Perspective. In: *Proceedings of the 7th International Conference on Data Science, Technology and Applications*. New York City: Association for Computing Machinery, pp. 245–252.

Schieferdecker, I., Bruns, L., Cuno, S., Flügge, M., Isakovic, K., Klessmann, J., Lämmel, P., Stadtkewitz, D., Tcholtchev, N., Lange, C., Imbusch, B. T., Strauss, L., Vastag, A., Flocke, F. & Kraft, V., 2018. *Urbane Datenräume – Möglichkeiten von Datenaustausch und Zusammenarbeit im Urbanen Raum*. Berlin: Fraunhofer FOKUS.

Scholz, R., Tcholtchev, N., Lämmel, P. & Schieferdecker, I., 2017. From Metadata Catalogs to Distributed Data Processing for Smart City Platforms and Services: A Study on the Interplay of CKAN and Hadoop. In: *International Conference on Cloud Computing and Services Science*. New York City: Springer Nature, pp. 115–136.

Smart Cities Dive, 2018. *Rise of the Chief Data Officer: Cities Learn to Crunch the Numbers*. [online] Available at: <https://www.smartcitiesdive.com/news/rise-of-the-chief-data-officer-cities-learn-to-crunch-the-numbers/521999> [Accessed: 7 June 2019].

Smart City Wien, 2019. *Framework Strategy.* [online] Available at: <https://smartcity.wien.gv.at/site/en/the-initiative/framework-strategy> [Accessed: 20 June 2019].

Smart Data Forum, 2019. *Homepage.* [online] Available at: <https://smartdataforum.de/en> [Accessed: 31 May 2019].

Smart London, 2019. *Building a New London Office for Technology & Innovation.* [online] Available at: <https://medium.com/@SmartLondon/building-a-new-london-office-for-technology-innovation-9b2b0c142127> [Accessed: 29 May 2019].

Smart Services, 2019. *Smart Service Worlds*. [online] Available at: <https://www.bmwi.de/Redaktion/DE/Artikel/Digitale-Welt/smart-service-welt.html> [Accessed: 31 May 2019].

Socrata, 2019. *Data Insights, Citizen Engagement, and Performance Optimization*. [online] Available at: <https://www.tylertech.com/products/socrata> [Accessed: 31 May 2019].

Stadt Graz, 2018. *Digitale Agenda,* Graz: Graz City Council.

Stadt Wien, 2019. *Data Excellence Strategy of the City of Vienna.* [online] Available at: <https://digitales.wien.gv.at/site/en/data-excellence-strategy-of-the-city-of-vienna> [Accessed: 29 May 2019].

Swan, M., 2015. *Blockchain: Blueprint for a New Economy*. Sebastopol: O'Reilly and Associates.

Techradar, 2018. *Container Technology.* [online] Available at: <https://www.techradar.com/news/what-is-container-technology> [Accessed: 31 May 2019].

TechRepublic, 2008. *The CIA Triad.* [online] Available at: <https://www.techrepublic.com/blog/it-security/the-cia-triad> [Accessed: 3 June 2019].

The City of New York, 2011. *Road Map for the Digital City: Achieving New York City's Digital Future*. New York City: NYC Digital.

The Data Management Association, 2014. *DAMA-DMBOK2 Framework*. s.l.: DAMA International.

The New York City Council, 2017. *Legislation Text: Int. 1696–2017*. New York City: New York City Council.

The New York Times, 2019. *San Francisco Bans Facial Recognition Technology.* [online] Available at: <https://www.nytimes.com/2019/05/14/us/facial-recognition-ban-san-francisco.html> [Accessed: 8 July 2019].

Triangulum Project, 2019. *Homepage.* [online] Available at: <https://www.triangulum-project.eu> [Accessed: 31 May 2019].

Triangulum Project, 2019. *Smart City Decision Making Tool.* [online] Available at: <https://www.triangulum-project.eu/?page_id=3576> [Accessed: 1 June 2019].

Trusted Cloud, 2019. *Trusted Cloud*. [online] Available at: <https://www.bmwi.de/Redaktion/DE/Artikel/Digitale-Welt/trusted-cloud.html> [Accessed: 31 May 2019].

UK 5G Innovation Network, 2018. *Liverpool 5G Testbed.* [online] Available at: <https://uk5g.org/discover/testbeds-and-trials/liverpool-5g-testbed> [Accessed: 16 May 2019].

von Radecki, A., Bradley, G. & Tommis, M., 2018. *SmartImpact Action Planning Network: Management & Governance of Urban Data Thematic Report*. s.l.: URBACT III – SmartImpact Action Planning Network.

von Radecki, A., Suska, P., Tommis, M. & Bradley, G., 2017. *A Thematic Report: Finance & Procurement for Smart Cities*. Manchester: URBACT III – SmartImpact Action Planning Network.

