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Fiber and the City: Internet Infrastructure in the Context of Urban Form and Planning

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Affidavit

I, **WOLFGANG OTTER**, hereby declare

1. that I am the sole author of the present Master's Thesis, "FIBER AND THE CITY: INTERNET INFRASTRUCTURE IN THE CONTEXT OF URBAN FORM AND PLANNING", 77 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and

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Abstract

Information and Communications Technology (ICT) has become an integral part of today's cities. It is not only incorporated into but shapes the built environment, it sustains and supports other critical infrastructure, and it has become one of the main methods for citizens to interact with the cities they live in. However, research into the complex interrelations between the urban fabric and ICT. has not kept up with the rising influence and integration of ICT – which is shown to be partly attributable to a number of structural impediments. In this work I will try to discern the influence ICT has on our cities and its citizens by focusing on the macro-, meso-, and micro-level respectively.

First, I employ a quantitative analysis of data and physical inter-city traffic between major European urban centers to showcase the rising importance of ICT in a global information exchange. Second, I concentrate on the district-level and qualitatively investigate three greenfield smart city projects and their implementation of ICT. Last, on the smallest scale I take a socio-political look at the interaction of citizens with ICT – prioritizing questions of access and availability; and large-scale data management, protection, and ownership. The city of Vienna and its policies will serve as a frame of reference throughout this work to effectively compare the obtained results and put them into context. I will show that despite the manifold effects of increasing ICT implementation, many cities and urban developments have yet to catch up and explicitly address this issue. Additionally, further research into this area from an urban-planning point of view is urgently needed to counteract a very deterministic, technology-fixated narrative dominated by large corporations.

Keywords: information and communications technology; ICT; internet exchange point; smart city; big data; broadband access; data ownership; New Songdo; Masdar; Vienna

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List of Abbreviations

ACI	Airports Council International
AP	Wireless Access Point
BND	Bundesnachrichtendienst
DE-CIX	Deutscher Commercial Internet Exchange
Euro-IX	European Internet Exchange Association
ICT	Information and Communication Technology
ISP	Internet Service Provider
IX	*see IXP*
IXP	Internet Exchange Point
NAP	Network Access Point; *equivalent to IXP*
NSA	National Security Agency
OS	Operating System
PCH	Packet Clearing House
RFID	Radio-Frequency Identification
VIX	Vienna Internet eXchange
WAP	*see AP*
XP	*see IXP*

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1. ICT and the Urban Environment

1.1. Introduction and Structure of the Thesis

In this work I set out to explore the complex web spanning between information and communications technology (ICT) and our cities. Marked by the rise of expressions such as 'smart city' or 'internet of things', the urban future seems to rely heavily on the prevalence of ICTs. These will gain an infrastructural importance akin to the electricity, heating, water or sewage system. It is needless to say that ICTs and the internet they enable not only generate a physical representation but are capable of heavily influencing and shaping our actual surroundings - the very fabric we live in[1]. However, how exactly ICT 'appears' in our cities has been relatively little explored, calling for much needed investigation into the matter.

In order to get a thorough grasp on the relation between ICT and urban form, planning, and processes, this analysis is split into three different spatial levels: macro, meso, and micro. For each of these a different set of questions is proposed within the according research framework. To 'ground' the research I will use Vienna as an example and anchor point on all three levels, providing an opportunity for a more in-depth analysis and in order to contextualize the obtained results.

On the macro-level I focus on inter-city networks in an ICT-mediated environment, addressing the main question of how strongly key urban centers in Europe are connected via ICT - also compared to physical transportation, in that case airline traffic. Delving deeper into the urban structure, on the meso-level I will take a look at what effects ICT has on the urban form, fabric, and planning. Lastly, on the micro-scale I will concentrate on the citizens - users and non-users of ICT alike - and ask what the level of access to ICT and the internet is, and whether Vienna has a city-wide strategy regarding inclusivity, data management, and ICT development. In the concluding chapter I will aim at providing a set of policy recommendations for Vienna based on the previous findings.

[1] I will follow Deleuze (2002) in using 'virtual' and 'actual' to differentiate between 'online' and 'offline' surroundings, as I view both to be just as 'real'.

Thus, this thesis is organized in three parts. To begin with, there will be a short introduction to the relevant terminology and technology, followed by a literature review of ICT and its integration into the urban environment. The first part ends with an explanation of the research framework for the three different spatial scales and an overview of relevant studies relating to either of the three. The second part contains the actual analysis on the macro-, meso-, and micro-level split into three sub-chapters, before the third part opens with a summary of the findings, condensed into recommendations for Vienna and its relation to ICT development and implementation. Lastly, the thesis closes with a brief note discussing possible areas of further research.

1.2. Definition of ICT

The term 'Information and Communications Technology' (ICT) was popularized by the OECD (2011, 58; 51), which defines the whole sector by its function to "capture, transmit or display data and information electronically" and includes mainly public switched telecommunication networks, cellular networks, the internet and all connected devices, radiocommunication, and the broadcasting system (Petermann et al. 2010, 66). However, in a broader sense this also covers the web of sensors deployed, the wired and wireless connections, and the related computing power. With the field in general being subject to rapid changes, overly precise definitions run the risk of being outdated within months (Neuman 2006, 21). It should also be noted, that an overlap is developing between ICT and other technologies; with more and more devices being equipped with sensors, becoming connected, and 'going online' - and specifically devices that were not necessarily considered to be part of ICT, such as doors, traffic lights, or other architectural elements.

1.3. Historical Development and Spatial Heritage

Historically, cities have always been depending on the quick transmission of information. What used to be a sophisticated postal network relying on ample horse supply (and later on railways and trains), would completely change with the establishment of telegraph lines in the first half of the nineteenth century. In 1866 the first undersea cable traversing the Atlantic was put into permanent use - cutting travel times for information exchange between Europe and North America from around ten days to a few minutes. With the increased use of the telephone, starting at the end of the nineteenth century, a new set of buildings was required - telephone hotels, where the switching between different lines took place.

It is these ancestors in urban communication that our modern-day ICT infrastructure oftentimes still follows very closely in a spatial regard. Telephone switching buildings have been transformed into Internet Exchange Points (IXPs), old copper cables have been replaced by fiber-optic ones, and the amount of information transmitted has risen exponentially. However, what is currently presented as brand new technology is still embedded in a societal context following long established routes of information and connecting centers of power (Dodson 2009, 4). Whether these technological advances serve to challenge existing structures of power or act as a tool of empowerment is largely not predefined by any inherent quality of the technology, but rather depending on the chosen mode of deployment by state, corporate, and individual actors.

1.4. Components of ICT Infrastructure

1.4.1. Broadband Access

Broadband access can be sorted into two categories - hardwired broadband access via a landline and wireless broadband access. Landline connections can use a coaxial, a twisted pair, or a fibre-optic cable; with services either relying on a preexisting phone line or establishing a new, oftentimes fiber-optic, connection. Wireless access can be provided via a Wi-Fi network that allows devices to go online through a wireless router. In most cases the Wi-Fi network itself then connects to the internet using a landline. Mobile connections are wireless too, but rather than relying on a wireless access point in the near vicinity, a prerequisite for a functioning Wi-Fi network, internet access is provided via cell phone towers.

‘Broadband’ is a relative term, with the *Federal Communications Commission* (FCC) of the United States in January 2015 updating its broadband definition from a 4 megabits per second download and 1 megabit per second upload rate to a threshold of at least 25 megabits per second downstream and 3 megabits per second upstream bandwidth (FCC 2015).

1.4.2. Fiber-Optic Cables

Fiber-optic cables form the backbone of the global information network, carrying the lion’s share of worldwide data and transmitting it between cities, countries, and continents. A few dozen undersea fiber-optic cables still are the linchpin of data transmission between continents, and the loss of fiber-optic connections can have far reaching consequences for singular networks or the internet connectivity of entire countries (Chang 2013; Omer, Nilchiani, and Mostashari 2009, 296; Parfitt 2011). Fiber-optic cables usually travel along the different infrastructure networks in cities; buried underground, right next to other urban arteries. In between cities, they mostly follow the main transportation routes from urban core to urban core, successively branching out to more remote locations.

1.4.3. Internet Exchange Points

Internet Exchange Points (IXPs or XPs) are the intersections of our worldwide communication infrastructure - global nodes where peering connections between different networks operated by different internet service providers (ISPs) or other carriers are established. This enables the traffic from one network to pass to another network, thus creating the very foundations of a global web – a network of networks. In essence, they are nothing more than a series of network switches connecting the different carriers. However, with the increase of worldwide internet traffic and the importance of safe and reliable connections, large IXPs have become sophisticated technical arrangements with multiple cores, large transmission capabilities, and built-in redundancy to prevent data loss. Currently the largest IXP in terms of peak traffic is the

DE-CIX in Frankfurt with a throughput of over 4,000 gigabits per second (DE-CIX 2015b).

1.4.4. Data Centers

Data centers are almost as varied as their uses, ranging from small server stacks in one room to large industrial facilities with an energy demand bigger than small towns. Essentially, they work according to the principle that it is cheaper to concentrate computing and storage capacities in one advantageous location rather than distributing it among the individual users.

1.5. Physical-Technical Aspects of ICT in the Urban Environment

The main components of ICT infrastructure are the hardware, the software, and the built structures to support their operation; with the hardware being further differentiated into computing, routing and storage technologies, network technologies, end-user devices, and all technology to operate the hardware (Petermann et al. 2010, 67). The network is divided into backbone connections that cover long distances and carry the main load of traffic, and local access connections that allow users to link to the network. These connections are either tethered or wireless, with a variety of different systems in place according to traffic volume, distance to cover, technological availability, and costs. ICTs form part of the critical infrastructure system of any city, and their smooth functioning is a key component of modern urban life. This is not only exemplified by the active use of ICT by a city’s population but by the reliance of many other urban infrastructures on ICT as a support and control system.

1.5.1. ICT in Disaster or Emergency Situations

Disaster or emergency situations (i.e. natural disasters, terrorist acts, armed conflicts, etc.) disrupt the daily urban life and put severe strain on the communications infrastructure. It is the failure of communication systems that characterizes many of these disaster situations, while the proper functioning would help to coordinate emergency response efforts, spread crucial information among the public, and save the lives of many. ICTs occupy a delicate spot within the array of critical urban infrastructure, as they are the system that will be most used and relied upon in emergency situations in comparison to regular usage patterns. Oftentimes, this increase in the load by itself is enough to bring down parts of the system, even more so if the system has suffered damage beforehand. In the aftermath of the September 11 attacks on the World Trade Center, half of the cell phone calls were effectively blocked in the wider New York and Washington, DC area, and when the Great East Japan Earthquake hit Tokyo in 2011, many people had to resort to social media to reach out - sometimes sending messages over half the globe on unblocked channels, that were then relayed back from the outside into Tokyo to the right recipients (Hickins 2011; Johnson 2014; Jung 2012; Masi, Smith, and Fischer 2010, 18)[2].

As modern warfare increasingly moves into the cities; with asymmetric conflicts, urban insurgencies, and counter-insurgency tactics (Graham 2011; Lind 2004; Sassen 2010; Weizman 2012, 185-220); infrastructure systems also become the focus of military campaigns (Lawlor 2007; Patterson 2000). When the NATO offensive in Serbia commenced in 1999, US-led airstrikes specifically targeted media transmission masts and the communications network, alongside the electrical generation system (Graham 2006, 180-181). During the U.N. mission in Somalia in the 1990s, television and radio broadcasting to communicate messages to non-combatants was almost non-existent in Mogadishu, and U.S. forces even lacked means to contact Somali clan leaders (Patterson 2000, 31-32). In the Second Gulf War from 2003-2005, telecommunications infrastructure, media installations, and antennae were specifically targeted by cluster bombs, together with the electricity distribution system (Graham 2005, 185).

There is, however, rarely a division between civil and military infrastructure or vital and merely supportive infrastructure in any modern city - most systems are tightly connected and the destruction of one part can lead to cascading failures throughout the

[2] In one case a teacher, together with students and others, trapped on a roof amidst fires emailed her son in London. He then tweeted the emergency and was retweeted until the Vice Governor of Tokyo took notice and alerted rescue forces. Over 400 people were saved from the roof of the community center via helicopters. (Johnson 2014; Twitter 2015)

whole complex. The disabling of the power grid has severe impacts on the telecommunications infrastructure, with many devices resorting to back-up battery power, that, limits the further use of most cell phone towers from a couple of minutes to a few hours (Elsberg 2014; Petermann et al. 2010, 82; Townsend and Moss 2005, 10). Without functioning ICT support, smart grids become impossible to operate. Thus, the outage of only one of the tightly connected infrastructure systems can have profound effects, as the experience of Iraq after the First Gulf War shows. Only around 3,000 civilian deaths are directly attributable to the bombing campaigns, but the estimates are of over 100,000 civilian casualties and a doubling of the infant mortality rate or up to 300,000 excess deaths of children under five due the destruction of Iraq's electrical system and the successive failure of the country's water purification, sanitation, and sewage treatment systems (Graham 2005, 184; Rizer 2001; United Nations 1999a; 1999b). Accordingly, Townsend and Moss (2005, 6-13) categorize three types of ICT failures in emergency situations: (a) physical destruction of the network infrastructure; (b) disruption in the supporting infrastructure; and (c) disruption due to congestion.

Physical destruction of network infrastructure

In the case of emergency situations, telecommunications infrastructure can be subject to damage by the collapse of built structures; fires and explosions; high wind speeds; flooding; the severing of cables, either intentionally or unintentionally; and electromagnetic pulses (EMPs) from weapons, accidents, or lightning (Neumayer et al. 2011, 1610; Parfomak 2008, 6). The physical destruction of the network infrastructure has the most long-lasting effects. The severing of undersea fiber cables takes up to a month to repair, depending on weather conditions. In the case of wide and large-scale destruction by earthquakes, tsunamis, or hurricanes, recovery and reconstruction can take significantly longer.

Systems that are highly concentrated in terms of geography are affected the most. While the telephone network has traditionally little redundancy and the loss of only a few key nodes can lead to severe disruptions, the internet offers a higher degree of redundancy and can reroute traffic to bypass affected lines. Additionally, connections can also be established via satellite links, the cellular network, and wireless connections. However, the destruction of links of the fiber-optic continental or undersea backbone network can still severely decrease transmittance speed and connectivity; and on a local level, traffic often still depends on a single cable connection.

Disruption in the supporting infrastructure

While a failure in the supporting infrastructure, specifically the electrical system, does not directly destroy ICT infrastructure it can disable it more widely and thoroughly than the loss of a few ICT nodes. This is because the ICT infrastructure is tightly connected and almost completely dependent on electricity (Petermann et al. 2010, 72). The ICT infrastructure cannot function independent of electricity, hence its continuing operation in the case of a blackout depends on battery power, back-up generators, or autonomous energy sources such as solar panels or fuel cells. Other concerns are damaged cooling systems and disruptions in the transportation sector that impede the supply of fuels for back-up generators (Townsend and Moss 2005, 10).

