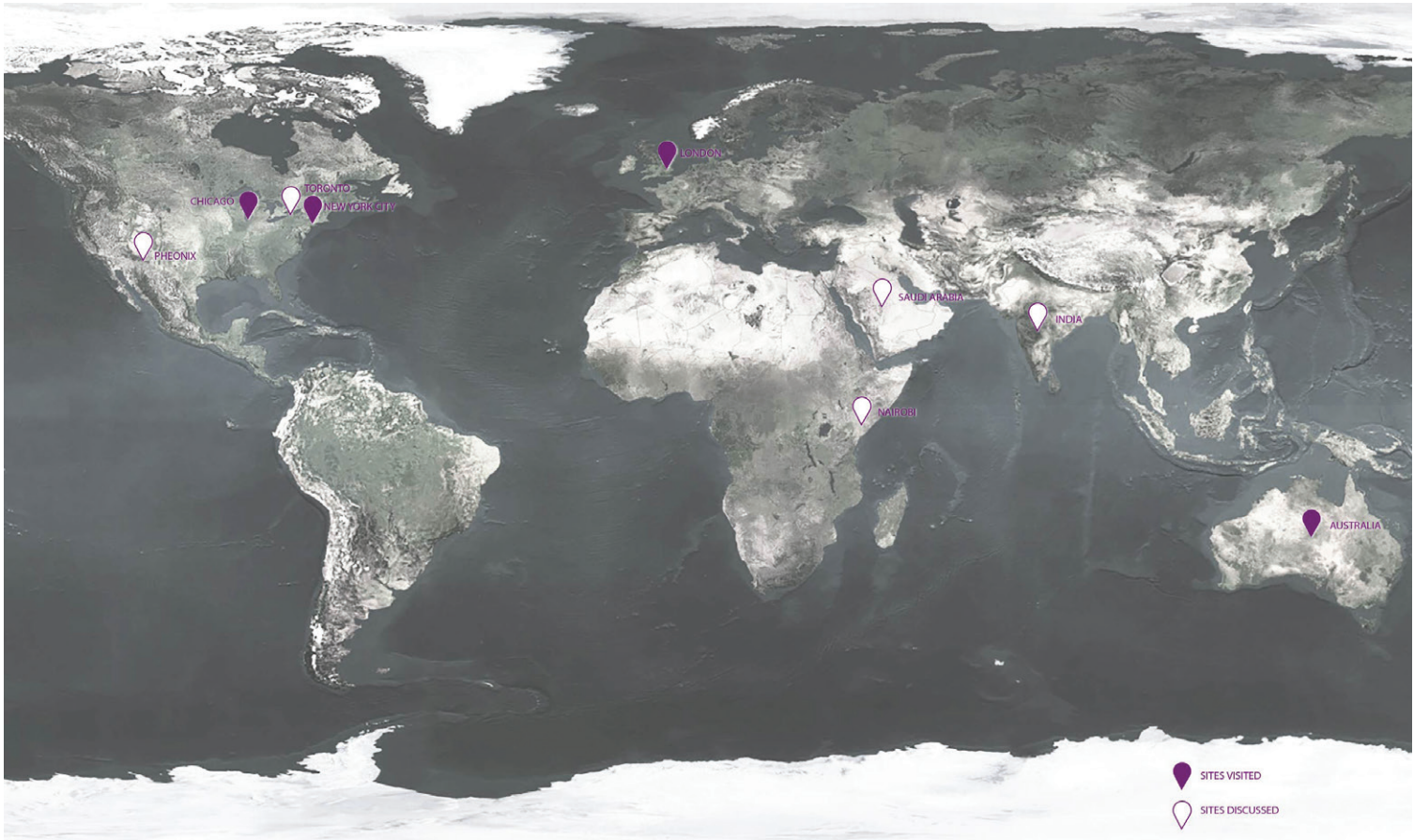




Nicola Balch - IoT (Internet of Things) in Public Space
Submission | Byera Hadley Traveling Scholarships | 2018

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Map of Traveled and Discussed sites, source: Nicola Balch

01 Contributing Conversations

I would Like to thank the following individuals for taking the time to meet me during my travels.

