

The Little Book of PUBLIC SPACE and the Internet of Things

Alexandra Deschamps-Sonsino,
Andrew Hudson-Smith and Duncan Wilson

PETR S

THE PETRAS NATIONAL
CENTRE OF EXCELLENCE
FOR IOT SYSTEMS
CYBERSECURITY



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Other contributors include Peter Bihr, Ben Cerveny of The Foundation for Public Code, Usman Haque and Ling Tang of Umbrellium, Emma Bearman of Playful Leeds, Alasdair Davies of the London Zoo and landscape architect Jeremy Rye.

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What this Little Book tells you

Our public spaces are changing, they are at the forefront of a technological revolution yet this is a revolution that often remains hidden from sight. Sensors are being installed and the ability to interact with objects in our spaces - from projects such as the PETRAS Talking Trees through to conversations with Lamp Posts or data interactions with local wildlife is changing our interactions both in and with these places and spaces.

Via a series of interviews with key players in the field and a deep dive into the landscape of the last 20 years of developments around the world, this Little Book explores the current implications of the Internet of Things (IoT) in public places and looks at the future of technology trends for these spaces.

We explore safety and security and move onto maintenance (it's more interesting than it sounds and is arguably a key driver for the use of the Internet of Things in our public realm). We then look at some of the issues affecting people and explore health, community building and culture while exploring the use of public space for play. After this, we explore conservation and culture, transport and signage, accessibility and then, finally, we discuss future trends.

The implications and insights in this Little Book are wider than public spaces. The use of sensors in our environment can open up a new understanding of how urban places work. From social interactions and the importance of play through to a feeling of wellbeing and simply acting as a break from the surrounding environment, our public spaces are all important. This importance is often focused on cities due to the history and importance of the public realm but it is equally applicable to the local park or town square in smaller cities, towns and villages. As ever with society and technology, things are always changing and arguably, at an increasingly rapid pace, our public spaces are perhaps not as public as we thought and with this shift in public/private ownership the ability to deploy technology changes. Things can also be taken to extremes, where the need for ethical and governance structures to help temper the rise of technology in our public life. This Little Book explores these factors with a number of examples. Yet at its heart, the Little Book is about our places and spaces and how the future is one of adapting and opening up access to not only space but the context and access to two multiway interactions via the Internet of Things.

We start by examining what the IoT actually is, in a sea of definitions, and move onto exploring different themes (mentioned above), supplemented by interviews with local stakeholders in London and beyond as well as partners of UCL CASA. At the end of every theme, we also highlight some of the thought leaders worth keeping an eye on in the years to come.



The Internet of Things?



Defining the internet of things (IoT) at the time of writing this book is to engage in an attempt to clarify a complex landscape of marketing terms. Referring to its origins when the term was coined by Kevin Ashton¹, the original thought was to add metadata to our physical world, especially when it came to stock management and supply chain verification. What it has become today is a shortcut for the digital capabilities of the physical world when sensors, cameras, motors, and microphones are distributed and connected to the internet.

Over the last 10 years, the internet of things has also been responsible for the creation of products with unintended consequences that has given the sector a complex reputation. This leads us to the slightly harshly termed, @theinternetofshit on Twitter, which chooses to focus only on the bad whereas much good can be gained from measuring things more precisely, in situ, from remote locations, whether that is from a few metres away or from thousands of miles.

The remoteness, however, represents a new shift in the power dynamic around physical spaces and acknowledging this shift is central to this Little Book. Having sensors connected to the internet - arguably the simplest view of the IoT - dotted around in our homes, our cities, and open spaces can mean that power is removed from local actors, decision-making moved away from the source, surveillance is supported, and essentially remote control actions are enabled. A remotely monitored society, with decisions made based on data viewed remotely, is, of course, a road that is to be avoided, but a path that is possible and indeed one that is opening up. This is why over the past three years, an active global conversation around ethics has taken place. The ethics around the Internet of Things in public spaces is at the heart of the movement.

¹ Ashton, K. That 'Internet of Things' Thing. The RFID Journal, 2009. <http://www.rfidjournal.com/articles/view?4986>.

We hope that as you explore the topics of how new technologies are applied in the public space; you'll consider the bad as well as the good and use these reflections when hearing about the internet of things in other rooms, with other voices. No one in technology, policy, planning, design or any profession linked to designing and managing our spaces can afford to be removed from the consequences of what they build and its impact on public space - this is truer than ever with the deployment of IoT devices.

COVID19 and the public spaces of the near future

As this little book goes to print, public space has already started to change because of the variety of responses to the COVID-19 virus. In many nations affected, a variety of 'lockdowns' have been imposed. From strict impositions in China to a more lax approach in sparsely populated countries like Sweden, there has been no universal experience of a lockdown. Some people spent months at home while non-essential retail was closed and only food vendors and essential services were opened. Others were simply encouraged to establish a 'social distance' of 2 metres when interacting with others. Plastic barriers have been erected in corner shops and supermarkets. N95 medical face masks are being worn to protect workers most at risk while the general public is encouraged to wear masks when in public transport and in cramped locations where air conditioning is likely to be inadequate. Sidewalks have been widened to allow for a 2-metre distance between pedestrians and cycling is encouraged when possible. Public spaces, have become the places we both feel safer in but also at risk, depending on both their size and use. As temperatures rise and we enter the start of summer 2020, COVID-19 will require a mixture of social and technological responses and many of these will start to appear in our public spaces.