The first point of failure, for both the telephone system as well as the internet, are the end-user devices. Cable modems, terminal adapters (establishing connections via Integrated Services for Digital Network or ISDN), or DSL (Digital Subscriber Line) modems usually all lack a back-up battery and will stop working immediately with the loss of power. Equipment that has a back-up battery or can connect directly to the cellular network (mostly tablets and cell phones) will be able to establish a connection as long as the closest cell phone towers or the digital subscriber line access multiplexer (DSLAM) are still functioning. These usually have some back-up power to allow them continuing operation for a few minutes up to a couple of hours, mainly depending on the importance of a node and the number of local connections it serves. Key switches in larger cities may have back-up generators with a secured supply for up to forty-eight hours or longer. (Fickert and Malleck 2008, 275-76; Petermann et al. 2010, 80-84)

Disruption due to congestion

Congestion is a major problem in many communication networks in emergency situations. With more than a ten-fold increase in traffic after the attacks on September 11, 2001, congestion in the cellular network led to a 92 percent block rate within New York City at 11 a.m. and a 75 percent block rate over the whole day (Masi, Smith, and Fischer 2010, 18; National Research Council 2003, 37-38; Seifert 2002, 4). In the aftermath of the Great East Japan Earthquake in 2011, both telephone and cell phone lines were blocked due to congestion. The internet, however, provided a relatively uncongested means of communication. Those being stuck somewhere away from home made use of that fact by sending emails or using social media from their handheld devices rather than placing calls or sending SMS messages (Hickins 2011; Jung 2012).

1.5.2. Assessing Resilience

The U.S. *National Security Telecommunications Advisory Committee* (NSTAC) report on communications resiliency formulates seven principles for assessing the resilience of telecommunications networks: (a) redundancy (multiplicity, spares); (b) diversity (multiple approaches and suppliers); (c) agility (ability to shift); (d) adaptability (ability to adjust); (e) prioritization (dedicated or shared resource); (f) geography (diversity, proximity); and (g) hardening (ability to withstand direct force). (NSTAC 2012, 1-2)

Redundancy (multiplicity, spares)

The need for redundancy clashes directly with cost considerations as redundant systems usually provide no direct operational benefits but additional costs (Seifert 2002, 12). In general, issues of lacking redundancy affect the local level more than the regional or international level. This is due to the fact that larger organizations not only have more resources to spend on redundancy but are also more spread geographically - an important factor in ensuring survivability of the redundant parts. The DE-CIX in Frankfurt, as the largest IXP in the world in terms of peak traffic, has four cores in different parts of Frankfurt, with one being live only for redundancy (DE-CIX 2015a). Major cloud space providers store data redundantly in different locations that are not only separated geographically but also divided into different time zones to ensure availability and that personnel is on duty at least at one node due to working hours (Amazon 2011). Such a level of redundancy and safety is hard to achieve on a local level, where it is impossible to have a back-up node for every local switching station; so prioritization among the structural elements becomes a necessity (Masi, Smith, and Fischer 2010, 21).

Diversity (multiple approaches and suppliers)

A certain grade of diversity in the array of available means of communication is already achieved through the rise of smartphones and tablets over the last years. These devices usually have a significant battery lifetime and are able to establish cell phone connections as well as access the internet through either the cellular network or through a Wi-Fi connection. This is of importance, as for both the conventional telephone network as well as internet access through DSL or ISDN, the first point of failure, in the case of a blackout, is almost always the end-user device. These will stop working immediately after the loss of power and will impede any communication, even with the local or international backbone network functioning without problems. While cell phones and tablets are capable to mitigate these problems partly, the local cell phone towers then become the next point of failure, as they are usually only supplied with back-up power for a few minutes up to a maximum of around eight hours (Elsberg 2014; Petermann et al. 2010, 82; Townsend and Moss 2005, 10). Devices connecting to the cell phone network, however, face a more serious threat through network congestion, which can block services in a wide geographical area even without the loss of power. Furthermore, these outages are decidedly more difficult to handle, as there is not one single switch to press to get a network back to normal. Rather, diagnosis of the problem is oftentimes cumbersome and takes a fair amount of time, making an immediate response difficult or even completely preventing it (Townsend and Moss 2005, 18). Thus, in the case of emergencies, connections via several different landlines by different providers, as well as satellite links, can ensure that communication and data transfer remain possible (Seifert 2002, 18-19).

Agility (ability to shift)

Agility signifies how well traffic is shifted from one system to another in the case of disruptions. This is, of course, very much related to diversity, as only the availability of an array of ICTs or different connections allows shifting. When Tokyo was hit by the Great East Japan Earthquake in 2011, many citizens with smartphones were relying on the data connection instead of conventional phone services. As phone lines were blocked, this shift was actively encouraged by authorities in Japan and from the outside, with the *U.S. State Department* tweeting: "Telephone lines disrupted; try contacting loved ones by email, text (SMS) message, or through @twitter & #facebook." (Stephens 2011)

People usually turn to ICT in emergency situations for three purposes: (a) to inquire about friends, family or acquaintances; (b) to give information on one's own situation and whereabouts; and (c) to receive information on the cause or scope of the emergency itself (Jung 2012). For all of these purposes different channels are available, especially with the rise of smartphones and handheld devices that are able to connect to the internet. While inquiring can be done via phone calls, SMS messages, emails, social media, and face-to-face conversation - all directly or indirectly via others; information about one's own situation is much easier to spread to a larger audience via social media - a feature that might be able to reduce traffic significantly. During and after the disaster, people in Japan turned to television and social media for general information. The use of hashtags that named provinces allowed narrowing down information searches on *Twitter* to specific locations and to respond and provide further information including locational data. However, in areas hit by blackouts, local and community radio stations and local newspapers surpassed national TV as information sources, largely due to the localized content and the availability without electricity. (Appleby 2013; Young 2012)

Adaptability (ability to adjust)

Adaptability is closely related to agility - it is the question of how well information providers and users are able to adjust to the loss of one or more information channels, either by shifting or by falling back to pre-established contingency plans. When nine local-area television stations lost their transmission facilities atop the World Trade Center during the September 11 attacks, two were able to swiftly restore service through back-up antennae at the Empire State Building, and in the aftermath broadcasters were allowed to temporarily set up replacement transmitters at suitable sites to resume transmissions (National Research Council 2003, 38-39). For internet service providers this mainly signifies rerouting traffic to cope with the loss of a node.

Prioritization (dedicated or shared resource)

Going back to the three aims of ICT usage in emergency situations, these all have different impacts on the network, and congestion can be significantly reduced through a coordinated approach. One example is the policy of *AT&T* to prioritize outbound, long-distance calls alongside emergency calls (identified in the U.S. by dialling 9-1-1), so that information on someone's situation can then be spread by those in other parts of the country, where networks are not congested. Additionally, this will reduce the number of inbound calls to the affected area. (Townsend and Moss 2005, 12)

Geography (diversity, proximity)

A general problem of ICT infrastructure is its tendency towards centralization. This was exemplified when the attacks on the World Trade Center in 2001 brought down two telephone switching facilities (one being destroyed, the other losing all power connections), which together handled 40 percent of the lower Manhattan phone lines and all of the New York Stock Exchange's (NYSE) traffic. Several cell phone towers in the near vicinity were also destroyed or failed due to power outages (Seifert 2002, 6).

Due to an economy of scale and the technical heritage of the telegraph system and the analogue telephone switches, most routing, switching, and data storage is done in a few central locations. Even the internet with its use of packet switching still relies on a few key nodes and connections. However, while there have been a few large-scale disruptions concerning the internet, most incidents occur on a local level. The large-scale disruptions involved mostly the severing of fiber-optic cables of the international backbone. In 2011, a woman in Georgia accidentally cut a buried fiber-optic cable while scavenging for copper, resulting in 90 percent of Armenia being disconnected from the world wide web for around five hours, when services were restored (Chang 2013; Parfitt 2011). In 2006, an earthquake south of Taiwan severed seven of the nine undersea fiber-optic cables connecting South Asia to the rest of the world (Blum 2013, 200; Erjongmanee et al. 2010, 136). In 2008, several undersea cables connecting Europe with the Arabian Peninsula and Asia were cut by a dropped anchor before the coast of Egypt, and another cut was made there, potentially intentional, in 2013 (Chang 2013; Omer, Nilchiani, and Mostashari 2009, 296). While these defects take quite some time to repair, interferences to users can usually be kept to a minimum through rerouting the traffic. Much more cumbersome in emergency situations are more narrowly confined disruptions when local telecom exchanges or switching stations are affected (Cowie, Popescu, and Underwood 2005; Erjongmanee et al. 2010, 134). These usually result in the complete loss of those lines that connect via the affected hubs, as there is no possibility for rerouting traffic due to the first, local link being cut. Thus in the case of Hurricane Katrina, three million telephone lines were knocked out of service and thirty-eight 9-1-1 emergency call centers went offline (Erjongmanee et al. 2010, 136).

The same is true for the Great East Japan Earthquake, where the disruptions in the electricity system led to serious impediments of communications, even though Japan boasts a highly media savvy population that was quick to adapt. Those hit hardest were people aged over sixty in rural areas, as there was a less dense network of different ICT channels available and as this group also was less likely to have diversified media usage patterns. This reinforces the importance of strengthening connectivity over the last mile and providing a variety of communication channels, with at least some being more or less independent of the electricity system. (Appleby 2013, 7-8)

Another important factor concerning geography is the spatial separation of redundant system parts. The DE-CIX in Frankfurt houses its four cores in different parts of the city, and data centers for cloud storage are optimally far enough apart to be in separate areas with distinct climate and weather patterns, unconnected geological activity, and served by different electricity providers and supporting infrastructure (Blum 2013, 227-62; DE-CIX 2015a).

1.6. The Framing and Societal Role of ICT

ICT is surrounded by different narratives, which shape not only hopes and expectations but ultimately also its implementation and control (Söderström, Paasche, and Klauser 2014; Townsend 2013). Considering the influence ICT is and will be exerting, it is important to analyze these narratives to understand how they translate into differing positions towards ICT and its integration into our cities. Graham and Marvin (1996, 77-122) identify four general positions concerning the relation between ICT and the city, which are still very much to the point today and which I will further elaborate on: (a) technological determinism; (b) futurism and utopianism; (c) dystopianism and political economy; and (d) the social construction of technology.

1.6.1. ICT as a Corporate Technological Solution

What Graham and Marvin (1996, 80-93) discern as two different approaches I will summarize as one, as increasingly the two narratives of 'technological determinism' and 'futurism' merge into a single narrative centering around smart cities (Hollands 2008, 303). The focus of this narrative lies on the combination of ICT and urban management in a technologically deterministic discourse, with technologies being assigned very rigid and specific roles in the management of urban agglomerations (Vanolo 2014; Wyly 2013). Technology is seen as the cure for many of today's cities' problems and the expected effects through the introduction of newly developed solutions are clearly defined and posited with assumed certainty. Influenced by computer sciences and a focus on technology, urban operating systems and 'Intelligent Operations Centers' are introduced (Greenfield 2013; Kofman 2014; Singer 2012; Townsend 2013, 65-69) - strategies more reminiscent of films like *Dr. Strangelove* or *Blade Runner* than actual urban concepts.

Cities started becoming the interest of large technology corporations (most notably *Cisco*, *IBM* and *Siemens*) in late 2000. With the global financial crisis hitting hard and sales declining, companies were looking for alternative areas to realize profits - preferably unsaturated markets with opportunities for large-scale investment (Harvey 2008). Urbanization had soaked up capital surpluses in various phases of history and specifically over the last 30 years, but by introducing the concept of 'smartness' another wave of potential investments opened up (Harvey 2009; Townsend 2013, 19-56; 79). For the technology corporations this meant modelling cities and city administrations after the workings of the global supply chain (Townsend 2013, 32). A stream of marketing brochures and glossy publications started to pour in and marked the rise of the term 'Smart City'. There is no clear definition of what constitutes a smart city (Hollands 2008, 305-07; Vanolo 2014, 886-87), and according to Greenfield (2013) and Vanolo (214, 891) the term deliberately remains generic. Smart city visions treat space, time, and technology only in abstract form, employing designations such as 'intelligent', 'interactive', 'smart', and 'adaptive' to describe technologies, sensor networks, or infrastructures. However, as Greenfield (2013, chapter 3, section 1, para. 4) writes,

> "[t]here's just no such thing as 'an' interactive smart wall or 'an' iris-recognition system, any more than there is 'a' bike-sharing scheme or personal rapid-transit network. What do exist in the world are specific deployments of components from specific vendors, laminated together as particular propositions, and each of these may differ profoundly from other, similar propositions, along all of the axes that condition human interaction with them. It's all but impossible to fairly evaluate claims about the performance of systems like these without knowing just what it is that's being suggested."

At the same time, the treatment of space and time only in generic form might prove equally problematic. Any infrastructure deployed has to function under a set of local circumstances in a specific city and the way these technologies are presented, 'smartness' always just seems to be one step away. But by mashing countless visions and claims together and portraying these technologies as one-fits-all solutions, it becomes increasingly hard to see them work in a specific city. Rather, they remain general visions, easily sellable due to their non-attachment to a specific time and place, sporting far-reaching claims on what they will achieve, and they might be better understood "as elaborate marketing ploys aimed at deflecting criticism or encouraging new markets and new public subsidies" (Graham and Marvin 1996, 111).

Söderström, Paasche, and Klauser (2014, 308) identify the mobilization of "two long-standing tropes" in this strategy: "the city conceived as a system of systems, and a utopian discourse exposing urban pathologies and their cure." To view the city as the biggest machine imaginable is not a particularly new vision; it is a strand of thought that can be traced back to Le Corbusier's urban visions, and even more notably to Jay Forrester's *Urban Dynamics* and the *RAND Institute*'s model of the New York City firefighting system. Both Forrester and *RAND* tried to model a city in a computer simulation to produce policy recommendations - with grave consequences. While models of San Francisco and Pittsburgh, inspired by Forrester's theories, produced nonsensical, off-the-mark or no results, they also limited the city planners' thinking, as they adjusted their questions to what could be modeled (Lee 1973, 166-67; Light 2003, 60). *RAND*'s simulation on the deployment of fire companies in New York City, on the other hand, led to the fateful closure of some of the busiest companies in low-income areas. These recommendations were due to shortcomings of the model, which only took into account response time but not availability of companies or traffic in the streets. When fires eventually broke out and the remaining fire companies were overburdened, the Bronx and other neighbourhoods paid the price, with estimates of people displaced by fires as high as half a million. (Townsend 2013, 76-82)

These efforts to completely model any city exemplify a data-driven approach, which not only understands cities as a technological machine, but also portrays a completely deterministic approach towards urban processes that are expected to follow computer simulations just as effect follows cause. This vision, in fact, bears more similarity to the popular computer game *SimCity*, where players are supposed to create a city from scratch. However, as Kofman (2014) notes, no set of parameters in such a simulation is based on neutral assumptions. What becomes adjustable in the game - the input variables - depends largely on the mode of thought behind the model. In *SimCity* the level of crime is directly related to the number of police stations deployed and high taxes drive away the citizens. While in the actual world, where any effect might be tied to an uncountable number of causes that are all interdependent, the translation of these factors in manipulable input variables can only scratch the surface of any city's complexity. Furthermore, the deterministic view faces another big problem - while it is relatively easy to arrive at far-reaching assumptions concerning future developments, these linear hypotheses inevitably fail, should only one of the building blocks crumble. And fail they do - in spectacular fashion the more rigid and one-sided the original outlook is. It is easy to smile over Pascal's theory of the 'vanishing city' now, but the linear assumption that new forms of communication would render the need for face-to-face contacts obsolete could only lead to such a hypothesis (Pascal 1987).