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City of Chicago Chief Information Officer & Commissioner



Danielle is CIO and Commissioner of the Department of Innovation and Technology. Most recently Danielle was the City's Chief Technology Officer, leading efforts to leverage data and technology to make government more effective, efficient, and innovative. During her tenure at the City, she directed many of the City's digital transformation initiatives, established the City's internationally-recognized open data program, and led digital inclusion efforts to expand access to technology resources and digital skills training.
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Charlie Catlett (CHI)
AoT Project Lead, Senior computer scientist in Argonne's Mathematics and Computer Science, Director of the Computation Institute's Urban Center for Computation and Data



Charlie Catlett is a Senior Computer Scientist at the U.S. Department of Energy's Argonne National Laboratory in the Mathematics and Computer Science Division and a Senior Fellow at the Argonne / University of Chicago Computation Institute. His current focus areas include cyber security, distributed computing and mobile/embedded computing. From 2007-2011, Catlett served as Argonne's Chief Information Officer.
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Douglas Pancoast (CHI)
Associate Professor of Architecture School of the Art Inst. of Chicago



Architect Douglas Pancoast has worked for firms including Richard Meier and Partners, 1100 Architect, BlackBox Studio at SOM, and agency.com. Pancoast examines how large, public data sets (economic, environmental, social, cultural, civic) are a context for creative practice and is a co-investigator for the Urban Sciences Research Coordination Network, an award meant to build inter-institutional collaborative research capacity around the subject of "big data" for social benefit. Pancoast is a frequent co-investigator in the newly established Urban Center for Computation and Data, specifically providing architectural knowledge, and visualization expertise for a network of associated projects.
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Mike Lydon (NYC)
Principle, Street Plans & Author



Mike Lydon is a Principal with Street Plans and leads the firm's New York City office. Mike is an internationally recognized planner, writer, speaker, and advocate for livable cities. NPR, The New York Times, CNN Headline News, ABC News, City Lab, Planetizen, Salon, Next City, Architect Magazine, and Streetsblog have featured his work, among other publications. Mike is the creator of the The Open Streets Project and the globally acclaimed Tactical Urbanism: Short-Term Action, Long-Term Change Vol.1 - 4. With Tony Garcia, Mike is the recipient of the 2017 Seaside Prize and co-author of Tactical Urbanism (Island Press, 2015).
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Brent Pearce (AUS)
Global Sales Director, Trendwise Analytics



Brent was Inhouse Group's flagship product 'Trendwise' Global Sales Director, Trendwise is a patented, leading edge analytics platform. Assisting a range of clients across government, retail and advertising sectors by helping them understand customer and visitor behaviour. He is now the CIO of MineARC Systems.

Constantine E. Kontokosta (NYC)
NYU Centre for Urban Science & Progress - Deputy Director for Academics; Assistant Professor; Head, Quantified Community



Professor Constantine E. Kontokosta, PhD, PE, is an Assistant Professor of Urban Informatics at the NYU Center for Urban Science and Progress (CUSP) and the NYU Tandon School of Engineering, Department of Civil and Urban Engineering, is the Director of the Urban Intelligence Lab, and is the Deputy Director for Academics at CUSP. He is also the Principal Investigator and Head of the CUSP Quantified Community research facility, a groundbreaking project underway at three districts in New York City - at the Hudson Yards development in New York City; in Lower Manhattan; and in Red Hook, Brooklyn - that is building sensor-enabled urban neighborhoods to study the impact of the built environment on well-being and human behavior.
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Ethan Kent (NYC)
Senior Vice President at Project for Public Spaces



Ethan Kent works to support Placemaking organizations, projects, and leadership around the world to build a global placemaking movement to build systemic change towards place-led urbanization. During over 19 years at PPS, Ethan has traveled to more than 800 cities and 55 countries to advance the cause of Placemaking and public spaces. Ethan has been integral to the development of Placemaking as a transformative approach to economic development, environmentalism, transportation planning, governance, resilience, equity and design.

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Daniel Latorre (NYC)
Co-Founder, Digital Placemaking Institute



Daniel is the founder of The Wise City, Co-founder of the Digital Placemaking Institute and Co-founder, McGolrick Park Neighborhood Alliance. Daniel set up PPS' Digital Placemaking program 18 years of digital media & product experience. He set up this practice at PPS to authentically marry Placemaking with current online civic engagement best practices and build the right staffing mix to communicate it.