Web Services Activity, n.d. *Web Services Activity*. [online] Available at: <https://www.w3.org/2002/ws> [Accessed: 31 May 2019].

Wolfgang, W., Grallert, H.-J., Wess, S., Friedrich, H. & Widenka, T., 2014. *Towards the Internet of Services: The THESEUS Research Program*. s.l.: Springer Publishing.

## ADDITIONAL RESOURCES CONSULTED

BABLE, 2019. *Barcelona's Big Data Integration Solution.* [online] Available at: <https://www.bable-smartcities.eu/explore/use-cases/use-case/useCase/barcelonas-big-data-integration-solution.html> [Accessed: 12 June 2019].

BABLE, 2019. *Big Data Visualization for Cologne.* [online] Available at: <https://www.bable-smartcities.eu/explore/use-cases/use-case/useCase/big-data-visualization-for-cologne.html> [Accessed: 6 June 2019].

BABLE, 2019. *Open Source Database.* [online] Available at: <https://www.bable-smartcities.eu/explore/use-cases/use-case/useCase/open-source-database.html> [Accessed: 6 June 2019].

BABLE, 2019. *Sharing Cities Urban Sharing Platform (USP).* [online] Available at: <https://www.bable-smartcities.eu/explore/use-cases/use-case/useCase/sharing-cities-urban-sharing-platform-usp.html> [Accessed: 6 June 2019].

BABLE, 2019. *Smart City Data Platform.* [online] Available at: <https://www.bable-smartcities.eu/explore/use-cases/use-case/useCase/smart-city-data-platform.html> [Accessed: 6 June 2019].

BABLE, 2017. *Data-Enabled Innovation Challenges*. [online] Available at: <https://www.bable-smartcities.eu/explore/use-cases/use-case/useCase/data-enabled-innovation-challenges.html> [Accessed: 6 June 2019].

BABLE, 2017. *Eindhoven Open Data Portal.* [online] Available at: <https://www.bable-smartcities.eu/explore/use-cases/use-case/useCase/eindhoven-open-data-portal.html> [Accessed: 6 June 2019].

Caragliu, A., Del Bo, C. & Nijkamp, P., 2011. Smart Cities in Europe. *Journal of Urban Technology,* 18(2), pp. 65–82.

DECODE Project, 2018. *D5.6 Deployment of Pilots in Barcelona.* [online] Available at: <https://decodeproject.eu/publications/deployments-pilots-barcelona> [Accessed: 15 April 2019].

DECODE, 2019. *DECODE DDDC Participatory Platform.* [online] Available at: <https://dddc.decodeproject.eu/?locale=en> [Accessed: 15 April 2019].

Dublinked, 2019. *Open Data for the Dublin Region.* [online] Available at: <https://data.smartdublin.ie> [Accessed: 17 June 2019].

European Political Strategy Centre, 2017. *Enter the Data Economy: EU Policies for a Thriving Data Ecosystem*. Brussels: European Commission.

FOLDOC, 2008. *Information and Communication Technology.* [online] Available at: <http://foldoc.org/Information+and+Communication+Technology> [Accessed: 12 July 2019].

Government of the United Kingdom, 2017. *Industrial Strategy: Building a Britain Fit for the Future.* [online] Available at: <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/664563/industrial-strategy-white-paper-web-ready-version.pdf> [Accessed: 22 February 2020].

Government of the United Kingdom, 2019. *About Us.* [online] Available at: <https://www.gov.uk/government/organisations/office-for-artificial-intelligence/about> [Accessed: 8 July 2019].

Hermann, M., Pentek, T. & Otto, B., 2016. Design Principles for Industrie 4.0 Scenarios. In: *49th Hawaii International Conference on System Sciences (HICSS)*. Piscataway: Institute of Electrical and Electronics Engineers, pp. 3928–3937.

Hughes, J., et al., 2005. *Profiles for the OASIS Security Assertion Markup Language (SAML) V2.0.* Burlington: OASIS Open.

International Telecommunications Union, 2012. *Internet of Things Global Standards Initiative.* [online] Available at: <https://www.itu.int/en/ITU-T/gsi/iot/Pages/default.aspx> [Accessed: 12 July 2019].

Kiivet, H., Areng, L. & Cybernetica, A., n.d. *X-Road Summary.* [online] Available at: <https://joinup.ec.europa.eu/sites/default/files/inline-files/EE03.pdf> [Accessed: 15 April 2019].

OAuth, n.d. [online] Available at: <https://oauth.net> [Accessed: 31 May 2019].