1.6.2. Dystopianism and Political Economy

This approach draws heavily from (Neo-)Marxist thought, specifically the work of David Harvey. The basic assumption is that capitalism is forever in need to create sufficient returns on investments, and if this cannot be achieved in the field of primary production, capital flows into other areas, where the prospects of profitable turnover are better (Castree 2009; Harvey 1975; 2001). A main target of these flows is the urban space, and the urbanization or "spatial fix" (Harvey 2001, 24) of capital investment is one of the main driving forces behind investments into urban infrastructure and the hype around smart city technology (Wang 2012, 2118).

Greenfield (2013, chapter 10, section 1, para. 13) notes that

> "the smart city itself, as a coherent object of discourse, arises out of a specific set of conditions produced by late capitalism, under which cities compete against each other as global destinations for capital and talent. In this light, the smart city's organic capacity for data-driven process optimization, its seamless interweaving of public and private action and its organization for the convenience of administration can clearly be seen for what they are: merely the most recent additions to the armature of enticements and amenities a city must offer in order to be considered a credible contender as a destination for these flows."

Castree (2009), Harvey (2001), or Wyly (2013), however, would go further and argue that it is the smart city, or rather, current forms of urbanization and ICT, that allow late capitalism to exist. The modern city is not only a result of capitalist expansion but the overflow that soaks up capital - a temporary solution to overaccumulation - and ICTs are a quintessential factor that enable the mobility of capital under modern production conditions. The main reasoning behind this is captured by Marx (1973, 459) in the *Grundrisse*, when he talks about "the annihilation of space by time", because

> "[t]he more production comes to rest on exchange value, hence on exchange, the more important do the physical conditions of exchange -- the means of communication and transport -- become for the costs of circulation. Capital by its nature drives beyond every spatial barrier. Thus the creation of the physical conditions of exchange -- of the means of communication and transport -- the annihilation of space by time -- becomes an extraordinary necessity for it."

And so the "production of cheap means of communication and transport [become] a condition for production based on capital, and [are] promoted by it *for that reason*" (Marx 1973, 459-60, original emphasis). Technology is not a neutral invention that is introduced into cities, it is brought about by the current mode of production, and in turn enables the expansion of this mode of production by reducing the time of travel from one place to another (Marx 1973, 472).

At the same time, while capitalism might aim for a maximum mobility of capital, the rigidity of urban infrastructures actually hampers future capitalist expansion. This is because of the large initial investment costs and the inflexibility of old infrastructure systems that present barriers to restructuring and further capital accumulation (Castree 2009, 50-51; Graham and Marvin 2001, 193-94; Hommels 2005, 336-37; Harvey 2001, 25). To overcome this barrier old infrastructure needs to be overhauled and replaced periodically - these improvements becoming a necessity for the functioning of the production process. New infrastructure then becomes 'spatially fixed' or fixed capital sustaining the inherent contradiction of this cycle (Marx 1967a, 384; Harvey 1975, 11; 13).

This analysis provides us with two dimensions of the role ICT has to play. First, as an enabler of the current production cycle by reducing the time of circulation and extending the market's reach; and second, by acting as the safety valve in crises of overaccumulation through soaking up excess capital. Through this, the (smart) city is thoroughly integrated into a capitalist mode of production and increasingly becomes a product itself. This happens not only by throwing cities into market-based competition with other cities, or recasting citizens purely in their roles as either producers or consumers - rather, the city as a whole is marketed as a product through the assistance of ICT. Where it used to be only parts of a city (e.g. shopping areas, event zones, sport grounds, etc.) and only at a given time, which were walled off and transformed into exclusive commercial zones (with draconian regulations, sometimes even outside the state's jurisdiction[3]), it is now entire cities. Where it used to be events like the Olympic Games or a Football World Cup, which allowed cities to place themselves strategically on the international market, it is now the city itself that has become the event. Test tube cities such as New Songdo, Masdar, or PlanIT Valley are advertised as spectacles that only wait to be consumed. Built in cooperation by real estate developers and technology corporations, and assisted by city operating systems, they offer 'a friendly business

[3] As can be seen through the establishment of special *Fifa World Cup Courts* during the 2010 Football World Cup in South Africa. The stance of these courts is expressed aptly by the *Department of Justice* on their homepage when they boast that "[d]edicated courts secure over 60 percent conviction rate" and talk about the "criminal justice value chain" - language that is more representative of a commercial endeavor than a judicial system (Department of Justice and Constitutional Development 2010). The courts acted according to the *2010 Fifa World Cup South Africa Special Measure Act* that made "'unauthorised commercial activities inside an exclusion zone' and 'enter[ing] into a designated area while in unauthorised possession of a commercial object' [...] a criminal rather than civil offence" (Hyde 2010).

environment' and 'first class living conditions' for all those who can afford it. They work like privatized enterprises and present themselves as easily accessible, highly connected, environmentally friendly, and so very convenient - but in all these claims, they indeed come much closer to what Debord notes in the *Society of the Spectacle* (2013, 7):

> "The spectacle presents itself as something enormously positive, indisputable and inaccessible. It says nothing more than 'that which appears is good, that which is good appears.' The attitude which it demands in principle is passive acceptance which in fact it already obtained by its manner of appearing without reply, by its monopoly of appearance."

However, for a city assuming such a part there are two important consequences. First, space has a key role to play as it turns into the prime mediator - at the same time being the barrier to movement and being 'annihilated'. It allows the development of an uneven geography, and it is the ICT with which this unevenness is exploited (Graham 2002, 39; Harvey 2001, 24). In this sense the means of communication and transportation are not only simple tools to 'annihilate space by time', rather, they are essential in harvesting profit from spatial/geographical differences. Space is not eliminated, it is annihilated by time, but only in certain directions and for certain goods/flows (Smith 2008, 122). Second, a city that has become a product requires control of access. On the one hand, to ensure the smooth functioning of its circulation processes and to prevent any interruptions in the cycle of production and consumption. On the other hand, to sustain the marketability of the city and realize its value as a commodity, or to reap the profits from the city itself and prevent people from using it for free.

ICT and an uneven geography

In the *Grundrisse* Marx (1973, 471, original emphasis) notes that "sections are travelled in specific *amounts of time* (even spatial distance reduces itself to time; the important thing e.g. is not the market's distance in space, but the speed -- the amount of time -- with which it can be reached)". However, this is only assuming that circulation is not impeded - once the free flow of traffic is not guaranteed or the appropriate infrastructure is not in place, space makes its return in force. For example, distance does become an important factor, when the mobility of labor is considered. In this regard, it is the mismatch between the two - the ‘annihilation of space by time’ in the movement of capital or goods and barriers against the movement of people - that allows the exploitation of this relation. This is what constitutes the uneven geography - an array of more and less developed territories and the differences in the available and accessible infrastructure. However, it is not just the simple aspect of what kind of infrastructure is present or affordable and the resulting difference in connectivity. The role of ICT is more complex than just providing such connectivity to assist certain spaces that can afford it in connecting faster and wider than others. ICT does not only help to exploit preexisting uneven geographies, it also plays its part in creating and reinforcing them.

The improvement of infrastructure tends to lead to more rather than less concentration, as Marx (1967b, 250) points out, with a tendency of further concentration of production or markets and a strengthening of centers of production, population, ports of export, etc. The economic geography of today’s internet with a focus on a few key nodes - almost all of them being in urban agglomerations with a far-reaching influence - is one facet of this intensification of spatial concentration (Malecki 2002; Moss and Townsend 2000). The cities with a very high connectivity are those that have traditionally played a major role in economic or political terms as well (Tranos and Gillespie 2011, 47). So, contrary to its image of being the ubiquitous connector and providing easy access to information for all, ICT is indeed firmly embedded in global production processes and may exacerbate a landscape of uneven geography by strengthening the position of those with already greater opportunities. This process works in a twofold way. First, it allows to make use of the imbalances and differences in development and geographical separation by generating profit through them; and second, by connecting - even geographically relatively close - areas with differing quality of ICT, it serves to further increase preexisting gaps.

ICT allows to harness even small differences between geographically separated areas. When space and time act as a barrier, capitalism is not able to extract sufficient profit from geographically differing investment or labor costs (Harvey 2009). However, with the possibility of bridging distances almost instantly, areas that are geographically far apart become connected economically and are drawn into the same competitive market (Marx 1973, 472-73). So rather than eliminating these imbalances, ICT increases the profit that can be harnessed through them. Such effects are exemplified in the outsourcing of jobs to countries with a lower wage level, while headquarters congregate in the financial and economic capitals of the world; but also in the high-speed trading schemes that function as automated processes, making use of minuscule price differences between different (stock) exchanges. While the first effect erases space-time barriers in a very specific way (that is, for example, by reaping the profits from low wage levels in different countries, but not allowing workers to have the same kind of mobility and travelling as fast as the goods they are producing), the second effect increases differences between areas that might even be in close proximity geographically. It does this by specifically strengthening the information flow between information-rich areas - connecting these areas globally but not locally. ICT allows information to travel from the City in London to Wall Street faster and more frequently than between the City and Brixton or Manhattan and the Bronx. Thus, networks form, containing geographically far apart areas or cities and linking them globally; and access to these networks is not spread equally over a city but ‘hops’ from node to node bypassing wide stretches of urban terrain, including the people in it. Ultimately, these provide access to information; allow, for example, the control of faraway production cycles, and generate more value/profits in the well connected areas or what Graham (2002, 43) calls “high-value enclaves surrounded by landscapes of marginalisation”.

It is important to note here that ICT has two functions to fulfill in both cases - that is *connecting* and *controlling* (information) flows. In the first case, ICT acts as semipermeable membrane, letting only certain flows pass and some only in one direction. ICT-supported international production processes enable goods to flow easily between different production sites and to consumers over international borders and far distances. The same information and transportation infrastructure, however, is used to tightly monitor people who are travelling - usually providing rather fast connections for people from the Global North, while being closed to travellers coming from the Global South. In the second case, ICT not only helps connect certain parts of cities globally, it is also employed to actively remove these areas from their surroundings. Through the increase in global connections, it becomes less and less necessary for the inhabitants to use local resources or come in contact with neighbouring areas. With wealth and social status distributions drifting apart between parts of cities that are in close geographical proximity, the call for tighter control and surveillance becomes louder and louder. Poorer neighbourhoods are stigmatized as being populated by “subjects supposed to loot and rape”, with a tendency towards criminal activities and not adhering to ‘law and order’ - effectively turning the inhabitants into faceless ‘others’, projecting racist anxieties and fears onto them (Žižek 2005). This line of argument then serves as the raison d’être for employing ICT in a tightly knit surveillance and control system.

An invisible system of access and denial

In describing the border checkpoint between the West Bank and Jordan at the Allenby Bridge, Weizman (2012, 138-60) notes that those wanting to cross only face the Palestinian guards, while the Israeli officers sit behind the Palestinian guards, hidden by a one-way mirror. However, it is them deciding who is permitted to enter and who is denied entry - but not only is there no interaction between those making the assessment and those seeking entry, those waiting in line also do not know who actually assesses them. In smart cities with their chip-coded doors, their sensor-equipped traffic cameras, and their tracking of people, technology becomes ‘invisible’, with doors opening seamlessly by themselves after having scanned the iris - just as denial of entry becomes invisible too. Reminiscent of the border at the Allenby Bridge, the decision is hidden behind a ‘one-way mirror’. However, in most cases it will not be an officer taking this decision, but rather an algorithm that assesses the level of danger based on collected data and statistics. This allows the control of access and space to become completely ‘individualized’ - shops could check whether someone seeking entry even has the money to buy goods; certain venues could regulate the entry of what they deem as high-risk individuals (young men in their teenage years, unemployed persons, those with a criminal record, etc.); or the police could easily shut off whole districts by diverting traffic, closing down public facilities, and blocking points of entry. Graham (2011, 106; 131) speaks of “ubiquitous borders” protecting “global homelands”, a “passage-point urbanism”, where those deemed risky are invisibly and at all times separated from those declared risk-free. All of this, of course, under the self-proclaimed veil of objective science, seemingly just following a data-driven approach that assesses risks based on statistical values and with the overall stated aim of achieving a more secure environment. The control of access to specific areas has to be seen in combination with other concurrent urban trends. Gated communities, private security services, urban sensing technology and surveillance equipment, and the general ‘militarization‘ of urban space (Graham 2002, 42; 2011) create a semi-permeable network of high-speed corridors for those who can afford it and a very constrained local neighborhood for those who cannot.

1.6.3. ICT as a Social Construction

The framing of ICT as a social construction is based on the assumption that ICT, and technology in general, is inherently biased and not neutral (Graham and Marvin 1996, 95-96; Gillespie 1991, 225; McNeil 1991). Technology is defined as a product of society and its complex inner workings, and cannot be viewed as an external variable that influences society but is not influenced by it. Thus, the resulting technology reflects a multitude of choices and views of a wide variety of users and developers, and it is the aim of social constructionism to make these processes visible.

In contrast to the political economy stance, social constructionism lays a strong focus on the micro level and the agency of users, who shape the social and political process but do not create one single, predetermined technological trajectory. It becomes hard to identify simple links of cause and effect, as ‘relevant social groups’ try to realize differing interests and are in return heavily influenced by the resulting technology (Bijker 2010, 67-68). However, the eventually dominating aspect or view of a certain technology reflects the power distribution within social groups that weigh in on the debate. As Pinch (2010, 79) writes, technology has no intrinsic meaning; rather, its meaning is to be found among social groups sharing certain convictions, and the framing of technology will tell us more about our society than about the technology itself.

1.6.4. A Question of Policy Rather Than Technology

What unites both political economy thinking and social constructionism is the rejection of a technological determinism and an emphasis on the socio-political processes and structures. Even though the latter, with its emphasis on the micro-level, might stress individual agency more than the former, with its focus on the underlying social structure, both approaches should lead to an important realization for municipalities and political stakeholders: while most technologies currently associated with smart city concepts can be used to collect data, track individuals, or be utilized as surveillance tools, the mode of their implementation is not a simple technological question - but inherently political. It is a question of who owns and controls the deployed systems, and whether these are open or proprietary. It is a question of who has access to new technology, to what price, and how well they are able to use it. It is a question of who owns all the generated data and who has oversight, and whether there is the political will to counteract tendencies towards a society in which powerful social groups acting as the surveyors with less powerful social groups becoming the surveyed (Graham and Marvin 1996, 100). While oftentimes the focus of discussion is only on the adoption or non-adoption of a certain technology, it is the mode of adoption that is essential (Guthrie and Dutton 1992, 574-97). Determining the main features of adoption, however, needs to involve political deliberation and should not be delegated to bureaucratic structures or private corporations.