Contact tracing mobile apps are already being developed using Bluetooth technology. From recording mobile phones within a 2m distance to notifying someone when someone they've been next to has tested positive, the potential for false positives and data breaches are numerous. (<https://tracing-risks.com/>) . Elsewhere, more personal data like temperature is likely to be

collected in public spaces using digital, sometimes connected thermometers (<https://bleepbleeps.com/pages/tony-tempa-smart-thermometer>) and thermal cameras. What happens to this data over time is unknown but it's not hard to imagine it might contribute to future profiling, immunity passports, creditworthiness scores or insurance products.

The capacity for the virus to spread in enclosed spaces is likely to drive the need for more ample public space to move our group activities. Parks are at the forefront of this and their current focus as places of recreation may well shift into an additional place of work, outside the confines and away from the risk of the offices. Indeed, the city could well have reached a forced tipping point, whereby the public spaces become more valuable than the offices, it is in these spaces where we are likely to see an increase in the use of technology but also more of a culture of tracking and tracing our activities. The health of our bodies is linked now more than ever to the health of our cities and public spaces and as the fears of a second peak loom, the future is hazy yet increasingly dependent on the usefulness of technology solutions.

What is public space?



'By its very nature, public space should be unscripted. It's not designed for a specific activity but it can accommodate a number of different things. The question is: who benefits from an unstructured space? Who designs, as Bernard Tschumi might ask, the script for a space? [...]. This isn't easy to do as it requires long-term investment and a clear governance structure in place that 'belongs' in a space that may change over time.'

Usman Haque, Founder of Umbrellium

Placemaking, space making, public space all compete for our attention, as per our analysis and research in 2019. The Oxford English Dictionary lists a number of different definitions for the word 'public':

1. Of or concerning the people as a whole
2. Open to or shared by all the people of an area or country
3. Of or involved in the affairs of the community, especially in government or entertainment
4. Done, perceived, or existing in open view
5. Of or provided by the state rather than an independent, commercial company

These definitions include concepts describing the way people negotiate living together peacefully in society and concepts of governance, transparency, community management and a 'collective' interest are also built into this definition.

Other ways to read the public realm, especially in a UK context is through the lens of the report on Public Space in London²: Public spaces are a city's living room, its lungs and a location for civic life, (p 8, Public Space in London).

The report goes onto to quote the current London Plan³ which states:

Whether publicly or privately owned, public realm should be open, free to use and offer the highest level of public access. These spaces should only have rules restricting the behaviour of the public that are considered essential for safe management of the space.,

(P9, Public Space in London).

The use of the term 'should' highlights the tension between public and privately owned public spaces; it is this tension where the IoT is increasingly coming into play. However, in general, when we think of public space, the focus is often on access to this space or the constraints in accessing it. The streets of our cities, the squares, and the parks we walk in, the roads we drive or are driven down all come to mind. The notion of public space focuses our mind's eye to the space we share with others.

By opposition, we then formulate our idea of private space. From the building we work in that requires we wear a badge or the shopping district that uses private police forces to monitor shoppers, we think we know public from private space. All land (except oddly for churches) in the UK is in fact privately owned. 4 Public good, the Commons⁵, and many other related philosophical constructs are extremely powerful, especially in politics, but they do not actually correspond to the way in which land is bought, developed, owned, rented and managed in the 21st century. Private interests are present at every level.

² Bosetti (N)., Brown (R)., Belcher (E)', & Washington-Ihime (M)., Public London: the regulation, management and use of public spaces, The Centre for London.

³ <https://www.london.gov.uk/what-we-do/planning/london-plan/current-london-plan>

⁴ <https://www.gov.uk/guidance/hm-land-registry-commercial-and-corporate-ownership-data>

⁵ <https://en.wikipedia.org/wiki/Commons>

Even with these interests in the mix, the success of private interests depends on aligning their interest with the other contributors to public wealth: shop tenants, schools boards, cultural institutions, hospitals, passersby, police, for example, all are required to make public life go round.

Most multi-stakeholder conversations will start with two common focus points: crime reduction and job creation in an area. However, other needs exist. In the following diagram, we have mapped them using Maslow Hierarchy of Needs as a model. (Maslow's Hierarchy of Needs is a motivational theory in psychology comprising a five-tier model of human needs, often depicted as hierarchical levels within a pyramid⁶.)

The visualisation in Image 1 could allow stakeholders to see their dependencies and their place in a complex ecosystem. Whether the stakeholder is a local authority, a waste removal company, maintenance contractors, security firms,



health services, social services, policing functions, retail tenants, urban planner, architect, developer, construction company, IT contractor, or landowner, they rely on others in their interactions with citizens. Everyone from the able-bodied local resident, disabled visitor or tourist should be able to interact with many of the services developed by these stakeholders and many of these are implementing interactions focused around the Internet of Things. This is only

⁶ McLeod, S. (2018), Maslow Hierarchy of Needs, <https://www.simplypsychology.org/maslow.html>

the latest in a series of technological developments which have had an impact on the public sphere and especially the delivery of services by cities and local authorities.

The desktop computing revolution followed by the growth of internet access and more recently smart mobile penetration in urban areas has had an important impact on the expected mechanisms of delivery of public services. From 'mobile-first' websites, mobile parking permits, paperless communications and digital wayfinding apps, cities and local authorities have had to partner with IT providers and think through the implications for citizens and local residents more specifically. Moving through a shopping mall, a visitor may expect free wifi connectivity, or good mobile network connectivity, to the point where a building might make it part of its Key Performance Indicators (KPIs)⁷. This seamless access in turn makes it easier for potential customers to search for an item they have found and order it online from a competitor.