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Project for Public Spaces, Senior Project Associate



Anna is an urban planner and urban designer who joined PPS to contribute to a variety of Placemaking Projects, including Southwest Airlines Heart of the Community Program and the Bass Initiative for Innovation and Placemaking, a collaboration between PPS and the Brookings Institution. Her work ranges from project management and design assistance to workshop facilitation and quantitative research.

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Camilla Siggaard Andersen (NYC)
Specialist in Technology & Evidence Based Design at Gehl Architects



Camilla Siggaard Anderson is an Architect and urban strategist with a focus on evidence-based design, applying technology in cities, and responding to societal changes - always with people's quality of life in mind. During the time of our interview Camilla was stationed at the Ghel Architects New York Office.

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02 Do smart cities mean successful places for people?

In the last two years, the opportunity for built environment professionals to realistically engage in the smart city movement has catapulted. In March 2017 the Australian Government launched a \$50million “Smart Cities and Suburbs” program to help finance the development of co-founded “innovative technology-based solutions to urban challenges” (Australian Government: Smart Cities and Suburbs Program, 2018). The intention of these grants looked toward Internet of Things (IoT) and Information Communication Technology (ICT), platforms prototypes and ideas that allow “data-driven decision making and people focused design to deliver economic, social and environmental challenges”. The application guidelines provided examples of applicable precedents ranging from Dublin’s intelligent and responsive street lighting and geo-spatial traffic monitoring sensors to Einhovens violence mitigating voice sensors (that can detect sounds of distress and alert authorities) well as a myriad of web tools enabling better communication between residents and councils for consultation and maintenance issues (Australian Government: Smart Cities and Suburbs Program, 2018).

In November last year, round one of the grant results saw \$28.5 million of this budget stretched between 52 proposals. The top grant of \$5 million fell to “Switching on Darwin”. A City of Darwin proposition to roll out standardized IoT civic safety products and public domain infrastructure such

as, increased CCTV, an expanded free wifi network, smart LED lighting and parking sensors. Given this it would be an exaggeration to describe this particular project as an investment in innovation. With the small exception of stress detection sensors proposed for Bicentennial Park The grant reads as an IoT shopping list, a plethora of shelf-picked products. While these may respond to real issues and challenges facing Darwin City Council, they could hardly be described as part of an innovative or holistic smart city plan. The project has already aroused discussion regarding the increased use of surveillance in our public spaces for policing purposes heightened by racial tension.

The second highest tier of \$2.5 Million fell to a project entitled “Resilient Energy and Water Systems” in Fremantle, WA. The aim of the project is to trial the installation and connection of low carbon and low cost distributed water and energy systems using blockchain* technology. This includes precinct sized battery storage, water catchment and treatment systems, electric vehicle charge stations, solar photovoltaic plants and rooftop arrays (McLean, 2018). According to Greg Morison of Curtin University, the use of a block chain trading system alongside smart metering and battery storage could have a physical and spatial impact on the planning of sustainable infrastructure in our urban environments as it will “allow energy and water efficiencies between critical dispersed infrastructures that

*Blockchain refers to the use of cryptography in securing records, here data ledgers/records for any transaction are permanent and unalterable, they can be distributed but not copied. Users can make changes to the same ledger, however each change is adding to a “chain” rather than altering the record itself. Think time machine on your computer, only completely transparent and shared between users, accessible but not alterable or replicable.

would have otherwise required physical co-location.” With the increased sell off and development of city and state land assets, the potential to disperse sustainable infrastructure could have profound consequences.

The point of this article is not to discuss the implications of either of these projects in detail but to indicate two key points.

The first, is to demonstrate how IoT and ICT have the potential to provide insights that have direct physical & experiential implications on our urban environment.

The second is to re-iterate that these examples are only 2 of the 52 “smart city & suburbs” proposals that have now received Australian Government Funding. Round 02 of applications is now open.

This program alone indicates how the moment we move into “smart city” territory we are not only having to keep track of developing technologies and associated terminology, but also juggle a vast range of subject matter pertaining to our urban environment. The result is unapproachable conversation and oversimplified reporting. It is for this reason that we repeatedly find ourselves comparing the apples and oranges, lopping examples such as waste management systems with self-driving cars into the same conversation/categorisation. Discussing smart cities is like discussing cities; it is a broad reaching, complex and

endlessly changing. Categorically, the smart city umbrella does make sense (given each project is a city data driven response) but as data driven processes become more normalized its likely to fade into the background of specialized disciplines and become “cities” once again. Today however it is in many ways used as a tagline for a product oriented framework with a clear vision, and an end goal of connected quantified intelligent and even automatic decision making. Media is delivered in broad hyperbolic brushstrokes portraying this world as if we are already there, and relying on a notion that if we can quantify a problem we can solve it. This solving falls into the same capitalist framework where data is the ambition and the solution, the holy grail of civic decision-making in a digital era. Smart cities are the next evolution in a history of attempts to “solve” our cities. But cities are not problems to be solved.