Pinsent Masons, 2018. *National Data Strategy to be Developed in the UK.* [online] Available at: <https://www.pinsentmasons.com/out-law/news/national-data-strategy-uk> [Accessed: 26 June 2019].

Russell, S. & Norvig, P., 2009. *Artificial Intelligence: A Modern Approach.* 3rd ed. New Jersey: Prentice Hall.

Shibboleth, n.d. *Shibboleth Consortium: Privacy Preserving Identity Management.* [online] Available at: <https://www.shibboleth.net> [Accessed: 31 May 2019].

Sikkut, S., 2013. *e-Estonia: Open Source Based.* [online] Available at: <https://joinup.ec.europa.eu/sites/default/files/news/attachment/estonia_sikkut_22may2013.pdf> [Accessed: 15 April 2019].

Triangulum Project, 2018. *Triangulum Smart City Decision Making Tool.* [online] Available at: <https://www.triangulum-project.eu/?page_id=3576> [Accessed: 15 April 2019].

van Winden, W. & de Carvalho, L., 2015. *The Open Data Economy: Promoting Digital Innovation in Dublin*. Saint Denis: URBACT II Capitalisation.

Vassil, K., 2016. *Estonian e-Government Ecosystem: Foundation, Applications, Outcomes*. Washington: World Bank Group.

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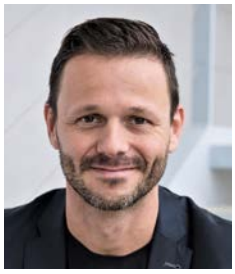

**Alanus von Radecki** founded the Smart City marketplace BABLE in 2017, and currently acts as CIO and Senior Consultant. He is also Head of the Competence Team Urban Governance Innovation at the Fraunhofer IAO, and Head of the Innovation Network Morgenstadt: City Insights. He has coordinated collaborations between more than 30 companies, 20 cities, and 12 Fraunhofer Institutes on innovation projects for sustainable urban development, leading to Smart City innovation projects all over Europe with an overall worth of around EUR €120 million.

In addition to his activities in project coordination and management, his work focuses on urban governance, systems analysis, and complexity research directly related to urban systems. While conducting research on urban governance and transformation management in complex socio-technical systems, he finished his PhD as a doctoral candidate in Technology Management & Urban Governance at Stuttgart University in 2019. He has been working closely at the interface between urban institutions and the private sector for many years, and has worked in the private sector (at the IT company Lexware) as well as the public sector (German Ministry of Environment).

Parallel to his role at BABLE and the Fraunhofer IAO, Alanus is the Lead Expert for the URBACT network's SmartImpact, and advises cities such as Stockholm, Manchester, Eindhoven, Porto, Dublin, and Zagreb on the transformation of the governance system within city administrations and beyond.

## NIKOLAY TCHOLTCHEV
### Senior Researcher & Project Manager, Fraunhofer FOKUS

**Nikolay Tcholtchev** is a Senior Researcher and Project Manager with a degree from the Berlin University of Technology. He is currently working for Fraunhofer FOKUS, where he leads and participates in projects related to the areas of Smart Cities (Open Urban Platforms), autonomic communications and computing, model-based testing, future internet, IPv6, and risk-based testing for security purposes. He is involved in activities within the German DIN standardisation body (DIN SPEC 91357 and DIN SPEC 91367), as well as at the European level (EIP SCC) relating to Open Urban Platforms and ICT reference architectures for Smart Cities.

In this capacity, Nikolay investigates the utilisation of blockchain technologies in future urban environments, such as the utilisation of Ethereum for smart energy trading and for the shared economy in general. He has a special interest in urban mobility and ICT infrastructures for electric mobility, and has been involved in various roles (including developer, technical project manager, and system architect) in the development and operations of Open Data portals such as GovData.DE.

## PHILIPP LÄMMEL
### Senior Researcher & Project Manager, Fraunhofer FOKUS

**Philipp Lämmel** is a Senior Researcher and Project Manager at Fraunhofer FOKUS. His main research areas include the design, specification and implementation of various Smart City platforms, together with ongoing requirements analysis, testing, and continuous integration. He has also been a project manager for several undertakings related to Smart Cities, and is active in the areas of DLT/blockchain, security, Artificial Intelligence, IoT, e-health, and cloud computing.

Philipp studied Computer Science at the Free University of Berlin, and finalised his Master's thesis on the subject of Security for Smart Cities at Berlin's Fraunhofer Institute for Open Communication Systems. His technical expertise also includes algorithms, programming languages, operating systems, and communication networks. An area of special interest within his research and development activities is the development of Proof of Concepts, which showcases the potential of different algorithms in the domain of DLT/blockchains, such as blockchain-facilitated Smart Energy trading, and AI.