More ubiquitous and good quality connectivity also implies that it can be embedded in the physical world instead of just staying on a device. Everything from bins⁸, lamp posts⁹, post boxes¹⁰ and animals¹¹ are being monitored with the help of a denser network of connectivity options that today includes wifi, Bluetooth, LoRa, LTE/4G & eventually 5G.

These projects and applications are often described as part of a wider umbrella term of 'Smart Cities'. In a recent report by Privacy International¹², two possible definitions of the 'smart city' are offered by The World Bank:

⁷ <https://wiredscore.com/uk/>

⁸ <http://bigbelly.com/>

⁹ <https://www.ubitricity.co.uk/>

¹⁰ <https://www.hellolamppost.co.uk/>

¹¹ <https://www.ucl.ac.uk/news/2017/jun/smart-detectors-monitor-urban-bat-life>

¹² <https://www.privacyinternational.org/topics/smart-cities>

The first one is:

A technology-intensive city, with sensors everywhere and highly efficient public services, thanks to information that is gathered in real-time by thousands of interconnected devices.

The second one is:

A city that cultivates a better relationship between citizens and governments - leveraged by available technology. They rely on feedback from citizens to help improve service delivery and creating mechanisms to gather this information.

The ability to connect things is real, but how they shape the experience of service delivery and crucially, how it affects people's expectations is not always straightforward. A digital 'swipe' is always quicker than what an ecosystem can deliver. Equally, varying levels of digital literacy make the widespread adoption of some solutions complicated and face-to-face, print and phone-based support services are still largely provided across all the services.

Finally, the digital rights of citizens get more complex when data is being gathered about them without their full knowledge because the sensing capability is not where it is expected. This is often the case when cameras are deployed in public space. The European Union's General Data Protection Regulation in 2018 gave citizens unprecedented rights to their own data but informing the general public of these rights and how they play out in public space is complex. Concepts of privacy and consent are executed differently in public than on a device and at home, where 'privacy' feels like a clearer concept. The refusal of local councils to share data with the Home Office¹³ about their homeless community in 2019 is an example of an ecosystem of services sharing responsibility for a person's experience of the city, their data and by extension, their privacy. Figuring out why you should invest in, install and maintain a new technology is a pretty well-known process for privately owned research and corporate IT groups. However, when that technology is deployed in the public realm and is comprised of complex hardware that needs updating or maintaining and has an impact on privacy, the ensuing complexity may not be worth it. Andrew Roughan, Managing Partner at Plexal positions this in relation to air quality monitoring, an issue we will cover later on:

¹³ <https://www.theguardian.com/society/2019/jul/17/councils-refusing-to-share-personal-data-of-rough-sleepers-with-home-office>

The economic case is often eroded by device management and life cycle management when a product is set up. Air quality is one of those instances where the return on investment is very poor once you connect the amount of maintenance required. Trials also suffer from having ambitions that are too modest, their objectives are too low to make them worth investing in the longer term.

Technology service providers are in the middle of an identity crisis and moving to 'software as a service' models to reach out directly to the end consumer. But that requires society-led outcomes to become part of the big business thinking which is a distinctively different way for large enterprises to think.

What lessons can we learn then from the work done and the experiments in public space? Is it all too complex already? Is it worthwhile looking to hardware solutions to help us with public life? In this book, we will explore the different ways in which technology in public spaces can provide some of the stakeholders a different set of opportunities but also highlight the risks and frameworks for future-proofing any public stakeholders' thinking. Because it's the public good and not only the public realm which is at stake.

Safety & Security



CCTV camera in London

The most well-known use of connected hardware in the public realm relates to issues of safety and security. Depending on the risk profile of a city in terms of political upheaval, terrorism and crime, the major stakeholders (land management companies or owners) will take different approaches to installing connected hardware.

The UK's use of CCTV since the early 1960s is a good example of security-related technology in the public realm¹⁴. Once installed, their potential application expanded from crowd monitoring to theft prevention, traffic monitoring and automatic number-plate recognition systems. The 1991 bombing of the Baltic Exchange Building and the 1993 bombing of Bishopsgate by the

¹⁴ <https://www.mrfsgroup.com/a-brief-history-of-cctv-use-in-the-uk/>

IRA subsequently and the ongoing 'Troubles' saw a 'ring of steel'¹⁵ installed to secure the public realm against terrorism in London and Belfast. After the attacks on the World Trade Centre in New York City in 2001, the idea that a camera could do the whole job was challenged. Cameras couldn't just be locally connected, they needed to be connected to more important crime databases and thus a bit more of 'the internet'.

More recently, the amount of technology in cars, taxis and freight vehicles means the cybersecurity landscape is larger than it was 10 years ago. Risk for building managers becomes a matter of priority as the attack surface becomes more important and especially when experimenting with new technologies is part of a modernisation agenda.

When it comes to the use of cameras, the website for Information Commissioner's Office (ICO) contains advice on CCTV¹⁶ cameras which includes taking the nature of the installation into consideration:

The CCTV operator must let people know they are using CCTV. Signs are the most usual way of doing this. The signs must be clearly visible and readable, and should include the details of the organisation operating the system if not obvious.

CCTV should only be used in exceptional circumstances in areas where you normally expect privacy – such as in changing rooms or toilets, and should only be used to deal with very serious concerns. The operator should make extra effort to ensure that you are aware that cameras are in use.

This is difficult to police and can be abused. An example of what can be called 'poor communication' has been the King's Cross Estate application of cameras with facial recognition. Kings Cross Estate is one of the first landowners to acknowledge it was deploying the software, described by human rights groups as authoritarian, partly because it captures and analyses images of people without their consent. The lack of public communication, clear consent and GDPR governance structures coupled with the ensuing PR scandal forced the estate to cancel the project¹⁷.