Given this, it’s hardly surprising that grant resources like “smart cities and suburbs program” lack an overarching incentive or ambition beyond “data driven decision making for our cities” nor any clear associated criteria. Grant programs are idea rather than outcome oriented, a holistic visions of where we want to go other than “data” and “automation” are few and far between. People focused design and outcomes often part of the script but forgotten in the solution.

Another example is India’s \$15 Billion dollar “Smart City” Mission. The

mission is essentially a competition to create 100 smart cities in India. Competing cities were allowed to take their own interpretation of how the funding could be used. The result of the 90 received applications was a host of projects that ranged from mobile apps to housing and even the building of new “greenfield” cities altogether.

Indias mission has recently come under increased criticism, while on one hand it demonstrates how the smart cities movement is not limited to the western and developed world, it also raises questions as to whether or not smart cities is the right avenue to invest when large swathes of the population face extreme poverty and don't have access to basic services. In June 2017 the Housing and Land Rights Network (HLRN) New Delhi

released critical paper entailed “smart for whom? cities for whom?” (Housing and Land Rights Network, 2017). The paper is no light reading material but an in-depth critical overview of the role out of smart cities across India. A primary concern is the focus on only a few key sites (100 against the 4000 Indian cities and towns) and the selection criteria of these (proposal based, rather than attributing funds to those in the most need). To Support these claims, the report documents reams of human rights issues including insufficient focus on the provision of housing for lower income citizens and reported incidents of forced evictions (Citiscopes.org, 2017). The majority of this critique is targeted at the investment in greenfield sites over lasting human based civic services and countrywide solutions.



Vacant Site for “Sidewalk Toronto” source: <http://torontostoreys.com/2018/03/quayside-project-risk-toronto/>

“The state should also take measures to guarantee the protection and realization of the ‘right to the city,’ which includes the right to equitable access to the city, to equitable participation in its development, and to an equal share of its benefits, for all residents. No city can be considered ‘smart’ if it ignores the interests of poor, marginalized, and vulnerable groups and communities.” (Housing and Land Rights Network, 2017)

There are capital realities at play here, grants in the smart city realm are largely based on a public private partnership (PPP) and/or funding matching requirements. It’s for this reason that when we begin to deal with greenfield smart city building initiatives, large private capital kicks in and the associated figures skyrocket. For example A \$500 billion price tag has been attached to Saudi Arabia’s plans for a new solar powered smart city. Belmont, a smart city outside Phoenix has now received an \$80 million backing by Mt. Lemmon Holdings (a subsidiary of the group that invests Bill Gates fortune). And more recently it was announced that Toronto waterfront will soon become home to Alphabet Owned Sidewalk Labs first smart city district. In the smart city realm a-lot rides on this project, that prides itself on “ Knowing that great neighbourhoods aren’t planned from the top down, Sidewalk Toronto will create the conditions for a community to be built and innovations launched by people, companies, startups, academic centres, and local

organizations over many years” (Sidewalktoronto.ca, 2018)

In many ways These utopic projections and their rebuttals are increasingly reminiscent of urban lexicons that rose from the 1960s, one that asks “why focus on making an existing city and community intelligence when you can build one from scratch?”. The HLRN even calls on Lefebvres “Right to the City” to make their case. The relevance of these arguments raises the question, is the HLRN critique really one of smart cities, or are they simply living the realities of community displacement in green and brownfield developments? Is it truly a condemnation of the use of IoT and ICT or a response to the use of government funded unethical development practices? Are we putting new labels on old issues?