1.7. Research Framework

In the following section I will outline the respective research methods for each of the three analyzed spatial scales - the macro-, meso-, and micro-level.

1.7.1. Macro-Level Analysis

On the macro-level I take a look at the relationship between cities in an information network that is spanning the globe. ICT infrastructure is not only crucial in connecting citizens all over the world, it also has increasingly become a marketing tool for cities to position themselves on the ‘global market’. Whether it is Bangalore, Barcelona, Rio de Janeiro, or Vienna - all praise their ICT sector, their business environment supported by ICT, and their smartness. Interestingly, in times when technology is supposed to be seamless and become invisible, it has to be made visible again to serve as an attraction for future investors. This is done in numerous advertising campaigns, glossy brochures, and pilot schemes - and while data centers and sensors remain hidden, it is the architectural combination of glass and steel that has to convey a sense of 'high-tech' and 'global business atmosphere' in rendering after rendering. In many cases the words of Graham and Marvin (1996, 51) have not lost their truth, when they argue that "efforts often have to be made to increase the visual and physical impact of telecommunications in cites". Immersion and technological ease might be mentioned in countless publications, but when it comes to portray a city, a district, or even a single building as a burgeoning hub of new technology, apparently nothing beats glass façades, giant screens, or heavily advertised 'digital opportunities'.

Still, cities that act as global information hubs and sit atop meeting streams of data occupy a structurally important position in other regards too. International flight schemes and other paths of transportation coincide markedly with data traffic routes (Derudder and Witlox 2008, 309; Moss and Townsend 2000, 45; Tranos and Gillespie 2011, 38). While from the 1970s up to the 1990s there was still a considerable amount of writing about information technology replacing physical forms of transportation and travelling, with ICT possibly even rendering cities obsolete, these hypotheses have proven to stray far from current developments (Nilles et al. 1976; Pascal 1987). Rather, ICT and rising data traffic seems to reinforce physical forms of traffic and vice versa (Devriendt, Derudder, and Witlox 2010; Graham and Marvin 1999; Mokhtarian 2002). Accordingly, smart city projects like New Songdo not only advertise their ICT infrastructure but also their connectivity via the airline network - claiming, for example, the title of "Aerotropolis" with a flight distance of only "3.5 hours to 1/3 of the World's Population" (Songdo IBD 2015a).

To assess the level of connectivity on the macro-level I will use data on the traffic passing through IXPs located in major urban centers. I will then contrast this with statistics of the airline network and the number of passengers transported by the same cities' airports. To keep the amount of data to a workable size the analysis will be limited to key urban centers within the European Union, as this sample size already accounts for a sufficient variation between regional capitals and global metropolises, and includes some of the world's largest IXPs, while providing for a similar legal framework and conditions concerning the 'digital market'.

This approach is influenced by the lack of precise statistics on data originating from or attributable to specific geographic locations, and examines the underlying set of infrastructure instead (Beaverstock et al. 2000; Rutherford 2011, 23; Tranos and Gillespie 2011, 36). Focusing on IXPs offers the advantages of having readily available metrics, published by the IXPs, and the fact that these are localized nodes, residing in clearly defined places/cities. An analysis of European IXPs has previously been done by D'Ignazio and Giovannetti (2007) - albeit centering on their peering policy rather than the amount of traffic - to assess whether there are noticeable effects of clustering between IXP-reliant providers. Tranos and Gillespie (2011) concentrate on internet backbone networks and their regional role, measuring the bandwidth of the backbone links. This might lead to slightly distorted results as these links only seldom operate at full capacity, and thus, the mere installed bandwidth might not be the best indicator of connectivity (Devriendt, Derudder, and Witlox 2010, 418; 423-24). Accordingly, Devriendt, Derudder, and Witlox (2010) use measurements on the actual data flow through IXPs and combine these with air traffic statistics. In trying to control for data packets that only pass through a hub on the way to the final destination, they apply spatial interaction modelling (SIM) that uses connectivity as an indicator and the number of possible traffic routes as an impedance factor. As I am interested in the actual relevance of the ICT infrastructure by itself, however, I view traffic flowing through an IXP equally as relevant as the one destined for that city, since this flow will still require a peering of ISPs at that location[4].

Other studies on intercity linkages have looked at hyperlinks and the number of web pages for city pairs in the *Google* search results to assess the connectivity and respective position of cities in cyberspace (Devriendt et al. 2011). Castells (1996) finds that these analyses shift the focus from a 'space of places' to a 'space of flows' and "[i]nstead of studying cities as entities with attributes (characteristics *of* areas), [they] study cities as comprising sets of relationships (characteristics of relationships *between* areas)" (Devriendt et al. 2011, 74, original emphasis). However, we would do well to heed

[4] Coincidentally, secret service agencies such as the *National Security Agency* (NSA) or the *Bundesnachrichtendienst* (BND) are interested in IXPs or other nodes for exactly that flow-through, allowing them to grab large amounts of data at a single location. Exemplified, inter alia, by the BND surveilling data traffic at the DE-CIX in Frankfurt (Denkler 2014; Mascolo, Leyendecker, and Goetz 2014).

Rutherford's (2011, 22) concerns vis-à-vis a focus solely on inter-urban flows, when he claims that "flows always have a start and an end point, [and] they are meaningful only if and when they become '(re)territorialized' (in cities) at their end points". He goes on to say that information is only usable at its destination, and thus, the "paradox of the network society is that nothing really happens in the space of flows". What studying web links and *Google* results may provide us with, is a context analysis of virtual urban geographies, but somewhat counterintuitively it will tell us less about local ICT infrastructure and its influence on a global network. It can be assumed that the number of web pages on a city will be driven by tourism, economy, politics, etc. and only to a small amount by the presence of IXPs or the available data infrastructure. So while we obtain insights on the virtual flows between cities, this view can hardly shed light on whether any political activity or economic development may be related or due to the installed ICT infrastructure. Furthermore, in acknowledging the production of world cities only "by what flows through them (people, information, knowledge, money, and cultural practices) rather than what is fixed within them", as claimed by Derudder and Witlox (2005, 232), it becomes hard to grasp effects of geographically bound infrastructure or other forms of investment that are 'spatially fixed' (Harvey 1975; 2001; 2009). The effects of the urbanization of capital, visible in the 2007 mortgage crisis or in gentrification processes all over the world, show that it not only matters what flows through urban centers but also what remains behind.

In regard to the second set of analysis, the study of airline flows to evaluate interurban networks has also been fairly popular; starting with Keeling (1995) and with recent entries, amongst others, by Choi, Barnett, and Chon (2006); Derudder and Witlox (2005; 2008); and the already mentioned Devriendt, Derudder, and Witlox (2010).

As with any index, ranking, or metric trying to quantitatively assess a city's 'position' in international networks, a word of caution is in order. These measurements are not problematic in themselves, rather, they become problematic by properties or qualities derived from them that they do not directly support. Therefore, these should be seen more as a tool to provide us with an idea of the effects of ICT development. It would be foolish to believe it possible to position something as complex as a city in something as wide and rapidly changing as the field of intercity relations through a simple index. What they can do, is measure one or two specific aspects of ICT activities and allow us to contrast this with a longer established transportation network. All in all, this will most likely tell us more about the airline network and ICT infrastructure than about the cities themselves. However, if we then use these results as a starting point for a qualitative assessment of a city's policies, we can see certain aspects more clearly and discern structural aspects from conscious efforts. This is in line with a critique by Watson and Beaverstock (2014), who pioneered some of the methods in this area. They argue that only a qualitative assessment can 'ground' the quantitative work and avert producing 'nice maps' without much theory behind them.

For this reason I will combine the statistics and maps on connectivity with an interview of the responsible department for Vienna's ICT planning and strategy regarding its international orientation. This will allow us to see Vienna's position on a European inter-city level more clearly and discern its intentional, strategic efforts in this area.

1.7.2. Meso-Level Analysis

Urban debates over recent years have increasingly centered on the effects of infrastructure on cities, even evoking the terminology of an 'infrastructural turn' in urban planning (Alizadeh, Sipe, and Dodson 2014; Dodson 2009; Graham and Marvin 2001; Neuman 2006; 2009). However, the relation between ICT, urban patterns, and spatial impacts on an intra-urban, neighborhood-level scale has been less explored. While there is a relative abundance of literature concerning the macro-level relations between urban strategies and ICT - intercity links, economic ties, and the cities' strategies in a globalizing world - and a theoretical focus beginning with Graham and Marvin (1996), this cannot be said outright of the meso-level. Most of what has been written on intra-city relations between ICT and the urban environment is focused on aspects of economic and social geography or policy (Castells 1996; Sassen 2012); and even papers that explicitly center on ICT-urban planning interrelations tend to concentrate on large-scale, general effects on traffic, social relations, or inequality, amongst others (Crang, Crosbie, and Graham 2006; Graham and Marvin 1999).

To a certain extent this might be due to the historical course of research into ICT-urban relations with quite a number of publications from the 1970s to the 1990s actually forecasting the demise of cities - akin to highways, ICT was seen as a centrifugal force drawing people further out on the countryside and only keeping them connected online (Graham and Marvin 1996; Nilles et al. 1976; Pascal 1987). Intra-city effects on a neighborhood-level would be neglected or of little relevance under such a view. However, the lack of studies exceeding the macro-level and delving into the concrete urban jungle is also relatable to a number of structural impediments.

First, the fast changing face of ICT that defies any easy and enduring categorization. For example, research focusing on digital divides underwent radical changes over just a few years with the advent of smartphones and their increasingly widespread usage, allowing a larger and larger group of citizens to connect to the internet on a frequent basis. With the increasing access to the internet though, other social and economic factors gain in importance: age, cultural capital, or social capital, to name just a few. As Crang, Crosbie, and Graham (2006, 2551-53) speak of “the emergence of a kind of ‘multispeed’ urbanism” more dependent on “the practices and modalities” of usage than on “the presence or absence of specific technological artefacts”. Thus, the simple provision of internet access cannot be seen as a panacea, and “[u]nderstanding the digital divide means viewing it not as simply a technological phenomenon, but a deeply social, economic, political, and spatial one as well” (Warf 2013, 2). As shown in the example above, much of what is now a reality in terms of ICT has only been developed in the last couple of years, and the temporal aspect is not only noticeable in older publications - in many cases the built environment also did not yet have time to react to the most recent developments. A swath of greenfield smart city projects exists only in plans and visualizations that already need adapting, and urban districts that are not built up from zero will even be slower in reacting to the presence of ICT.

Second, ICTs appear as tightly interwoven components of the urban fabric and life. Therefore, secondary (social, political, economic, etc.) effects of their implementation become very hard to distinguish, evaluate, or categorize (Maeng and Nedovic-Budic 2004, 71-72). Thus, most studies concentrate on measuring easily quantifiable characteristics of ICT such as bandwidth, traffic, etc. (D’Ignazio and Giovannetti 2007; Moss and Townsend 2000; Tranos and Gillespie 2011); and directly related factors such as broadband access, patterns of internet usage, etc. (Crang, Crosbie, and Graham 2006; Holloway 2005; Warf 2013). Or they keep a more general view on macro-level effects like suburbanization, increase of physical traffic, rising inequality on an intra-urban level, etc. (Alizadeh, Sipe, and Dodson 2014; Graham 2002; Mokhtarian 2002). As many ICT elements that serve as infrastructure are designed to be almost invisible or remain as inconspicuous as possible when working properly, their presence oftentimes goes unnoticed even by users, possibly distorting research methods such as interviews with users (Anacker and Evans-Cowley 2005, 40-41; Greenfield 2013; Maeng and Nedovic-Budic 2004, 62). The surrounding network of ICTs typically becomes most noticeable when it does not function as intended or in emergency situations that put severe strain on the network, which is why research frequently concentrates on these more uncommon situations (Greenfield 2013; Townsend and Moss 2005).

Third, ICT oftentimes appears as a 'black box'. Specifically a characteristic of commercial marketing brochures and publications, the mention of ICT serves as a metaphor for modernity and being up-to-date, without ever explaining who is supposed to do what exactly with which technology. This is a recurring feature of the way smart cities are portrayed in general, combining a generic and bland tech-speak with far-reaching claims into the future, but neglecting the fact that most aspects of technology can only be seriously evaluated once they have been clearly specified, including the mode of deployment and the manufacturer (Greenfield 2013). However, even in scientific literature Crang, Crosbie, and Graham (2006, 2553) note a tendency towards generalization in a deterministic fashion vis-à-vis technology - in their words "urban analyses rarely attend to how new technologies are configured and 'domesticated', in everyday practice, as means of remaking the time–space fabrics, and the logistical dynamics, of everyday urban life". Such simplistic views on technology also run the risk of assuming that the implementation of ICT would have very similar or almost the same effects in any city, exhibiting a complete lack of situational analysis (Graham and Marvin 1996, 83; 1999).

Last, there is a political aspect to take into account as well. As Morozov (2015, 59) points out, many technology corporations and service providers avoid framing their technology as a utility or as part of the urban infrastructure system, as this could entail questions of public oversight, control, or even ownership. Overall, ICT remains little associated with the public sector, even when it clearly fulfills functions of an urban infrastructure. Preventing such a framing of ICT, technology corporations are able to obtain significant freedom from regulation and to guard their internal information. Releasing data only warily or not at all, hampers further research into the area.

A notable exception to this lack of focus on the urban form on a meso-level are studies by Page and Phillips (2003) and Maeng and Nedovic-Budic (2004). Page and Phillips investigate the development of Jersey City and its fragmentation as an infrastructural city. Jersey City is extremely reliable on its proximity to Hoboken and New York City for the provision of many services, while at the same time attracting businesses from its neighbors. The infusion of corporate headquarters or outposts, which rely on the good infrastructure provision, has led to very uneven development within Jersey City, now sporting a prominent waterfront more resembling New York City and uneven and fragmented urban fabric in the hinterland. "The resulting urban form reinforces intra-city boundaries as wired, secured developments dissect the context" (Page and Phillips 2003, 86).

The study by Maeng and Nedovic-Budic (2004) concentrates on spatial development and land-use patterns in Chicago and Seoul due to the dispersion of ICT infrastructure. For their qualitative approach they rely mainly on interviews with public sector officials in planning agencies or the municipal administration. However, many of those interviewed report finding it hard to discern any directly attributable spatial effects yet. This forces Maeng and Nedovic-Budic to revert to evaluating more easily distinguishable factors such as internet access, before venturing into a more general assessment assuming that an increase in ICT-related businesses has transformed areas previously accommodating mostly manufacturing and service industries. The study exemplifies the difficulties in finding an appropriate research framework to counter the structural limitations while trying to analyze the interactions between ICT and the urban form on a neighborhood-level. Oftentimes, the authors only find refuge in rather general and slightly vague findings, as they remark on the limited amount of information provided by the case study (Maeng and Nedovic-Budic 2004, 87).