¹⁵ [https://simple.wikipedia.org/wiki/Ring_of_Steel_\(London\)](https://simple.wikipedia.org/wiki/Ring_of_Steel_(London))

¹⁶ <https://ico.org.uk/your-data-matters/cctv/>

¹⁷ <https://www.theguardian.com/technology/2019/sep/02/facial-recognition-technology-scrapped-at-kings-cross-development>

While the use of camera technology with facial recognition is concerning, the culture and politics of the country have a very important role to play in deciding the appropriate level of intrusion of any technology in the public realm.

In Singapore cameras in private hire cars or taxis record both audio and video while buses were considered by the local authorities closer to public space, so are so far exempt¹⁸.

Cameras are also involved in capturing public space without the same stakeholders involved, for example when security cameras installed for domestic real estate use is installed at street level. This also applies to doorbells that have been enhanced with cameras and internet connectivity in the past years to help owners manage visitors, Airbnb guests and home deliveries.



Amazon's Ring doorbell which includes a camera pointing towards the street.

Doorbells like 'Ring' by Amazon or 'Nest Hello' from Google are being used for law enforcement. In the U.S., 600 police forces have signed up to use Ring and are now able to request up to 12 hours of video from anyone within half a square mile of a suspected crime scene, covering a 45-day time span.¹⁹

¹⁸ <https://www.todayonline.com/singapore/audio-recording-be-allowed-vehicle-recording-devices-taxis-private-hire-cars>

¹⁹ <https://www.washingtonpost.com/technology/2019/11/19/police-can-keep-ring-camera-video-forever-share-with-whomever-theyd-like-company-tells-senator/>

Not every solution has to use camera readings though, sometimes Bluetooth connectivity embedded into lamp posts can also give authorities enough information in spaces that are more enclosed, but an extension to public space. The MyGuardian app²⁰ was developed and trialled on the University of Surrey Campus to help students alert someone when they were going to be walking home so that an unexpected delay was noticed straight away and their last location documented clearly.

Another way to develop safety and security in public spaces is tracking the number of mobile phones connected to a Wi-Fi network can indicate the size of a crowd across an entire area while keeping people's information private.

So far, we have talked about safety in terms of a fixed piece of hardware, but some of them are becoming mobile, moving around our public spaces. For example, rape or personal alarms have also been upgraded by connectivity²¹. Companies like Ignius²² offer a geolocation aware cardholder or pendant that allows a wearer to report an incident in real-time.



Sammy Screamer, the remote movement monitor by Bleep Bleeps

²⁰ <https://ics-iot.weebly.com/eyehub.html>

²¹ <https://wealarms.co.uk/>

²² <https://www.womenofwearables.com/new-blog/wow-woman-in-wearable-tech-chakshu-saharan-founder-and-managing-director-of-ignius>

Sammy Screamer²³, a product of UK company Bleep Bleeps, is a movement sensor which alerts parents via an app when a pram might be moved or something else is leaving a set parameter around the app.

These solutions don't strictly require the public realm to change, but enabling them, encouraging access to these solutions while offering clear signposting is also part of a public safety and security agenda within the Internet of Things.

Thought leaders you should follow

- Privacy International (privacyinternational.org)
- Big Brother Watch (bigbrotherwatch.org.uk)
- Urban Analytics, Alan Turing Institute (turing.ac.uk)
- Alison Powell, Ada Lovelace Institute (adalovlaceinstitute.org)
- Doteveryone (doteveryone.org.uk)

²³ <https://bleepbleeps.com/pages/sammy-screamer-motion-alarm>

Maintenance



Big Belly solar powered bins

Connected sensors and actuators can also help city stakeholders manage crucial upkeep functions. What sensors are especially good at is rapid reporting of change of condition. From a change of state (on or off) to a more subtle change over time (levels in a bin), this can be useful to make decisions remotely, more rapidly and more strategically.

Applications in this space haven't historically taken advantage of internet connectivity. For example, monitoring ambient light levels to turn on street lights, or measuring the presence of a car and the swipe of a card to open a barrier are closed systems without any reliance on the internet. However, by looking at weather patterns, a small sensor can act differently and different kinds of contextual patterns can help make very different decisions.

Seeing a multitude of bins dynamically fill up in a park on a warm day or during an event while accessing the number of people connected to a local Wi-Fi network can help cleaning teams deploy resources very differently than if they see one bin at a time without any extra layer of information.



Bins by Renew London which tracked IP addresses.

There is of course a balancing act, just like the examples in the previous section showed us. The overzealous use of sensors on bins was fatal to the Renew project²⁴ around Liverpool Street Station. The project was shut down because it captured too much information, collecting the IP addresses of mobile phones that walked past them. Far from being necessary to the job of keeping these bins empty, the company tried to develop dynamic

²⁴ City of London calls halt to smartphone tracking bins, BBC News, August 2013
<https://www.bbc.co.uk/news/technology-23665490>

advertising on the side of the bins that would cater to the average person working or commuting to the area. This is a key example of a business model that is too focused on advertising as a way to prop up the company instead of focusing on a realistic market dynamic.

The Big Belly Bin²⁵, pictured at the beginning of this section, is a more successful example of a bin that uses a solar panel to power its sensor and internal waste compactor. Data is dynamically sent to a proprietary platform allowing waste removal companies to access information and thus send out their staff at the optimum time. Domestic waste removal is also going to move on to be more connected. By making citizens pay for their food waste via weighing them in RFID enabled communal bins, South Korea was able to dramatically reduce food waste²⁶. This relies on a system of national ID cards, which many countries have not been successful in rolling out²⁷, so again, the local geopolitical situation matters in how the internet of things is adopted and shaped locally.