Its no surprise that specific IoT offers far more rigor. Take for example BRCK, Nairobi based software developers and engineers who are targeting large scale issues using tech that does not rely on traditional infrastructure. This approach grew from a response to devices designed overseas being applied to African specific conditions and problems often finding a mismatch between their need and the infrastructure available such as the common lack of Internet connection in rural and urban areas. Their SupaBRCK self powered router allows off the grid areas connection to the Internet with the capability of providing free public Wi-Fi in previously discon-

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nected cities. The same companies IoT platform Pico-BRck targets water quality monitoring and the agriculture industry. Described as “The rugged IoT device” Pico can track vehicle drivers, measure soil moisture content, temperature and humidity and understand water flow as well as controlling valves. There are many outcomes from this, one is smart auto watering systems for small holder framers another is off the grid water quality monitoring for wells. The team recently tested this on the site of the worlds largest refugee complex a tent city with 235,269 registered asylum seekers near the Kenyan-Somalian border. The pilot, a part of UNHCR WASH project used PicoBRCK as

an IoT platform to provide remote monitoring of water generation and water treatment. (Jeff Muthondu, 2018) Each of these examples are both problem and outcome oriented working to develop a solution via IoT and ICT that will work for existing communities to solve serious issues.

As designers we cross between planning curating space and experience with data based realities and requirements. We use this information to make real decisions that impact the health of our cities and their inhabitants. During my travels I would hear over and over, “Now we have all this data, what do we do with it?”. Data is a tool, it is not in itself a solution. We



BRCK, UNHCR project instalation source: <https://www.brck.com/about/blog/>



have always used data, it is one of the primary drivers of our decision making. But the question on everyone's lips regarding smart cities is mis-directed.

Take for example the first writing in human history, a partial script from the Sumerians of Ancient Mesopotamia. It was not developed for poetry, nor could it be used for it, it was a means of record keeping, used to store key information within a limited field of activity for future recollection and decision making (Harari, 2015). The use of data is nothing new, what's new are the tools we have for recording information and means of storage and communication. New

mechanisms for recording and communicating do not negate our vast historical archive of urban theory and understanding of place. The Sumerians didn't develop our species first form of writing by asking "what's technology is available and what can it do for us", they needed a mechanism to record tax, debt, crop yield and property and used the available technologies to achieve it. When we think about smart cities we need to be careful we don't get distracted from the outcomes we are trying to achieve, as those who sell them to us sure aren't.

To engage meaningfully in smart cities



BRCK, UNHCR project instalation source: <https://www.brck.com/about/blog/>



you do not have to be well versed in tech, but in asking questions and identifying what types of information may be needed to provide insights and gain valuable understandings for future decision making. There is nothing tacky about this process. But by giving it a shiny label we have allowed it the illusion of something that can be critiqued as a whole, or a new trend to be exploited.

There is no understatement to express the “excitement” that is being handed to the “smart city movement” and the Utopian attitudes that accompany it. Yet as we slowly begin to witness the unforeseen consequences of prolific technologies like social media we are reminded once again, that there is an undeniable need to pay close attention to the most variable and complex parameter - “people”. IoT and ICT have the potential to provide insights that have direct physical implications on our urban environment. So when it comes to smart cities, the power lies in those who are asking the questions, and finding answers. Right now that primarily falls to engineers and tech giants. Technological development solves problems, and with it undeniably brings new ones to the fold. We need to think more critically about what we are collecting and why. The questions “smart for whom? cities for whom?” ((Housing and Land Rights Network, 2017)) are not only pertinent to the India case study but for each and every smart city project undertaken.

In today's landscape a smart city does not mean a successful city for people but that's not to say it can't play a role in progressively working towards making more livable urban environments for its citizens. Like any tool it is intent and application specific. One thing is for sure, smart city's is not a silver bullet, it is a continuation of an age old way of problem solving given new tools and means of communication. If we don't learn to interact with these new tools, we'll end up on the back foot, in the sidelines.

“There is no logic that can be superimposed on the city; people make it, and it is to them, not buildings, that we must fit our plans.”
Jane Jacobs

03 What does IoT mean for our public spaces?



Standing only solar phone chargers stand largely unused in the highly popular NYC DOT parks

Smart City technology within the public realm broadly falls into four categories. These include overhead analytic IoT platforms (like fixture to street poles and buildings) that measure a range of microclimatic characteristics such as footfall, air quality and traffic; street infrastructure products that provide a fixed solution to a problem (eg urban USB charging stations and fixed infrastructure like benches with wifi counting/tracking capabilities); ICT platforms which aim to map and display data findings and provide an interactive interface between users, data and each other (and in the best cases cross refer-

ence, share, trade data for meaningful insights) ; and the development of new research oriented “placemetrics” and parameters, where professionals investigate more nuanced and insightful measurement systems (for example, the percentage of women as an indication of the safety of a public space or the number of people using their mobile phones on streets). Along side each of these are developed software’s which work with a range of given metrics aiming to test and optimise design outcomes (such as existing cad software plugins).