While there might be certain hurdles to take, it is important to keep in mind that with a strong focus only on very generalized, technologically deterministic, macro-level models we risk to overlook questions of individual agency, political deliberation, and effective policy-making (Graham and Marvin 1999). Additionally, the current framing of ICT does almost nothing to challenge the notion of ICT being concentrated in private hands and prevents viewing the development and implementation of ICT as a public agenda (Morozov 2015, 59).

With an eye on these four structural limitations a different approach has been taken in this work: an analysis of the planning documents of newly built or projected smart city schemes and their integration of ICT. I try to capture the most recent developments at the intersection of ICT and urban planning as they have been expressed in planning documents, project descriptions, and the recently built environment. For this purpose I will focus on three projects that acknowledge ICT as an essential part of their planning schemes - New Songdo, Masdar, or PlanIT Valley - and try to assess the influence ICT has on the planning process, the urban form, and the social aspects. While it is clear that all of these districts or cities are shaped by a multitude of different factors - climate, real estate considerations, culture and lifestyle, envisioned target audience, etc. - the plans, images, and newly erected urban fabric still present the most recent aspects of planning in times of ICT prevalence.

1.7.3. Micro-Level Analysis

Any analysis on the micro-level that is focused on small-scale ICT-mediated environments and on the citizens - users and non-users of ICTs alike - is bound to branch out into various other areas of study: software engineering and computer studies, sociology, political science and legal studies, to name just a few. Given that there is a limit to the scope of this work, I will concentrate on three key topics pertaining to citizens: (a) internet access and the availability of broadband; (b) handling and ownership of user data; and (c) an example case of a small-scale, ICT-enabled urban space.

The topic of internet access presents itself as a rather complex subject, even though, at first glance it might seem as if there are simple quantitative indicators at our disposal. Bandwidth and broadband distribution are two of the preferred parameters used in investigations, but with increased availability and speed of broadband connections, the importance of usage patterns is rising at the same time (Crang, Crosbie, and Graham (2006, 2552; Warf 2013, 2). More and more the question of having access to the internet is changing to knowing how to use it and what for. This concerns, for example, those already at a disadvantage and lacking access to important economic processes or social capital. On the other hand, those who already have a large network of important contacts at hand, stand to profit from ICT to a proportionally much greater extent. Whether a city aims for inclusivity will play a large role in determining its ICT policy, as it will otherwise risk aggravating preexisting social divides and inequalities through the growing focus on ICT (Graham 2002).

The question of user data arrives at the heels of rising and expanding corporate smart city visions. Right now there is one key facet that most of these visions concentrate on - the importance of data, its collection, and its use (Greenfield 2013). Additionally, should more and more objects of our daily lives become equipped with sensors and be able to go online, then the amount of data collected will certainly grow significantly (Townsend 2013, 4). This, however, begs a range of questions. While most users seem to accept, albeit grudgingly, the concept of paying for a service with their personal data when it comes to social media, email, or other online services; such a stance would entail serious consequences on an urban level. In a city equipped with cameras and sensors the possibility of opting-out becomes very unlikely, especially when this concerns a city's key infrastructure. Thus, the attribution, control, and use of this data will be an integral part of any city's policy relating to the topics of surveillance, democratic oversight, and securitization of the collected data.

Quite a number of smart city strategies do not express any limitations to data collection, with some schemes planning to record all movements of all citizens at all times (Greenfield 2013). Such an outlook truly seems to be more reminiscent of dystopian works of fiction such as *1984*, *Blade Runner*, or *Minority Report*. Not only would this signify a huge breach of any citizen's privacy, there is no clear account of what the benefits to such a strategy should be. Most planned usage schemes of the data are kept in completely generic terms, speaking only of 'improving efficiency' or 'reducing resource consumption' and 'providing a better user experience', so that the motto seems to be: 'collect first, ask questions later'. However, in contrast to the aforementioned tales of fiction, it would not be an overbearing state or city collecting all the information but private corporations. So while future applications for citizens remain vague and unclear, all this data would already prove very useful to those collecting it. Be that as an asset that can easily be monetized through selling the information to insurance companies, banks, commerce and retail, etc.; or by selling ad space and targeting citizens through advertisements that are tailored to fit individually. Democratic control and public oversight naturally do not feature in these corporate visions, and the fact that this data would be created by the movement and actions of citizens, and thus might be theirs to use or restrict its usage, is also lost in these schemes (Pentland 2014).

An alternative approach is presented by Morozov (2015, 61), who talks about "a different legal regime around data, perhaps ensuring that they cannot be sold at all". "Data would accrue to citizens, and could be shared at various social levels. Companies wanting to use them would have to pay some kind of licensing fee, and only be able to access attributes of the information, not the entirety of it" (Morozov 2015, 64). This is similar to ideas of a New Deal on Data by Pentland (2014), and would of course entail a completely different economic and legal approach, including regulation by the state. While the involvement of the state is reminiscent of the dark tones of *1984* or the Stasi, the revelations of Edward Snowden have shown that under the current framework it is already the intelligence agencies that have access to huge swaths of data without any public oversight or democratic control. Redefining the role of the state in a meaningful way would require the introduction of a system of checks and balances and strengthening the role of the judicial branch to protect the rights of citizens and hold the executive branch at bay. Although this would signify a stronger involvement of the state in general, such a system could potentially better shield users from unrestricted access to data by intelligence agencies, while allowing for the use of certain data sets in a regulated way. Apart from the haunting specter of surveillance, another issue with such a large assembly of data is the problem of apt protection from criminal organizations. Especially with recent breaches in both corporate and public databases, the question of how to keep such a large amount of sensible data safe has again come the forefront of discussion[5] (Pentland 2014).

[5] After the hack of *Sony* in late 2014, which led to the theft of thousands of confidential emails, social security numbers, salary lists, and company data, intruders managed to break into the systems of the two dating portals *Adult FriendFinder* and *Ashley Madison* in May and July 2015 respectively (Cieply and Barnes 2014; Dewey 2015; Peterson 2014; 2015; Tsukayama 2015). In April 2015 the *Office of Personnel Management* (OPM) of the U.S. government also admitted having been subject to a serious security breach that compromised the data of 22.1 million employees, relatives, and former job applicants; ranging from social security numbers to information on relationships, medical details, and criminal records (Chideya 2015; Nakashima 2015).

Lastly, there remains the matter of cross-platform compatibility and proprietary hard- and software. If indeed a city-wide operating system (OS) was to be implemented, as is being proposed, for example, by *Living PlanIT* and *Microsoft* in their plans for PlanIT Valley, this might seriously impede the development of future software-supported city applications (Greenfield 2013; Living PlanIT 2015a). Just like on a regular computer a proprietary OS would enforce a specific set of rules on all those using it, give control of development only to those having access to the source code, and might entail hefty licence fees, essentially preventing any outside changes or additions by those not willing or not able to pay such fees[6].

In terms of the framework of my analysis, I will first take a look at access to the internet in Vienna based on the factors bandwidth/speed, pricing, and the availability of public Wi-Fi hotspots, and compare this to other cities and international examples. On a qualitative level I will then assess Vienna's data policy and strategic outlook regarding the urban application of ICTs and measures of inclusivity based on interviews within the city administration and officially published documents. In the last section I will take a closer look at *Train of Hope*, a private initiative supporting refugees at Vienna's main train station, and how it relies on ICT in all of its operations - giving an apt example of an urban, ICT-mediated micro-environment.

[6] Coincidentally *Living PlanIT* already put a trademark symbol behind the term 'Urban Operating System' (Living PlanIT 2015a).

2. Analysis on Three Spatial Levels

2.1. Macro-Level Analysis

In the first part of the macro-level analysis I focus on intercity connectivity. For this I evaluate peak traffic data from IXPs and the number of passengers transported by the respective cities' airports. The cities considered were Amsterdam, Brussels, Frankfurt, Istanbul, Kiev, London, Madrid, Moscow, Paris, Prague, Rome, Stockholm, Vienna, and Warsaw. This sample comprises the nine European cities with the most IXP traffic, including nine of the ten IXPs with the most traffic in Europe; and the eight cities within Europe with the most airline passengers, including eight of the ten busiest European airports (ACI 2014; Euro-IX 2015; Packet Clearing House 2015; Rogers 2012).

2.1.1. Data Structure and Sources

All data on IXP traffic is based on published statistics by the IXPs and including compiled datasets by *Packet Clearing House* (PCH) and the *European Internet Exchange Association* (Euro-IX) as secondary sources. Peak traffic throughput within the last year is used as an indicator to compare the level of connectivity. This is in line with Euro-IX reports, which also collect peak traffic statistics; and by focusing on actual data traffic, circumvents the problem of including unused bandwidth that could seriously distort the results (Devriendt, Derudder, and Witlox 2010, 424; Euro-IX 2015). Traffic at IXPs exhibits a very distinctive pattern with a pronounced daily peak usually somewhere in the evening, between 6 and 10 p.m. Peaks can be almost double that of the traffic average. However, as a number of IXPs do not give any information on the traffic average, data on peak traffic is more reliable, and because of the very repetitive characteristics with little variation between the daily peaks at the same IXP, presents a statistically stable data set. Furthermore, peaks occur once per day at all included IXPs and signal the highest level of activity, thus designating the state when the surrounding region is 'most connected'.

Statistics on the annual passenger volume are published by almost all of the included airports and only in the case of Stockholm, statistics by the Swedish civil aviation authority were used instead. Data compiled by the *Airports Council International* (ACI) and the respective national civil aviation authorities were included as secondary sources where available. Transfer passengers that board a connecting flight are counted twice in these statistics, which also lack information on the origin and final destination (Derudder and Witlox 2005, 236). However, given the limited availability of data on the percentage of transfer passengers, and the fact that the economic impact of these airports is largely determined by additionally serving as transfer hubs and the total number of passengers and flights arriving and departing, the utilization of this data seems justified. Furthermore, the emphasis of this study lies on the influence of large-scale infrastructure on a city's position in global networks, not on the strength of ties between specific cities that could get obscured through stopover connections.

Data for both IXPs and airports is aggregated at city-level, when there is more than one IXP or airport serving the same urban region.

2.1.2. Virtual and Actual Intra-European Connectivity

Amsterdam tops the list in terms of IXP traffic (table 1), closely followed by Frankfurt, and then London. This is due the the presence of the three world's biggest IXPs in these cities, which outscale all other IXPs by a large margin. All three cities also play an important role as physical traffic hubs, albeit in reverse order, with London topping the list, and Frankfurt and Amsterdam coming in at ranks five and six respectively (table 2). This is not a surprising result, considering that historically London has been a world city for centuries. Frankfurt's international position, however, is probably mostly due to its importance as a transportation and communication hub, thus attracting other industries and businesses to the city. Accordingly, Frankfurt was introduced as the only German alpha world city in the *Globalisation and World Cities* (GaWC) research inventory, and specifically in comparison with other German cities, Frankfurt seems to have a decidedly more international than national outlook (Anacker and Evans-Cowley 2005, 41; Beaverstock et al. 2000, 58).

Table 1. Inter-City Connectivity Based on IXP Peak Traffic.

Rank	City	Gbps
1	Amsterdam	4,863
2	Frankfurt	4,086
3	London	2,692
4	Moscow	2,425
5	Stockholm	1,023
6	Kiev	1,021
7	Warsaw	989
8	Prague	565
9	Paris	403
10	Madrid	290
11	Vienna	274
12	Brussels	95
13	Rome	28
14	Istanbul	0

Sources: Data from AMS-IX 2015; BNIX 2015; Data IX 2015; DE-CIX 2015b; DTEL-IX 2015; ESpanix 2015; Euro-IX 2015; France-IX 2015; Giganet 2015; LINX 2015; LONAP 2015; MSK-IX 2015; NaMeX 2015; Netnod 2015; NFX 2015; NIX-CZ 2015; NL-ix 2015; PCH 2015; Peering-cz 2015; PLIX 2015; SFINX 2015; SOLIX 2015; STHIX 2015; Thinx 2015; TPIX 2015; UA-IX 2015; VIX 2015a.

Three cities post very similar IXP traffic numbers that represent second-order nodes with a relatively large gap to the top four: Stockholm, Kiev and Warsaw. While Stockholm also serves a significant number of airport passengers, especially Kiev and Warsaw are interesting examples of cities that have passenger numbers lower than Paris or Istanbul by a factor of roughly ten but attract significantly more IXP traffic than these. In the case of Kiev, the number of people arriving and departing by plane has even been decreasing by 13 percent from 2013 to 2014 at Kiev's main airport and continued to fall in the first months of 2015 due to the conflict in Ukraine (Kyiv Boryspil 2015a; 2015b). This heightens the importance of Kiev's IXP connectivity, which can surely not replace physical transportation but continues to grow in spite of the tense situation (DTEL-IX 2015; Euro-IX 2015; Giganet 2015; UA-IX 2015).

The next trio of cities with comparable IXP traffic comprises Paris, Madrid, and Vienna. While accruing a similar level of data traffic, they vary greatly in their airport passenger volume, with Paris outscaling Vienna by a factor of five. Paris has the second most airport passengers but only ranks at position number nine in regard to IXP traffic, not comparable to the ‘Big Three’ (Amsterdam, Frankfurt, London) in Western Europe.

Table 2. Inter-City Connectivity Based on Airport Passenger Volume.

Rank	City	Passengers
1	London	146,709,210
2	Paris	96,700,543
3	Istanbul	80,586,673
4	Moscow	77,340,831
5	Frankfurt	59,571,802
6	Amsterdam	54,941,000
7	Rome	43,648,394
8	Madrid	41,833,374
9	Brussels	28,373,147
10	Stockholm	24,797,375
11	Vienna	22,463,158
12	Warsaw	12,293,219
13	Prague	11,149,926
14	Kiev	7,980,563

Sources: Data from Aena 2015; Aeroporti di Roma 2015; Brussels Airport 2015; Brussels South Charleroi Airport 2015; Civil Aviation Authority 2015; Domodedovo 2015; Flughafen Wien 2015a; Fraport 2015; Gatwick 2015; Heathrow 2015; International Airport Kyiv 2015; ISG 2015; Kyiv Boryspil 2015a; London City Airport 2015; London Luton Airport 2015; London Stansted Airport 2015; Prague Airport 2015; Schiphol Group 2015; Sheremetyevo 2015; TAV Airports 2015; Transport Styrelsen 2015; UAF 2015a; 2015b; 2015c; Vnukovo 2015; Warsaw Chopin Airport 2015; Warsaw Modlin Airport 2015.