Waste management is also tied to the current conversations in politics around climate change. Councillors in Bristol have been keen to offer connected domestic waste bins so that citizens can get a better view as to what happens to the contents of their waste²⁸. This desire for more transparency on waste removal and recycling will only intensify and much research is being done about bins that sort materials automatically using cameras like Clean Robotics' own 'Trashbot'²⁹ or Bin-E³⁰, which is targeting office spaces. These levels of automation will possibly become a feature of public waste management.

Other applications are hyperlocal and take advantage of digital rating systems to let facilities managers know what is going on with a space. For example, the feedback application 'Happy or Not'³¹ allows a stakeholder to gather dynamic in-situ feedback remotely with a smart connected sticker.

Thought leaders you should follow

- The Restart Project (therestartproject.org)
- Festival of Maintenance (festivalofmaintenance.org.uk)
- Connected Places Catapult (cp.catapult.org.uk)

²⁵ <http://info.bigbelly.com/sc-data-sheet>

²⁶ <https://www.weforum.org/agenda/2019/04/south-korea-recycling-food-waste/>

²⁷ <https://www.ft.com/content/2ec95b9a-4709-11e8-8c77-ff51caedcde6>

²⁸ <https://www.bristolpost.co.uk/news/bristol-news/calls-chips-monitor-how-much-3207902>

²⁹ <https://cleanrobotics.com/>

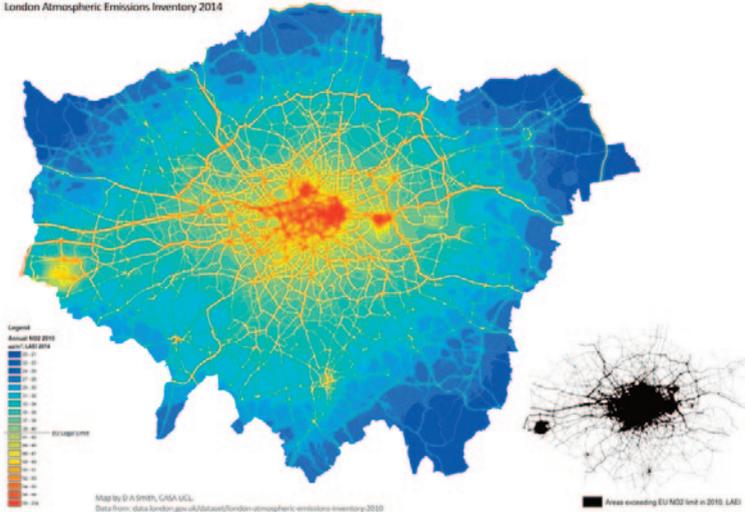
³⁰ <http://bine.world/howitworks/>

³¹ <https://www.happy-or-not.com/en/smiley-wall/>

Health & public good



Greater London Annual NO₂ Concentration 2010
London Atmospheric Emissions Inventory 2014



NO₂ Annual concentration in London 2010, modelled by the London Atmospheric Emissions Inventory. All of Inner London and many major roads in Outer London greatly exceed the EU limit

Another function of public life and public spaces is in supporting healthy lives and active communities no matter the level of urbanisation.

Air quality monitoring using internet-connected sensors has become a technological tool to talk about health in cities. Since the Guardian started actively reporting on this issue, UK boroughs and their performance in terms of particulates have been under public scrutiny³². Knowing the level of particulates isn't enough though as public space stakeholders consider the

³² <https://www.theguardian.com/environment/2019/feb/27/pollution-map-reveals-unsafe-air-quality-at-almost-2000-uk-sites>

return on investment as highlighted by Nathan Pierce the Program Director for Sharing Cities and Head of the Smart London Team:

When it comes to something like air quality, for example, the business case is more difficult to define because the benefits are mainly social and environmental, not necessarily financial. This is why more effective air quality related projects have been led by public-private partnership structures like the work we are doing with the Alan Turing Institute, the Mayor's Air Quality Fund and Transport for London's ULEZ program. We also want to encourage people to use more varied methods to get around the city, getting more people on public transport and less journeys done by petrol cars. To support this we are increasing the number of charging stations like Ubitricity or shared economy /mobility as a service scheme.

Raising awareness can have a double objective: to raise citizen awareness and give them the tools to change their own interaction with the public realm or raising awareness at a policy level so the vendors capturing the data are encouraged to report on the results.

Investing in technological and connected solutions in this space can only be useful if coupled with long-term policy changes such as banning diesel vehicles or banning cars in some areas. All the stakeholders, including car owners themselves, need to be educated. If a car-free experience of the public space is the future in terms of improving health in crowded cities, then capturing longitudinal data remains one of the ways to convince first diesel and petrol car owners of their impact and then the people they love of their impact. Obviously, this can only happen when alternatives are available so public transport provision is crucial, especially in rural areas.

The growth of the electric car market and the infrastructure needed to charge cars varies across nations so a medium-term solution is still the coverage of public transport. A future comprehensive network of charging stations that are public, shared, work-based and at home will make it easier to make the leap in the instances where public transportation investments are weak.

Unfortunately, much has been written of the impact on traffic of car-sharing services³³ like Uber, Lyft and others. They are not an option when considering our need to lessen the number of cars on the road unless their entire fleets are 100% electric.

³³ <https://usa.streetsblog.org/2019/08/07/uberlyft-responsible-for-a-large-share-of-traffic/>

Cycling is also a healthier option but the overall infrastructure is often skewed to cars and cycle sharing schemes have also proved very wasteful and blurring the lines of responsibility as illustrated by the experience of Phil Gyford³⁴, a London-based technologist:

Last night I came across a Lime e-bike, dead on its side in a disabled car-parking space. I set about rescuing it, thinking that its conventional home, annoyingly littering the pavement, would be less bad.