When exploring the development



Standing only solar phone chargers stand largely unused in the highly popular NYC DOT parks

of each these categories, one thing became startlingly apparent, while interest is ripe, there is a lot less work being done in this area than one would assume. Products, companies and research initiatives popped up and dropped off like flies continuing a trend emblematic of today's digital entrepreneur, a lot of reporting, not much delivery. Many projects purported the capability to measure, yet very few had engaged measurement systems in an urban testing process or were developed enough to deploy physical design responses to these findings and provide measured outcomes. For example, a leading company Placemeter who used foot

fall data to assess pedestrian activity before and after transport and place-making interventions (such as the removal of a road or street pedestrianisation) were bought out by net-gear and are now working on home security systems could not comment on comment on previous applications.

This is not to say that there is no interest in public space targeting IoT products, successful models, though limited were in hot demand. Charlie Catleet, the lead of the city of Chicago's and Argonne laboratory Array of Things (AoT) project along has received 90 expressions of interest from different cities glob-



soofa analytics bench, source: https://www.edmonton.ca/programs_services/wireless_edmonton/soofaselfie-contest-how-do-you-recharge.aspx

ally. With 9 projects underway, the team is now grappling balancing the intent of these modules (that being research) with a growing product demand. All this while only 12 out of the ambitious 500 units had been deployed in Chicago at the time of our discussion. “When we started we thought we would be one of many” in fact the lack of comprehensive options has started a game of tug and war between product based and research based directions “Its not a product” he re-iterated, “more than anything we are interested in finding new ways of measuring things that will help scientists and communities”. Many councils looking to deploy IoT are risk adverse, and interested in

place specific research only if it has been done before and is delved as a tried and tested product with a clear outcome. This does not bode well for researchers trying to find new ways to measure and understand place via data. Such lack of context specificity calls for greater partnerships between municipalities, universities and Architects/Landscape Architect/ Urban Design consultancies and the community.

We are moving tech from our homes to our streets, measuring empty car spaces, the capacity of bins, the number of people on a street, deploying usb charging stations in out public spaces, providing interactive way

finding stands. Yet growing critique is being to target the type of data being collected and begun to debate whether many of these initiatives are resulting in meaningful outcomes in our public realm. Are we simply carrying on the engineered trend toward greater city efficiency and filling out streets with gizmos or can they work to provide something more meaningful for communities on the ground. When looking at many of the IoT products in our public spaces today, its hard not to ask if much of this will quickly become obsolete.

When it comes to localized smart city solutions in the public realm we are sitting smack bang in the middle of an awkward beta-phase wherein a large amount of data is still siloed, and the vast majority of products developed are rigid in their application. One thing is clear, that within the public realm, where we stand right now is far from the networked future that we speak of as imminent and intellectually strive too. We are still far from testing physical interventions in response to data inputs let alone soft behavioral change. With the rate of technological change, undeniable links between public space, mental and physical health and community activity these questions are more important that ever.

Our smart city projects need to be bespoke, have an ambition that is contextually specific and responsive to both the eccentricities of place and the communities that make them.

Smart city plans should not resemble shopping lists, but seek meaningful outcomes to complex problems. Without this change we run the risk of The Internet of Things just becoming more “Things” claustrophobing our sidewalks without any meaningful contribution. In short, the smart city movement is in desperate need of place and community based design thinking.

The question is how do we, as practitioners who rely on being paid to design a solution engage meaningfully in an area dominated by a product oriented framework for the city dominated large scale software engineers and developers where grants lean on applicants proving an already defined outcome and the provision of 50% of the funding through PPP arrangements. It is no wonder that this realm of exploration is either niche, or monopolized by larger scale companies such a CISCO. Surprisingly, hardware for sensor technology itself is alarmingly cheap, the expense lies in the supporting framework such as ICT platforms and those that provide the research and data analytic work that underpin them.