The cities with the lowest IXP traffic in this sample were Brussels, Rome, and Istanbul. Rome and Istanbul in particular attract a large volume of airport passengers, ranking third and sixth respectively, but only play a limited role in terms of data traffic. Istanbul has one IXP that does not post any traffic statistics but only sports a very limited number of registered prefixes, and another IXP is scheduled to open in late 2015 (DE-CIX 2015c; PCH 2015).

2.1.3. Vienna's Role as a European Traffic Hub

Vienna's position is not tilted strongly to either side, coming in at rank eleven for both IXP traffic and airport passenger volume. The number of passengers is comparable to Brussels or Stockholm, with the airport serving as a regional hub, indicated by a share of 29 percent of all travels being transfers compared to only 16 percent for *Brussels Airport* (Brussels Airport 2015; Flughafen Wien 2015a). The passenger volume at *Vienna International Airport* is also intended to grow further with the newly opened terminal building and the proposal for a third runway (Austrian Airlines 2015; Flughafen Wien 2015b).

In regard to IXP traffic, Vienna acts as a regional hub too and exhibits a more or less stable volume of traffic over the last year (Rutherford, Gillespie, and Richardson 2004, 18-19; VIX 2015a). The *Vienna Internet eXchange* (VIX) is present at two locations in Vienna, in the eighth and the twenty-first district, and is maintained by the *University of Vienna*, with the peering infrastructure in the twenty-first district being accommodated at *Interxion*, a private company. Both sites are connected via redundantly routed fiber-optic cables, and the VIX currently has 122 participants with a peak traffic volume of 274 gigabits per second (VIX 2015a; 2015b).

Overall, Vienna does not have a separately defined international ICT strategy - instead this task falls under the responsibility of the departments already engaged in maintaining international relations. Vienna does not explicitly emphasize its capability as an ICT hub in terms of city-marketing, but aims to strengthen technical cooperation at various international levels - this extends from talks with regional neighbors, like Bratislava, to the EU level. The focus of the municipality, however, lies more on their Open Government and Open Data initiatives, and large-scale ICT provision as well as the VIX are not being framed as one of their prime concerns. In a similar vein, the city administration is more occupied with the proper functioning of their infrastructure and the easily accessible provision of their services, than with influencing or strengthening Vienna's international position via ICT. ICT and data flows are not viewed as key parameters for Vienna's international strategy but only as necessary prerequisites in regard to overall city service quality. (Weidinger 2015)

2.2. Meso-Level Analysis

In this foray into meso-level ICT-urban interrelations I will focus on recently developed greenfield urban schemes that are either in the building or even just the planning phase. Almost completely unfettered by any constraints through pre-existing built structures, these projects are free to showcase current urban thinking and what role ICT is assigned in this constellation.

2.2.1. New Songdo

New Songdo is a privately developed real estate project of roughly 600 hectares on a landfill in close proximity to the *Incheon International Airport* and part of the Seoul greater metropolitan area. Designated as a free economic zone, New Songdo is marketed as a global business hub sporting all the 'required' amenities from private schools, waterfront apartments, to a luxury golf club and including an arts center that "will act as a powerful magnet for business people around the world" (Songdo IBD 2015b). The project was initiated in 2001 and the current master plan was completed in 2004. The progressive land reclamation was finished by 2007 and while construction is still under way, a significant number of buildings has already been finished and is in daily use. Overall, New Songdo is by far the most developed of the three examined greenfield urban projects.

Interestingly, there is little to no mention of ICT deployment within New Songdo in the marketing material. Rather, green building standards and carbon-reducing transport schemes are praised and the general lifestyle with all the available amenities is marketed. The smart transportation scheme that is supposed to reduce emissions and make Songdo a 'green' city also relies very much on conventional technology: four metro stations, twenty bus stops, twenty-five kilometers of bike paths, a water taxi and 5 percent of all parking spaces dedicated to "fuel-efficient and low-emitting vehicles" (Songdo IBD 2015c). There is no mention of self-driving, autonomous vehicles or other strongly ICT-reliant transportation schemes.

Only when we turn to *Cisco*, one of New Songdo's main partners, we find a more widespread mention of ICT. In short promotional videos 'smart and connected' appartments are presented, where residents can access all controls over lights, blinds, temperature and more via a central control panel or remotely through their smartphones. However, the mainly advertised feature of New Songdo's ICT-reliant applications is *TelePresence*, a video conferencing tool that is supposed to reduce the carbon footprint of New Songdo's inhabitants considerably by allowing them to connect via video instead of physical travel (Cisco 2012b). With the plan to deploy more than 20,000 units city-wide, videoconferencing should be available from offices, classrooms, and living rooms (Cisco 2012c). The reduction of carbon emissions through a decrease of transportation is altogether a rather curious claim for a project that at the same time aggressively markets its great connectivity via the adjacent airport - even naming itself an 'aerotropolis'[7]. Studies also indicate that a high level of connectivity actually increases the amount of physical travel, rather than decreasing it (Devriendt, Derudder, and Witlox 2010; Graham and Marvin 1999; Mokhtarian 2002).

However, there might still loom a more deeply rooted problem, regarding specifically *TelePresence*, and more generally rather rigid, but permanently integrated technology. While in 2012 the videoconferencing system was still praised as a paramount building block of the future district, this feature becomes a lot less impressive, when smartphones, tablets, laptops, and computers all allow you to connect to the internet wirelessly and make use of a wide range of videoconferencing and communication tools that are continuously developed. Furthermore, these devices can easily be moved within an apartment or taken somewhere else, and if need be, can still be connected to a larger screen. In a way, Songdo's videoconferencing scheme is being outsmarted by the easier and more flexible solutions, which might not be prepared by the developer, but that allow for more room to maneuver, constant updates, yet unforeseen combinations with other technology, and easy and most probably cheaper replacement.

Overall, it seems as if New Songdo consciously aims for the image of a 'green', 'eco-friendly', and international business district instead of an ICT-driven smart city. Partly, this might be because of the advanced status of development, which does not allow for any bold but unfunded claims, but rather relies on technology that already is in

[7] Or as Stan Gale, CEO of New Songdo's developer *Gale International*, says: "Where in the world, can you get on a plane that is only 18 minutes from your doorstep and be in Shanghai in an hour and a half, have lunch [and be] home in the evening?" (Cisco 2012d)

regular use. In this sense, New Songdo has bent to the inescapability of the material - accepting that what has been deployed in the actual world can be tested and reviewed. On the other hand, the rather discreet mention of ICT might also be due to an increase in privacy concerns and the fast development in this sector, with which many of the proposed plans cannot keep up.

In terms of the general urban layout, the influence of ICT is hardly felt directly. The master plan sports a conventional segregation into residential, commercial, and green spaces. While the residential units are organized into two large clusters, the commercial space is set along one main axis, separating the two residential blocks. In the middle of the new district is the large *Central Park*, but by far the biggest green space is indeed the private golf course located at the south-western end of Songdo. (see fig. 1)

However, a distinct feature of the project in development is the spatial fragmentation that fundamentally defines the relationship between New Songdo and the adjacent parts of Seoul. Through trying to attract mainly international corporations and in combination with its status as a free economic zone, New Songdo mainly caters to a class of well-connected business people. This is embodied in the premise of the international school and the luxury golf course, together with the close connection to the airport. Nothing in the marketing material of New Songdo under the 'Lifestyle' section even remotely references the existence of Seoul, let alone South Korea. While some might find it exciting to move into one of the world's metropolises with all its rich offers and struggles - these are seemingly not the future citizens of New Songdo, who, connected via ICT, are closer to other business enclaves all over the world than to their immediate urban neighbors.

Lastly, the question arises whether New Songdo can even be called 'urban' - with spaces so closely defined and tightly controlled that the room for flexibility or reprogramming appears to be very limited. The prime concerns seem to be stability, control, and security. Exemplified in a tracking system for children that lets parents see their exact location at all times and sends of an alarm when they leave designated zones, the predominant framing is one of efficiency and manageability (Galileo 2015). Everything urban and 'messy' is managed or removed - leaving behind a 'green' and secure, but rather bland and artificial space.

Figure 1. The masterplan of New Songdo.
Source: Songdo IBD 2015d.

2.2.2. Masdar City

Masdar City is located in Abu Dhabi, in the United Arab Emirates, and was conceived in 2007 as the first zero-carbon and zero-waste city in the world. The ambitious plans were partly shattered when the financial crisis hit in 2008 and the initial building time of only eight years was largely extended. Zero carbon became low carbon, and while parts of Masdar are already finished and in operation, the overall completion date was postponed indefinitely. (Ouroussoff 2010; Walsh 2011)

In regard to ICT Masdar's proposals are modest at best, at least in comparison to its 'co-competitors'. A 'smart' transportation scheme is implemented through the use of autonomous vehicles driving beneath the city but only serves a few predefined stops. Apart from this, there is no explicit mention of ICT, even though there is a lot of talk about 'high-performance' buildings and resource efficiency. Indeed, the master plan is slightly reminiscent of New Songdo with its residential clusters and the diagonal axis that connects the commercial space and large institutions (see fig. 2). Just like Songdo, Masdar is accessible from the 'outer world' through a few key roads and the metro, and is located in close proximity to the international airport. Moreover, in both cases the new districts give the impression of actively shielding themselves from their surroundings and of not wanting to be part of any larger urban conglomerates.

Under the current state of development Masdar cannot be called a city. It deems itself to be an urban project but is indeed not more than an assembly of newly erected buildings with only very few people living in them - more or less empty facades starring onto deserted streets, or a concrete backdrop eerily devoid of humans (Quartier Libre 2014).

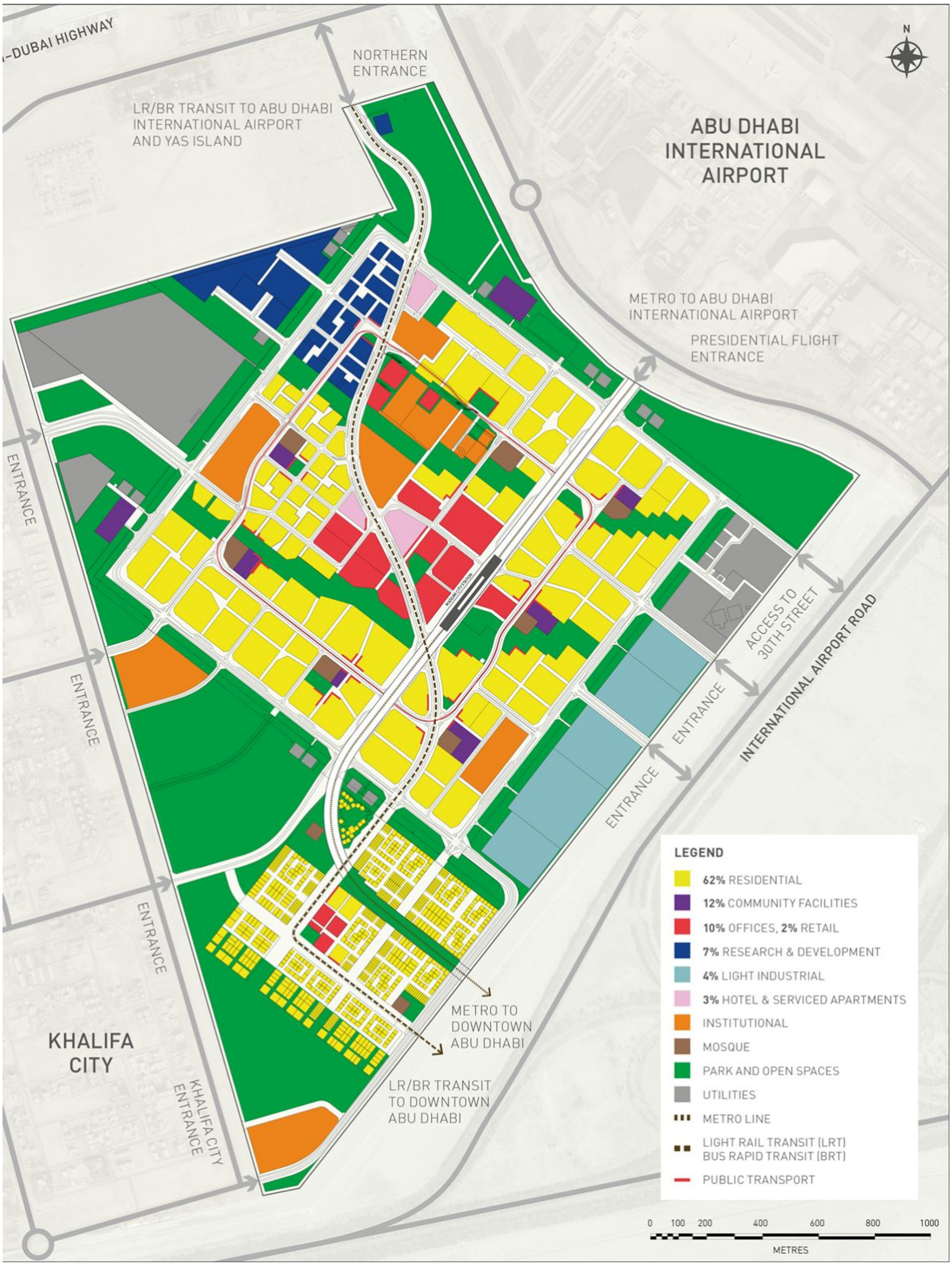

Figure 2. The masterplan of Masdar City.
Source: Masdar 2015.

2.2.3. PlanIT Valley

What was supposed to become "a truly smart, sustainable city" does not exist in concrete plans yet (Living PlanIT 2015b). Only a small paragraph on *Living PlanIT*'s homepage acknowledges the project in very crude and general terms in combination with an even blander image of white cubes in some sort of idealized rural setting (see fig. 3). Indeed, it is now the urban operating system of *Living PlanIT* that is promoted heavily and which is proclaimed to be nothing less than "integral to successfully envisioning, retrofitting, building and managing cities in the 21st century" (Living PlanIT 2015a). While the role of ICT and specifically the urban operating system is almost the sole concern of the promotion material, its application remains completely generic. The reappearing trope of bland marketing terms that describe unspecified technology can partly be explained by the absence of actual urban plans. In fact, without any concrete examples, all that remains, are the marketing slogans themselves.

Figure 3. Aerial visualization of PlanIT Valley.
Source: Living PlanIT 2015b.

2.2.4. Smart City Dreams?

There are a number of parallels between all three of the smart-city projects that raise two important points in regard to the relationship between ICT and currently trending urban developments.

First, all three project represent very tightly controlled systems - as much in their urban layout as in their technological set-up. A distinctive strength of cities, however, is the ability to adapt and showcase a high degree of flexibility, and it remains questionable whether these projects are capable of dealing with changing circumstances. They seem to be, what Taleb (2012) would call ‘fragile systems’ - very rigid in nature, with closely defined programmes, and dependent on the proper functioning of most parts. This is exemplified by Songdo’s videoconferencing appliances, a massive sunk investment that risks to become seriously outdated within a certain timeframe. More generally speaking, infrastructure once in place has a tendency to remain and ‘lock in’ a certain technological path, and the obduracy of urban infrastructure strongly influences the future course of urban development (Hommels 2005). Thus, with complex and expensive systems deployed in rather specific ways, the opportunities for reprogramming appear to be limited.