As soon as I picked it up it started beeping, loudly. Then a computery woman's voice began saying, "Please unlock me to ride me or I'll call the police!"

I set the bike upright on its stand but the beeping and the verbal warning repeatedly alternated. I continued walking home, quickly, while the once quiet street was filled with the alarming noise, which slowly faded as I turned a corner. Maybe it's still going.

Horrible. One good deed rewarded with a scary blend of the so-called sharing economy, the commercialisation of communal spaces, and authoritarian surveillance capitalism, all sugared with the unbearable style of wackaging. May every dockless bike and scooter scheme go bust as soon as possible.

Building healthy communities doesn't only mean air quality. Communal and individual behaviours around health, whether that is by helping someone find a public toilet, a sexual clinic or a place to exercise in their neighbourhood, are more and more enabled by digital services but connected hardware also has a role to play. GPS embedded inside the soles of shoes for Alzheimer's patients³⁵ can help find a person without the help of emergency services. Wearable technologies help people track their levels of exercise (iWatch, Fitbit, etc) but they could also act as ways of identifying areas that feel safe to people³⁶ at different times of the day.

Just like smartphones, the technologies that are initially 'personal' can influence the way in which public space is used if that data is shared. In all these contexts though, and especially when it comes to health-related issues, the ways in which data is shared matters in public spaces. Citizens need to

³⁴ <https://www.gyford.com/phil/writing/2019/10/06/weeknotes/>

³⁵ <https://gpssmartsole.com/gpssmartsole/>

³⁶ <https://neos.co.uk/can-wearable-technology-help-us-design-better-cities/>

be encouraged to be early adopters without fear. As Emma Frost from the London Legacy Development Corporation concludes:

Questions that should be asked include: how public is the public realm? Is it a galvanising force in the community? Sometimes, it's less about the built environment and more about the spirit of doing the work, engaging with communities, respecting the heritage of the communities that are already there. Communities are not a petri dish though and cannot be treated as predictable sets of conditions, there has to be some flexibility, especially if the space is being used to learn, explore, test and try new things. What people are willing to do, engage with and trust is important to the outcome.

Thought leaders you should follow

- Playable City (playablecity.com)
- Emma Bearman, Playful Leeds (playfulanywhere.fun)
- Tom Armitage (infovore.org)
- Jane McGonigal (janemcgonigal.com)
- Six to Start (sixtostart.com)
- Frank Kelly, King's College London, London Air Quality Network (londonair.org.uk)
- Michelle Murphy, Technoscience Research Unit (technoscienceunit.org)
[Runfriendly \(runfriendly.com\)](http://runfriendly.com)

Biodiversity & Conservation



Oracle's Bee Project which tracks the behaviour of swarms in and around a hive

Part of public life that is becoming increasingly important is the preservation and growth of natural spaces and the conservation of urban species. Many non-profits have been working with new technologies to track endangered species³⁷, but it's also the creatures closest to us in cities that matter. Many technologically enabled projects are there to help count or protect bees, butterflies, birds and trees.

Not every project is necessarily commercially viable but ideas are plentiful. Fieldwork Facility is a design studio who made the Nest Project that encourages a DIY approach in providing birds with more spaces to nest in³⁸. The Internet of Trees is a London-based startup looking to add sensors on trees in heavily forested areas to help alert and locate the source of forest fires³⁹. Oracle has been working with the charity The Bee Project to use

³⁷ <https://www.wwf.org.uk/project/conservationtechnology/acoustic-monitoring>

³⁸ <https://fieldworkfacility.com/projects/the-nest-project>

³⁹ <http://internetoftrees.tech/>

camera technology to help with bee conservation and identify when a swarm might be about to move⁴⁰.



Arup's Nest project provided a type of housing for bees and insects.

British Land worked with Arup on a series of insect hotels and green roof studies⁴¹ and smart beehive project like that from Pollenity⁴² have helped people become better beekeepers. Rewilding practices in both public space and private gardens are also on the up, contributing to more diversity in both types of natural resources.

Keeping an eye on the diversity of a space includes endangered species as well as more common ones. The work of companies like Arriba⁴³ focuses on building open source technologies for the conservation sector but closer to home, UCL's Nature Smart Cities focused on tracking bats on the Queen Elizabeth Olympic Park. They built smart bat monitors (Echo Boxes) that work like a "Shazam for bats". The box, once installed on a lamppost or other structure in the park captures the soundscape of its surroundings through an ultrasonic microphone, then processes this data, turning it into an image called a spectrogram. These are then scanned, identifying possible bat calls and even a possible diversity of species on the site.

⁴⁰ <https://www.oracle.com/uk/corporate/pressrelease/ai-smart-hives-network-helps-conserving-global-honey-bee-2018-10-16.html>

⁴¹ <https://www.britishland.com/sustainability/our-views/articles/2012/biodiversity-takes-root>

⁴² <https://pollenity.com/product/uhive/>

⁴³ <https://blog.arribada.org/>



Bat monitors in the London Olympic Park built by UCL CASA

Not every solution is technological or connected. In some parts of the Queen Elizabeth Olympic Park, for example, lower lighting was installed to protect the natural habitat of some animals. This has the power of becoming a solution that is rolled out to parks everywhere, especially in cities where parks remain open at night but should be balanced with the need for safety. Helping people request more light on demand or digitally could help city officials assess the usage of those spaces too and their impact on animals in the area.