## GRETEL SCHAJ
### Junior Consultant & Communications Manager

**Gretel Schaj** is the Communications Manager and Data Governance Consultant at BABLE UG. As a consultant, she advises governments on matters of organisation, stakeholder engagement, data policies and governance.

Gretel holds a Master's degree in Environmental Governance from the University of Freiburg, Germany. Her Master's thesis explores how data governance takes place and is shaped inside and outside local public administrations, and was written in the context of the EU co-founded Horizon 2020 project UNaLab (Urban Nature-Based Solutions Laboratory).

During her Bachelor studies she interned at Avina, a foundation working towards sustainable development in Latin America, where she designed an index to measure sustainability in cities. After completing her studies, she worked for a year and a half at the Los Verdes political foundation as Project Leader, coordinating several activities between governments and other stakeholders and researching and reporting on environmental issues. She also worked for three years as a Research Assistant on a project for the Universidad Católica de Córdoba in Argentina, exploring the linkages between regional integration and energy policies.

## BABLE UG

BABLE UG is a for-profit start-up founded in April 2017 and supported by the Fraunhofer Society. BABLE UG offers an exchange platform for the Smart City community and provides a digital toolkit to facilitate implementation of smart and sustainable solutions in cities. It enables innovative companies, public authorities, and experts to exchange information, ideas, products, services, and Use Cases as reference projects. The BABLE platform provides neutrally described Smart City solutions as blueprints and complementary services to its community, and helps companies understand how their products match urban demand and supply. The objective is to enhance economic potential, reduce costs and open new business opportunities. Some of the features offered include market consultation, technical expertise, innovative procurement, promotion mechanisms (such as own Use Cases, local SMEs, and so on), building capacities, and space for dialogue with other cities, companies, and research institutes.

The platform, along with its automated services, revolutionises the European Smart City market by facilitating innovative public procurement methods, promoting best practices, and increasing visibility of new and innovative technologies introduced by other SMEs. With the inherent structural ontology of the BABLE Platform Assets, the platform is highly scalable and will expand into global market after gaining a strong foothold in Europe.

## FRAUNHOFER FOKUS

With around 450 employees, the Fraunhofer Institute for Open Communication Systems (Fraunhofer FOKUS, www.fokus.fraunhofer.de) is one of the largest Fraunhofer Institutes. With more than 25 years of experience, FOKUS is one of the most important actors in the ICT research landscape, both nationally and worldwide. Market-orientated solutions are being distributed by a total of 15 spinoffs.

This neutral research institute develops solutions for digital interconnectivity, with the goal of making the networked world safe, reliable, scalable, and trustworthy. FOKUS acts as a supplier and technology-independent agent between industry, science and public administration, combining long-standing scientific expertise with experience from various branches to generate optimal solutions for its customers. The researchers concentrate not only on technical infrastructure, but also develop practical concepts, prototypes and applications in a pre-competitive environment. At the centre of the research activities lies the development of cross-domain and cross-organisational solutions which are both interoperable and user-centric. General services of Fraunhofer FOKUS include:

- Development of communication and information technologies, components, platforms and services for the digital transformation, specifically for applications domains and cross-domain
- Integration, networking and analysis of systems and organisations
- Quality assurance and certification of networked systems and organisational processes
- Practical demonstration, piloting and evaluation of the latest technologies
- Customisation of proprietary interfaces and systems to industrial, national and international standards
- Methods and tools for secure and efficient development of software-based systems.

# ABOUT THE HESELTINE INSTITUTE FOR PUBLIC POLICY, PRACTICE AND PLACE

The Heseltine Institute for Public Policy, Practice and Place is a non-partisan, internationally recognised University of Liverpool research institute, bringing together expertise from across the University and policy communities to co-create, impact upon and influence public policies for tomorrow's cities. We do this by:

- Undertaking, funding and publishing fundamental and applied research
- Providing thought leadership, consultancy and advice
- Convening and hosting events, including conferences, policy provocations, workshops and seminars
- Building and strengthening academic–practitioner networks
- Developing capacity-building and providing training courses
- Providing an evidence base to have impact on public policy.

This Good Practices Reference Guide, an accompanying Heseltine Institute Position Statement, Briefing Notes on key case studies examined herein, and a special international symposium held in March 2020 represent the Heseltine Institute's contribution to unleashing the potential presented by big data in the Liverpool City Region whilst preserving and championing 'tech and data management for public good'. Through our activities and outputs in 2020, we hope to contribute to the clarification of what a citizen-centred *Smart* Liverpool City Region might look like, and how we might build it.

Outputs can be downloaded from the Heseltine Institute website **www.liverpool.ac.uk/heseltine-institute.**

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Further details about the Heseltine Institute can be obtained at:

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Copies of the report can be accessed at:

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