Second, these smart-city projects showcase a distinct disregard for any of their surroundings. While openness and connectivity are constantly emphasized, this feels more like a one-way connection. Indeed, they seem to exemplify further intra-city fragmentation - essentially strengthening the position of already privileged areas, groups, and interest within the same city (Graham and Marvin 1999). Or what Audirac (2002, 223) defines as a “product of urban telecommunication planning dominated by pro-growth, pro-business regimes, whereby the planning responsibilities of local [...] and regional governments [...] are disproportionately devoted to satisfying the new connectivity and mobility demands of businesses and knowledge workers”; leading to developments, where “in addition to being control centers of geographically distributed value networks, these new built forms are a new style of affluent, 24-hour work-live neighborhoods intended to attract and retain the mobile high-tech talent”. Specifically under these circumstances it is essential to emphasize that metropolitan-wide planning is of great importance to prevent urban ‘splintering’ into ‘multispeed’ cities and a further fragmentation by theses economic free zones and ex-urban areas (Crang, Crosbie, and Graham 2006; Graham and Marvin 1999; 2001).

2.3. Micro-Level Analysis

In this last chapter of analysis I will turn to the smallest spatial level and concentrate on internet access, the issue of user data, and local ICT-mediated environments with the close involvement of citizens.

2.3.1. Broadband Availability and Price in Vienna

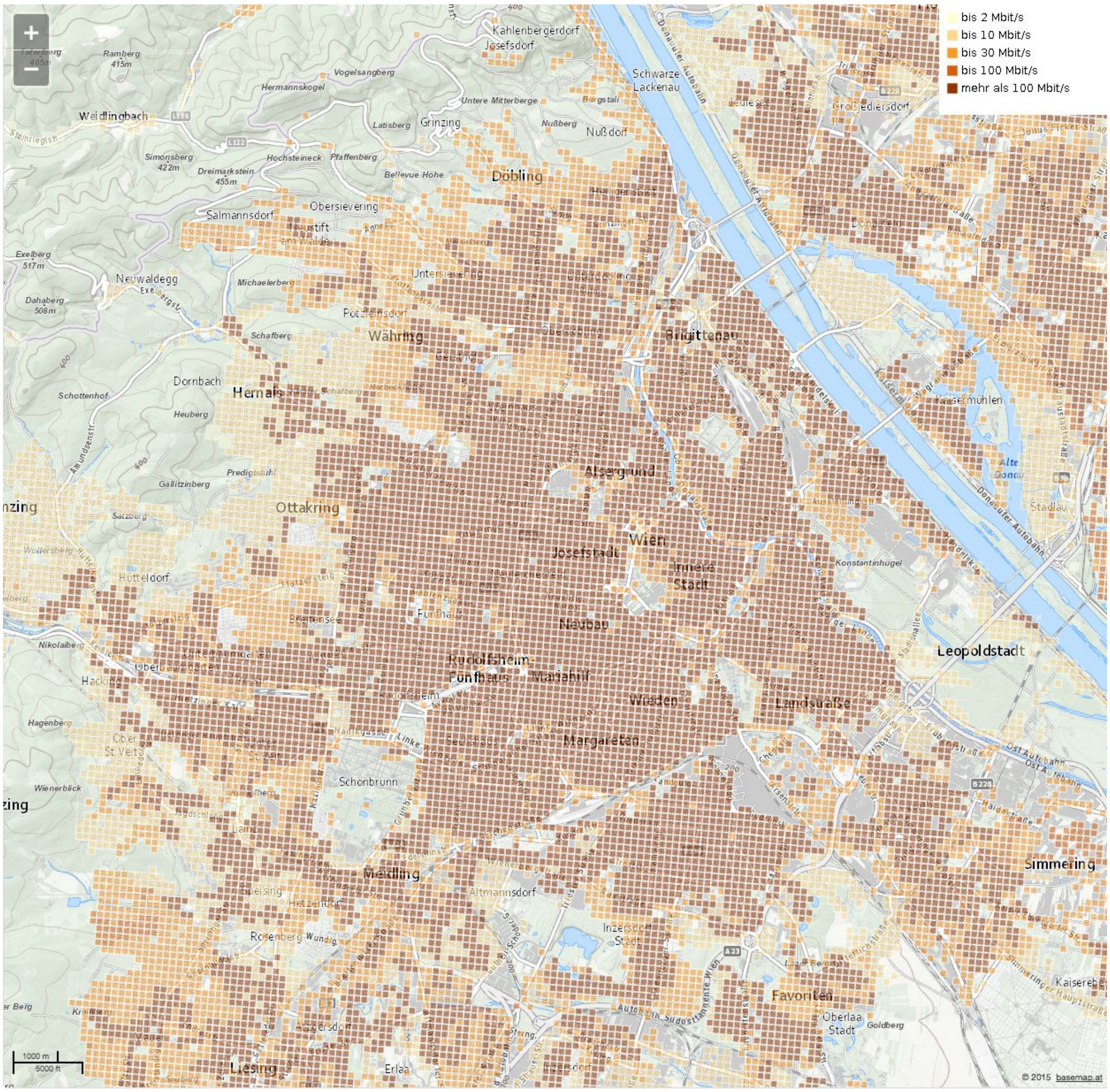

Figure 4. Available download bandwidth in Vienna via landline subscription.
Source: BMVIT 2015.

The question of internet access has become paramount for large groups of people over roughly the last ten years, with even the *Bundesgerichtshof* (2013), the Federal

Court of Justice of Germany, stating that internet access is a basic right belonging to all citizens. The *Austrian Ministry for Transport, Innovation and Technology* offers a continuously updated database of broadband connectivity all over Austria. It is based on data by the ISPs and the maximum download rate offered. Figure 4 shows the region of Vienna and the available download speeds via landlines. According to the specifications offered by the ISPs, almost all of Vienna, with the exception of parks or free spaces and a few areas mainly in the outer districts, is being supplied with a download bandwidth greater than a hundred megabits per second. The same can be said for service via mobile networks, where a theoretical bandwidth of more than a hundred megabits per second downstream is even more widespread (see fig. 5).

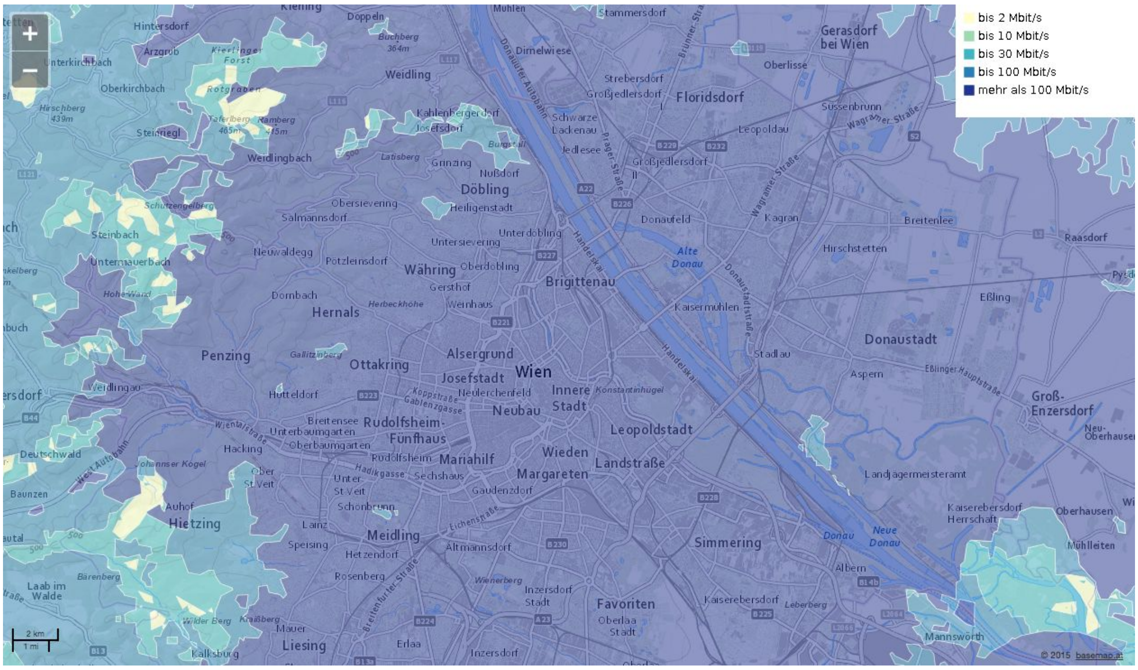

Figure 5. Available download bandwidth in Vienna via mobile subscription.
Source: BMVIT 2015.

However, both of these maps are based on the maximum available bandwidth according to the ISPs and do not take into account that many users opt for a cheaper subscription plan with less bandwidth. They may also not have an uninterrupted connection with the full nominal speed, especially when going online via a mobile device, or may have older equipment that is not capable of reaching such high download speeds. To, at least partly, control for this problem, figure 6 maps actually tested download speeds over the last six months. Here we can see a download rate distribution between a little over zero and above a hundred megabits per second, but with the the larger part of actual measurements falling in the range from five to 25 megabits per second. The median over the last six months is 17 megabits per second for mobile connections and 14 megabits per second for hardwired connections via a browser (RTR 2015).

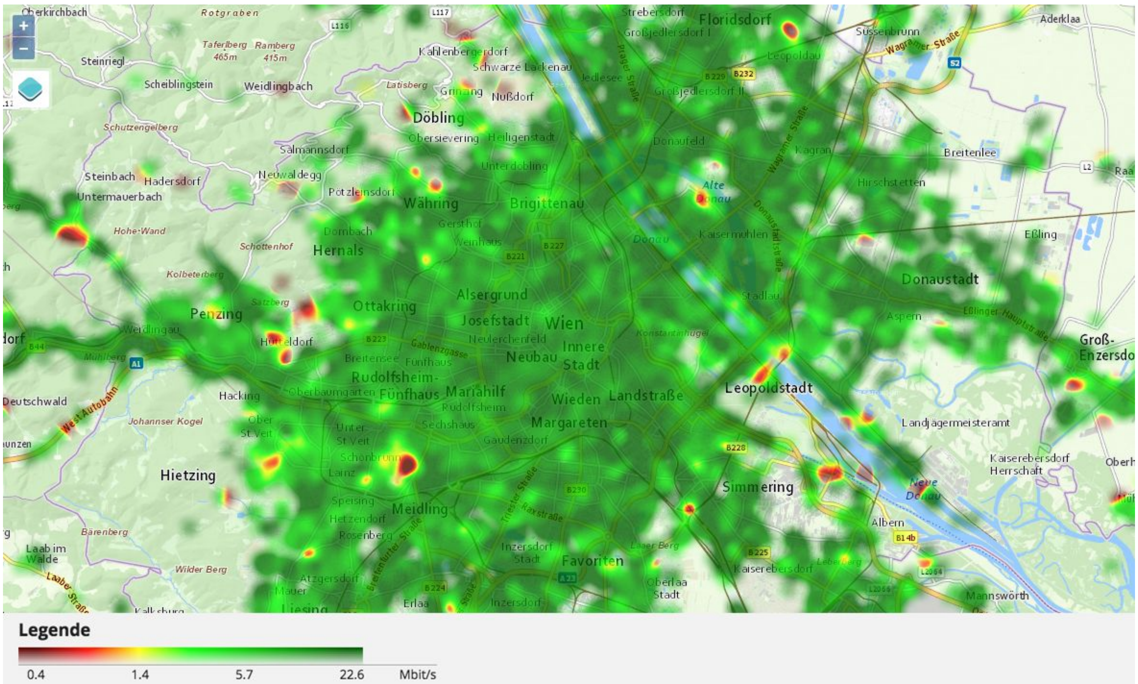

Figure 6. Actually tested download speeds in Vienna.
Source: RTR 2015.

Looking at the prices for broadband connections, Austria ranks at position 17 within the OECD with US$ PPP 0.30 per megabit per second for the cheapest available subscription plan. In comparison, people in Japan can pay as little as US$ PPP 0.02 per megabit per second while prices in Germany are rather similar with US$ PPP 0.32. Interestingly, the price range in Austria is rather small with the most expensive plans coming in at US$ PPP 4.23 per megabit per second, whereas this number can be as high as US$ PPP 25.58 in Germany or US$ PPP 29.15 in Japan. This is explained by the availability of rather cheap broadband plans in Austria, starting at US$ PPP 20.36, but with much lower bandwidth compared to the slightly more expensive Japanese broadband plans at US$ PPP 21.74 that offer far greater download rates (and hence lower the price per megabit per second drastically). The OECD statistics also give an overview over hardwired and mobile broadband subscriptions per 100 inhabitants. Regarding mobile subscriptions Austria ranks at number 19 with 67.1 subscriptions per 100 inhabitants and below the OECD average of 81.3. In terms of landline subscriptions Austria comes in at position 23 with 27.5 subscriptions per 100 inhabitants, also slightly below the OECD average of 28.2.

However, all of the before analyzed services are proprietary and usually only accessible via a paid subscription plan. The city of Vienna, on the other hand, does provide free and open Wi-Fi at various locations all over town. Until the end of 2015, 400 Wi-Fi access points are scheduled to be ready to use, with 150 already being in operation. These Wi-Fi access points are clustered largely around the city center and the inner districts but with a large number also located on the *Donauinsel*, an island in the Danube and a highly frequented and popular recreation area (see fig. 7). Download speed, at present, is limited to one megabit per second. (Stadt Wien 2015a)

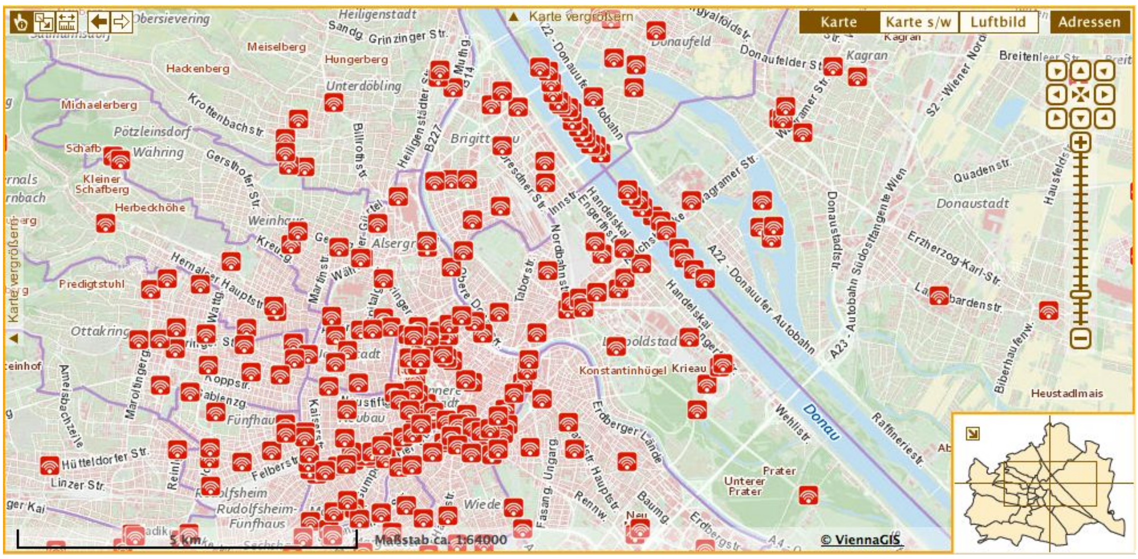

Figure 7. Wi-Fi access points in Vienna.
Source: Stadt Wien 2015a.