Thought leaders you should follow

- Jeremy Rye Studio, landscape architect (jeremyrye.com)
- Alastair Davies, Shuttleworth Fellow from London Zoo (blog.arribada.org)
- Nature Smart Cities (naturesmartcities.com)

Transport & Signage



Dynamic LED display developed by design agency Breakfast NYC

Signage and wayfinding in public space hold a dual functionality in making a space both legible and aiding safety. If you don't have a good sense of where you are heading to, you may not want to go there at all. This can be expressed through signs that point in a direction or maps. The gold standard in this area is the IV system⁴⁴ by Mijkesenaar at Schiphol Airport, which, with its black Frutiger typeface on a yellow background cuts across its environment and helps passengers at key moments find their way no matter where they are going. As a general principle, the craft of good signage takes a view on how much information to communicate at any given time in a particular context (destination, time it would take to walk, number of meters, etc).

⁴⁴ <https://uxdesign.cc/wayfinding-at-schiphol-some-design-considerations-behind-the-world-famous-vi-system-and-what-29842b368252>

The Legible London program⁴⁵ in London Boroughs focused on maps which promote walking and encourage a walking view of a neighbourhood, giving people confidence they didn't have to take other modes of transport, helping relieve public transport usage for short distances for those able to walk.

The role of signage is distinct from advertising or temporary events based information however the distinction is blurring and when it comes to the role of new technologies, the two are often combined.

Screens which contain both directional information and advertisements have sprung up in indoor malls, transport infrastructure and on the sides of complex office buildings.

The work of Lancaster University researchers in providing bespoke content to a network of signs⁴⁶ is intriguing as the volume of passers-by is likely to provide competing pieces of information. The idea of dynamic and relevant surfaces was also explored by the now defunct UK design studio BERG⁴⁷ in their project 'Media surfaces' which used different e-paper solutions for travellers to get relevant information about the journey they were about to undertake. The idea that shared spaces can communicate bespoke pieces of information is a complex one when most public space tries to address as many people's needs as possible but there are plenty of opportunities for exploration.

Advertising or mapping isn't the only use of these screens. Elevators in Canary Wharf also include a screen with the status of various Underground lines, helping people make a travel choice from within their office building.

Reversely, information that is present in the physical world doesn't connect up to maps and signage often enough. Currently, Google Maps does not know when public construction works happen, it simply indicates there is traffic. In the future, we can expect multiple physical objects to weigh in on publicly accessible mapping systems and this may extend to digital maps and signage. Construction materials and barriers may add information to a city mapping system, which then helps cars reroute more effectively.

⁴⁵ <https://tfl.gov.uk/info-for/boroughs/legible-london>

⁴⁶ <https://www.lancaster.ac.uk/scc/about-us/news/public-displays-that-change-to-show-content-tailored-for-you>

⁴⁷ <http://berglondon.com/projects/media-surfaces-the-journey/>

Thought leaders you should follow

- Stamen (stamen.com)
- Mapzen (Linux Foundation Project) (mapzen.com)
- Geovation (geovation.uk)
- Benchmark Initiative (benchmarkinitiative.com)

Accessibility



Fraunhofer's system to help the blind using microchips connected to satellite networks.

One of the many challenges of the public realm is offering access to all, no matter what their levels of ability in an environment that is rapidly becoming augmented by technology. From dangling cables to charge electric vehicles to e-bikes and scooters, the pavement of large cities is one of the least accessible places for those with disabilities. These are not new problems, the electrification of cities and advances in telecommunication started the population of our streets with devices. It is however transforming rapidly and for wheelchair users through to enabling access for blindness, tackling these new problems is a challenge. Lack of common sense is hard to police.

A clear example of where Internet of Things technology is moving for accessibility was the 2014⁴⁸ joint Transport for London and Future City Catapult project to use Bluetooth technologies to offer indoor positional information to someone with a visual impairment. Cities Unlocked, with the additional parts of Microsoft, Guide Dogs and University College London, included a headset someone might wear which connected with GPS, Bluetooth beacons and wifi along a route between London and Reading. With the corresponding mobile app, it provided the wearer with

⁴⁸ <https://futurecities.catapult.org.uk/project/cities-unlocked/>

3D-soundscapes, augmenting reality to provide a richer understanding of their surroundings. Cities Unlocked is a clear example of how the Internet of Things is able to augment and enhance our public spaces.

Another example is a series of wearable devices that used hardware connected to global satellite systems to help the blind navigate city streets. Designed by Fraunhofer Institute for Integrated Circuits (IIS) in the context of an FP7 European funded project, this bespoke hardware won many awards but has not been commercialised.⁴⁹ Other solutions have moved into the more commercial application space, such as BlindSquare, an app that describes to someone what is around them⁵⁰ via audio messages.

If we take this one step further and consider building voice assistants, such as Alexa, into public spaces, we can imagine a future where a more 'public' version is enabled in the city and available for someone partially, or indeed fully sighted, to use on top of their own devices - providing voice based information in our public spaces.

This is, in a way, what the LinkNYC kiosks could have been. Started in New York City and known in the UK as BT InLink, these on-street units offer free Wi-Fi access, USB charger and emergency access with a touch of a button. They are replacing telephone boxes and while likely to generate more revenue than an analogue phone box, they are yet another addition to the street for a blind person to contend with. One of the features being developed⁵¹ is for the screen to act as a street side emergency signage but this has not been deployed yet.