When I began my Byera Hadley I intended to investigate available solutions that were trying to quantify the value of quality public space through Smart City Technology and assess their accessibility to smaller councils and company’s yet we also must ask how we can make these processes available to us as design practitioners.



In order to do this we need to have an insight into successful and deployed IoT case studies and learn from them.

In response my focus shifted to two major citywide projects, to understand how these projects get off the ground and the issues they have faced. The intention was to select two that had completely different funding mechanisms, ambitions and levels of community engagement.

These two projects were the Array of Things in Chicago which we have briefly touched on and Link NYC in New York. Both projects represent an entirely different means of going about IoT in public spaces that could have large scale implications on their immediate and overarching urban context.



04 Personal information as Capital, The privacy conundrum in public spaces

When it comes to the use of sensor technology to analyze our public space, privacy is always one of the first questions raised, and for good reason. Today, the private ownership of Personally Identifiable Information (PII) is more prolific than ever. Catalysts such as the Cambridge Analytica scandal have ushered in prolific public and governance awareness on how personal data may be used to influence decision-making, heighten segregation and undermine democratic processes.

The continuation of this trend into public space makes such intrusions seem inescapable. If data mining and targeting can play a role in political segregation, it is not a stretch to see how these ramifications could play out spatially. Public space has and will always be a site of intense spatial politic. For my study I looked into the capturing of PII in public spaces comprehensively to get an understanding of exactly what information on individuals could be archived, and then assessed this information against my two key case studies the Array of Things and Link NYC. It seemed paramount that if built environment professionals are going to interact with IoT in public space in any capacity, we need to consider the potential uses and ramifications on personal privacy. When I met with Danielle Drummer, the City of Chicago's Chief Technology Officer in October 2017, one of her first comments on data privacy, was one over public or private ownership.

“Often people feel more comfortable with their data being owned by a private entity than a public one, there is a conception that we are going to use it for something else.” Since then we've witnessed Mark Zuckerberg testify before the US senate, and the EU evoke deeply changed data privacy laws. In only 6 months we've seen a radical shift in public perception.

Everyday we use personal information as a form of capital, trading it (often unknowingly) for services. In reality regardless of what we install in our public spaces we are already being monitored, our smartphones in fact are the most prolific piece on IoT we find on our streets today. They are smorgasbord of sensors, where your bottom line level of privacy is altered by everything from the make of your phone, what type of account you have, who your provider is and most strikingly what apps you use. Giants like Google and Apple instantly start logging data as soon as your device is activated. While Apple keeps much of this anonymously or held within your phone (unlike Google) third party apps may not. For example Face ID and location tracking is stored on your i-phone, however as soon as you open an app the privacy policy and the specifics on how your data can be used shifts (Williams and Dvorsky, 2018). Granting a third party access to your photos for example could also grant access to your location via geo-tagging (Williams and Dvorsky, 2018). Public perception of this sort of “privacy exchange” often