2.3.2. Citizens' Data

In today's world every citizen produces a huge swath of data, some of which may be recorded under full awareness but including a larger part that is saved without individual knowledge or even consent. Some of that data is recorded by private corporations, either as prerequisite or payment for using specific services or along the way, other data is collected by the state or municipal authorities, and under the catchphrases of ‘ecology’ and ‘resource efficiency’ the amount of gathered citizen data is set to further increase. When ‘smart buildings’ that turn off the heating and cooling while nobody is home record their occupants’ daily schedules and ‘smart cities’ track their citizens’ movements to turn off streetlights in unvisited areas, an array of new sensors and connected devices needs to be introduced into the urban environment. Going online they then form what is known under another current buzzphrase - the ‘Internet of Things’. However, there are two questions that loom large in the discussions on the implementation of more and more sensors into the urban environment: first, how much is being recorded; and second, who controls the amassed data? Furthermore, both of these questions are located partly in two different areas of concern - one pertaining to the field of surveillance and control, and the second one to the field of monetization and the financial value of data.

Privacy, Surveillance and Data Security

Not least with the revelations of Edward Snowden on the large-scale spying activities of the NSA, the question of surveillance once again became a pressing concern. It would be foolish, however, to assume that this is just a matter of missing public oversight of the activities of intelligence agencies. The very same exploits, backdoors, and bugs can and are being used by criminals, and once hitherto unconnected objects of our everyday lives go online, the consequences and concerns are exactly the same as on our computers and laptops. Spying and surveillance, malware, scams, and identity theft are just a few of them, but the list also includes remote control of an attacked system. While this may already be troublesome if a laptop or computer at home is concerned, the stakes are even higher if, for example, cars are involved. The two computer scientist Charlie Miller and Chris Valasek in July this year showed that they could take over a regular *Jeep Cherokee* from the comfort of their couch and not only fiddle with the onboard entertainment system, but accelerate the car, control or disable the brakes, and commandeer the steering. This was made possible through the introduction of an internet connection into the onboard system that allows users to make phone calls and offers a Wi-Fi hotspot, but also enabled the two researchers to attack and exploit the car's system from anywhere in the world via the internet. A few days after the publication of the exploit *Chrysler* was forced to recall 1.4 million vehicles in the United States. (Greenberg 2015)

With examples like these, it is interesting that technology corporations like *Cisco* apparently see no wrong in aiming to collect as much data on every citizen as possible. At least, this seems to be the stance in New Songdo, where cars are tagged with radio-frequency identification (RFID) chips, citizens use their individualized key cards to access anything from the metro to the automated trash collectors, and children are supposed to be equipped with sensors so parents can check their exact location at all times. The vast amount of data collected is sent to the city control center to be analyzed and to tweak city parameters for efficiency and performance. Furthermore, through cameras mounted on the main roads connecting New Songdo to Seoul and through the personalized key cards used in the metro, it is closely monitored who enters and leaves the city - measures that are justified by claims of crime prevention. All of these systems put a big question mark behind the topics of privacy and surveillance, but also concern the safekeeping of such a vast amount of sensible data. As neither government agencies nor criminal organizations have shown any restraint in exploiting critical systems and forcefully accessing data, the question stands whether the private corporations running Songdo's control center have the tools and interests to keep the data safe. (Cisco 2012a; Galileo 2015)

Open Data and the Monetization of Data

While New Sondo dabbles in schemes of surveillance and control, any questions of data ownership or the attached value are even less discussed. This might be of little surprise in a project developed primarily by a private real estate firm, but with an ever-increasing net of sensors in cities all over the world, the topic will be paramount to the experience of citizens and the use of future cities. Pentland (2012) specifically distinguishes between information about our beliefs that we might actually share freely and willingly, and the, for him at least, much more powerful information about our behavior that we leave behind in little pieces all along our daily paths. Leaving the issue of surveillance on the sideline, with city-wide operating systems and data collection being in private hands, it also means that a vast transfer of wealth is taking place. What is created by the actions of all citizens becomes an economic good in the hands of a few corporations without public oversight or control - and while on social media sites users might share their data willingly to pay for a service, the possibility to opt out is not necessarily available in an urban environment.

One way to address the topic of ownership and control over data is being tried in the town of Trento in Italy, where the *Mobile Territorial Lab*, a joint project between the *MIT Media Lab*, *Telecom Italia*, the *Fondazione Bruno Kessler* and *Telefonica* is carried out. Over a hundred selected inhabitants of Trento are registered in the *Personal Data Store* application, an online platform that collects all of their recorded personal data. The users can control privacy settings and decide how data upon them is collected and stored. In the sharing area they can then decide what parts of their personal data they want to share and how, with options ranging from 'Don't share' to 'Anonymously share' and 'Share in clear'. Finally, users have the option to delete records either via selecting a specific area or time interval, or just searching for specific single data points. What the project is supposed to achieve is to give citizens control over their data and confidence in the system, so that they are willing to share some of their data in areas where this can be helpful. (Mobile Territorial Lab 2015a; 2015b)

Vienna's approach is a slightly different one - while individual citizens cannot see exactly what information is gathered on them, all the anonymized data by different city agencies is openly accessible to the public. Via the homepage https://open.wien.gv.at citizens can download large packets of data - from traffic aggregates, environmental and climate readings to budget data - and use them to develop apps and services. The city of Vienna also has its own guidelines in terms of open data and the provision of the data sets. First, to make accessible all public data and municipal services that are not subject to privacy protection. Second, these should be provided online, with clearly defined terms of use, under the aim of maximizing usage opportunities, and ideally completely free of charge. Last, the provision should be handled using standard interfaces and formats to allow for the best possible use. All of this is complemented by regular conferences and events where developers can get feedback and support. Thanks to this, up to the end of July 2015 around 175 apps that make use of Vienna's open data have been developed. These range from giving information on the public transport system, including travel times and disruptions, to a register of all the trees in the city, or a map of all the publicly available defibrillators. (Stadt Wien 2015b; Weidinger 2015)

2.3.3. Train of Hope[8]

On September 1, 2015, a group of private individuals started to organize the first reception and care of arriving refugees at *Hauptbahnhof Wien*, Vienna's main train station. The initiative was named *Train of Hope* and took over large responsibilities usually associated with the state. Within the first two weeks they welcomed and assisted over 27,000 people; provided food, fresh clothes, and hygiene articles; and offered first aid and legal assistance. Through donations, refugees were also supported in buying train tickets for their further journey to Germany.

Critical in the (daily) operation of *Train of Hope* were the social media platforms *Facebook* and *Twitter*. These acted as central connecting platforms and the whole initiative was built up around them. While the location was fixed through the train station as the hub for physical travel, the whole organisational space became a heavily ICT-mediated micro-environment. Large amounts of incoming donations (food, sanitary products, medicine, clothes, etc.) had to be coordinated through a continuously updated list of needed things. This list was then regularly published on *Facebook* and *Twitter* to communicate both the most pressing needs and what was *not* needed - a requirement due to the limited storage capacities. But it was not only the restricted space availability at the *Hauptbahnhof* that necessitated coordination via social media platforms, the whole collective of helpers was organized in a very fluid, temporary manner. Daily operations and pressing concerns or emergencies were primarily managed on site, with no officially established organisation behind *Train of Hope*. The constant need for the presence of at least 50 people at the train station 24 hours a day was handled largely through these online platforms.

The ICT-based tools of communication - mainly *Facebook*, *Twitter*, and email - thus ensured a number of key conditions. First, they allowed for the uninterrupted arrival of a stream of needed goods while keeping momentarily unneeded donations, which would

[8] The example of Train of Hope as an ICT-mediated urban space is largely based on personal experience of the author within the initiative's social media team.

clog the storage, at a minimum. Second, they ensured that a sufficient number of relief workers were present at all times without requiring a fixed table of shifts and a large organizational structure including human resource management. Rather, people could come by and help only once, a couple of times, or continuously without needing to be registered and contacted individually. Third, for the more regular helpers they provided a means to connect and coordinate with the additional help of messaging platforms like *Telegram* or *WhatsApp*. Fourth, with an outreach to almost 1.2 million people over two weeks directly via *Facebook* alone, they helped secure much needed donations, even in very short timeframes, and ensured that enough volunteers were present at the train station. Fifth, they worked as a tool for communicating important messages and updates, missing person reports, or news on the general situation at the *Hauptbahnhof*. Last, they served as the main communication platforms with the press, interested citizens, or the general public; as any kind of information or request could easily be sent via email, *Facebook*, or *Twitter* message to *Train of Hope* and, with a response rate of under ten minutes, was answered almost immediately.

Overall, this allowed for the creation of a very fluid, reactionary space that adapted to changing needs but was united largely through the the ICT-enabled means of communication. The *Hauptbahnhof Wien* was as much a loose online congregation as it was a physical meeting place, and the online presence of *Train of Hope* became as real as the train station. However, even with communication and the organization of donations and volunteers as the specified and prime tasks, there were wider effects to be observed. Mainly through the large outreach, *Train of Hope* became a communication hub that collected and relayed information on the situation in various refugee camps, train stations, and towns in Hungary, Austria, and Germany. At the same time, donations and volunteers that would go to these places would leave from the *Hauptbahnhof*, so what started to happen online left traces in the actual world. For all of this, uninterrupted access to ICTs was key and a deciding factor in the success of the initiative, as the communication infrastructure allowed for a rather broad base of volunteers with heavy day-to-day fluctuations and a more open and less hierarchical structure than at other places of refugee-support or with the involvement of established NGOs.

3. Conclusion and Recommendations

3.1. Conclusion and Areas of Further Research

Almost twenty years after Graham and Marvin (1996) decried the missing research into telecommunication-city relations, there is still a more than considerable lack of studies and publications in that area. Partly, this is due to the aforementioned structural research barriers (chapter 1.7), but a stronger focus on the topic and funding directed into that field could very well reduce some of these barriers. The scarcity of studies in that area is also quite surprising, considering the hype that surrounds ICT and the immense opportunities that are time and time again praised in marketing materials and Silicon Valley tech speeches. However, as Graham and Marvin (1996, 7) write, this might not just be a surprising fact, but rather part of the problem. With only little on that topic coming from an urban studies background, this void is filled with publications from non-urban fields of study that often showcase a rather poor understanding of cities or urban problems. By and large these publications also tend to view ICT as the panacea for long-existing urban issues - issues that might even be aggravated by the unreflected implementation and use of ICT.

To counteract such tendencies, further in-depth research is much-needed with specifically three areas coming to mind. First, a serious evaluation of the effects that conglomerating ICT infrastructure has on its immediate urban surroundings. This includes questions of energy provision, excess noise and heat, and less easily distinguishable social effects. With large-scale facilities that sport a very low ratio of employees compared to floorspace, neighborhoods may lack the customer base to sustain shops, cafés, bars and restaurants, or any streetlife worth mentioning, especially after office hours. At the same time, extensive security measures and windowless façades give an unwelcoming image and further influence how people feel and act on the street. Second, on a slightly larger scale an approach would be needed that combines gentrification research with ICT distribution and its effects. Thus evaluating impacts on land prices and rent, and looking into processes of expulsion and replacement with a focus on the role of ICT. Third and last, we need to analyze the role ICT can play in the marginalization of different social groups - or positively framed, how they could be used to work against such marginalization.

3.2. Recommendations for Vienna

What follows are five recommendations, which, for the most part, are not only applicable to Vienna but of a rather general nature in terms of city-ICT relations. The list is by no means meant to be exhaustive and would profit greatly from input via the aforementioned research opportunities.

First, and this should come as no surprise, ICT cannot serve as a replacement for spatial urban quality. With master plans that seem to be ripped straight off proposals by the Congrès International d'Architecture Moderne (CIAM) and Le Corbusier or so-called 'smart cities' that are nothing but commercialized and privatized real estate developments, the impact ICT has, in terms of urban quality, is marginal. Second, a clear focus on fighting social marginalization is essential when implementing or regulating ICT. City-sponsored policies with clearly defined and stated aims that are regularly revised and vetted on the effects they have, can help to ensure that ICT indeed serves a purpose in bridging 'digital divides' instead of further aggravating them. Third and in close relation to the point above, ownership structures and policy approaches are a key factor in determining the role of ICT. ICT, as all other technology, is not only framed based on societal concepts but also molded into roles according to social, economic, and political structure. If its designated role is to decrease and alleviate marginalization within a city, then structural aspects such as ownership and general orientation (open, proprietary, profit-oriented, etc.) are deciding factors and directly influence pricing, access, and availability. The mode of implementation is a question of policy, political will, and individual agency, but does not follow a technologically predetermined trajectory.

Fourth, it is paramount to further strengthen the role of citizens. As the importance of ICT grows and slowly invades almost every aspect of our lives - the private and the public - the influence and control of citizens needs to develop concordantly. The implementation of systems that are hidden from sight and offer no level of control, is diametrically opposed to concepts of open and democratic cities. Instead, this signifies an approach that frames cities, or rather the provision of certain key services and control over it, as massive management endeavors, in nature very akin to large-scale corporations, whereas the rest of the city is to be left alone in an entrepreneurial 'mindset'. Overall, this is not a surprising stance, given that a lot of these visions stem from technology corporations and that Harvey (1989) already diagnosed such a shift over twenty-five years ago. Today, under cover of imperatives of ecology and resource efficiency, this stance remains in full force through countless smart city proposals and the call for efficiency above all. This is particularly troublesome, as most projects are presented as 'ideology-free' and motivated by 'unbiased' science, but indeed greatly reduce the amount of control in the hands of citizens or democratically elected and legitimized bodies. What would be needed instead, is a clearly defined strategy acknowledging the role of citizens or users, providing all of them with access to ICT, and giving them control over their data. This would also include ensuring a high level of usability and a low-threshold approach that allows for the largest possible number of citizens to participate. All in all, the aim should be an inclusive policy, which addresses not only the provision of ICT but also questions of digital literacy and empowerment of citizens.

Fifth and last, cities and municipalities have to proactively perform their role as regulators and agenda-setters. This concerns as much their direct involvement in regulating ICT infrastructure and its deployment as their general strategic framing. Very akin to the aforementioned need for research, an active stance by municipalities is essential in not leaving the field to technology corporations, free to dominate the agenda.

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