Thought leaders you should follow

- Alastair Sommerville, (acuitydesign.uk)
- Superflux, (superflux.in)⁵²
- Open Inclusion, consultancy (openinclusion.com)

⁴⁹ https://www.researchgate.net/publication/232100201_A_Flexible_and_Portable_Multiband_GNSS_front-end_System

⁵⁰ <https://www.blindsquare.com/>

⁵¹ <https://www.rbkc.gov.uk/idoxWAM/doc/Other-2051879.pdf?extension=.pdf&id=2051879&location=Volume2&contentType=application/pdf&pageCount=1>

⁵² <http://superflux.in/index.php/work/elastic-cities/#>

Future trends



Public display with the energy captured by a solar panel on top of a building in Japan

Not everything that counts can be counted, and not everything that can be counted counts.

Bruce Cameron

As we have highlighted throughout this Little Book, with data gathering comes great policy-making responsibilities. Every city, local actor and citizen will be working with a set of local values, which will influence how the internet of things is implemented, accepted or shut down. The introduction of more network options with 5G⁵³ and LoraWAN⁵⁴ add to telecommunication infrastructure and multiply the potential for these complex dynamics.

Having more products connected to our information networks and to ourselves also creates dependencies we are not necessarily able to predict but thankfully, toolkits are available to enable leaders to reflect and plan accordingly.

We will highlight here areas that leaders can think about in the coming years and add to their strategic approaches as well as their risk registers.

⁵³ <https://www.businessinsider.com/5g-high-speed-internet-cellular-network-issues-switch-2019-4>

⁵⁴ <https://www.edp24.co.uk/news/politics/temperature-senors-norfolk-roads-gritting-money-save-1-5778802>

1 Early-ish collaboration platforms

San Francisco has recently launched 'Civic Technology Centre' points to respond to the growing need to build bridges between the city's stakeholders and technology companies. The problems that Uber have had with license provision in London are one example of processes that bring policymakers and technology companies to interact in expensive and public ways. Having platforms where public servants, lawyers and government officials at all levels can give feedback to scaling companies should enable better decision making on the part of the provider and preparation on the part of each local actor. This is different from FixMyStreet or SpaceHive as it is about an active early engagement with companies, instead of necessarily funding new ideas or only responding to problems as they are reported.

2 GDPR for the physical world

However weak the GDPR may be in terms of local enforcement, it has enabled a large community to discuss issues of digital consent. It has also increased the level of literacy around digital services and their use of marketing tools. As surveillance tools are turned into marketing tools, we can expect GDPR to move beyond digital borders and into the public realm. What may initially be in-site terms and conditions may become a pan-European approach to public space and how much information can be gathered about the people who traverse it. It may also mean more transparency around ownership of land, space and buildings. It will also help citizens understand who owns the sensing hardware that surrounds them, especially when the infrastructure isn't owned in a typically top-down way (eg. LoRaWAN masts). We also expect there to be more transparency around small, lower power sensors and where they are, what data is being gathered and how to ask for one's own data to be removed.

3 Act local

There is much focus on inequality and whether it is human trafficking, slavery, domestic abuse or drug networks, cities must enable citizens to report the issues they identify in their own communities with the help of technology. Whether it is the use of drones by citizen journalists or Hello Lamp Post to

help people signal a change in their neighbourhood anonymously, the tools for reporting must become diverse and close to the problems they are connected to.

4 Greener cities

Changes in the environment will continue to be monitored closely as the effects of climate change start to disrupt bee populations, flowering seasons and harvest patterns. This is an area that is likely to receive a lot of technological attention and monitoring. Satellite imagery is already being used to assess what the climate risk of an area is but we can expect public space in cities to start to be 'rated' as ecologically prosperous or not. Measuring how 'green' a city looks based on CCTV footage may be a happier byproduct of millions of cameras in London. Tree planting opportunities may be identified more easily using footfall counters in busy areas, to 'lighten' the carbon load of busy streets. Camera technology may be pointed at an area to measure the amount of light received and make recommendations for plantings or rewilding projects.

5 Cash vs. cash-less

Libraries are places that may also see a return in popularity. Some even let you know how much you've saved in Amazon purchases by choosing your books there⁵⁵.

Cashless interactions are not prevalent everywhere but they are starting to affect the way in which services are delivered. Cash may also make a comeback as the ultimate anonymous transaction. Local currency projects like the Bristol and Brixton Pound encourage people to shop in their local area. Will digital bank apps encourage people to do the same, geofencing someone's spending? Or rewarding them for shopping in a business which is within a certain distance of home. Can a building ask for anonymous donations via a swipe or tap of a card just like a busker does? Many non-profits may use their window display or real estate to try these kinds of engagement solutions.

⁵⁵ <http://www.openculture.com/2019/08/public-library-receipt.html>

Conclusion

As our city lives continue to get busier and more pressured by larger and ageing populations and amongst many issues, increasing pollution, the role of technology will be of most importance in harnessing the most relevant piece of information instead of gathering as much information as possible. As public literacy around the use of cameras or sensors increases, cities can expect either polarising conversations, vandalism, or adoption en masse - this could shift either way. Currently, the public at large seems content with home-based listening devices installed and monitoring of activities via their smartphones. With CCTV being a given in the UK, the move towards facial recognition at large and a complex set of monitoring capabilities in the public realm is bound to attract much of the attention in the short term.

We shouldn't however, abandon all technological implementation in the public realm when some many needs still go unmet.

No city should expect a rollout to go smoothly without engaging with citizens and hyper-local stakeholders. In many ways, the opportunities of the future city are opportunities to develop literacy in its teams, an open dialogue with technology firms and a willingness to experiment over long periods with consent from all. The challenge is to use the IoT for the public good while avoiding the Orwellian overtones of things and devices sensing and listening into our public spaces - a notable challenge for the future of public space.



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