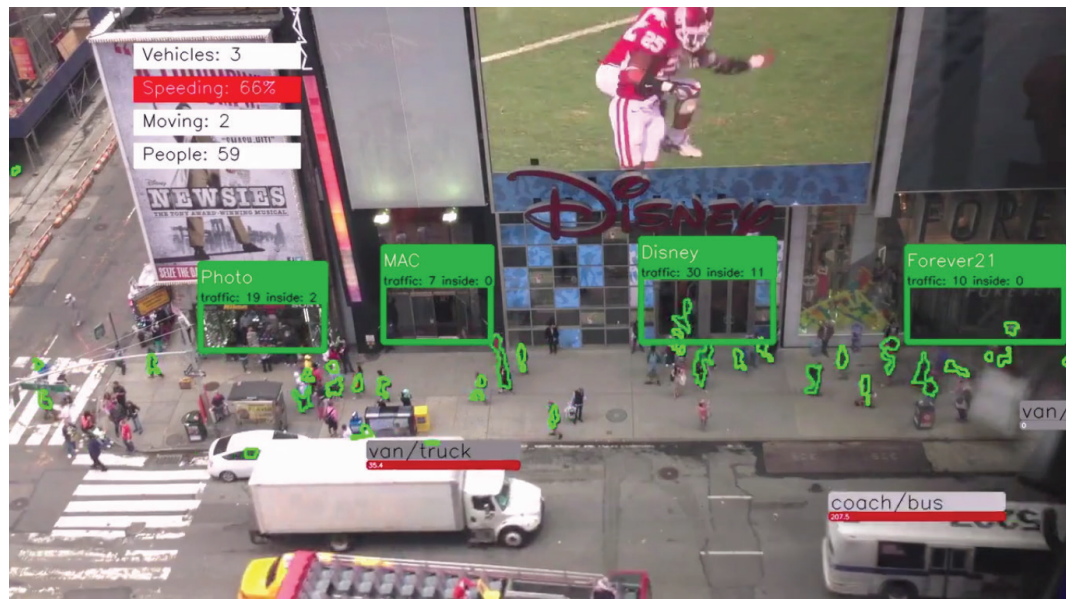
Trend-wise wifi tracking device

falls down to whether or not something is gained in return. On your phones its clear what service you gain in exchange, in public space all we see is surveillance without return. In reality the question is not weather IoT should be used in public space, it already is. The question is one of anonymity and for who, what and why it is being used. In most cases the answer is “tech giants”, but that is beginning to change.

The AoT provides one of the most holistic and community oriented approaches to data privacy and the deployment of IoT in public space. They have achieved this not simply though consultation on privacy policy but

by allowing the community to have a direct role in the data capture and access to the outcomes. This means that community and research groups can opt for a node to measure concerns specific to their community. Data is then fed into a transparent open data portal allowing the modules to cater to site-specific issues while adding to a broader understanding of the livability of the city. To achieve this citizen privacy had to be number 01 on the agenda from the projects inception. Danielle DuMerer, Chicagos CIO and Commissioner indicated how they achieved this;

“The first thing we did was bring together privacy experts. People form



Placemeters Image recognition software that could be run over existing CCTV footage. Screen Grab from Placemeter Video now obsolete and owned by Netgear source: <https://technical.ly/brooklyn/2014/02/24/placemeter/>

the ECLU and the EFF and the University of Indiana, so both in academia and non profits for advice on how to approach the privacy policy. We didn't want to assume we had the answer to those issues...then we drafted an initial policy and got community in on it, at the public meeting. It really struck me that we didn't get as much concern about the privacy issues as we thought we would ...There were a lot of people who understood the value the sensors could bring. They had particular questions or concerns about their communities and recognized how they potentially solve and advocate for an issue though this technology." (DuMerer, 2017)

The project is a key example of how

urban data does not always have to be a top down form on monitoring but could be explored as a bottom up resource so long as the appropriate frameworks for accessibility are put in place. In this case accessibility takes the form community ownership of a public asset. The data itself is the service and one that could potentially be used for community advocacy. Right now PII consuming IoT in our public domain primarily falls into two categories. Wifi Tracking and Image recognition technology. Both of these are often deployed to fit the same purpose (counting and measuring the movement of people) but lead to quite different outcomes. Wifi tracking detects any active wifi signal from a smart device (so you don't have

to be connected to be registered). Each device is in turn recognized into the analytic system with a unique but anonymous code. This means that within any given array, without knowing who you are, these systems can detect exactly where you went, how long you spent there and even whether or not you returned a week later. While currently concentrated into localized hotspots, flash forward and this could theatrically track your movements throughout city on any given day. It remains however opt out, flick off your wifi signal and you drop off the radar. You may no longer be tracked by the city, but the apps running in the background of your phone still have you pinned, unlike the city's applications are not anonymous. Image recognition however works completely differently by utilizing video cameras as sensors. Limited to the field of view of the camera, image rec relies on differentiating appearance, movement, trajectory and proximity. Using these parameters it can decipher between cars, bike and people even if they are all moving at the same speed. Technically you can track people using image rec, the parameters however become tricky in crowded scenarios. Most software used to do this has to focus on a single person at a time, re-running the program for each individual making tracking multiple people though a crowd very difficult (Hutson, 2017). This particular area of research in crowd dynamics is currently only in development but is gaining a lot of attention for its potential application

amid the rising number of crowd related disasters, such as the Manchester Terror Attack in 2017. (SRI international) . The strength and intent of image recognition in the public domain, lies not in its tracking capabilities but in the diversity of what it can measure. This all falls down to what its associated programming team can train it to recognize. Number of children, Prams, Dogs, water pooling, cycle, traffic and pedestrian congestion are only a few examples, the team at the AoT in Chicago for instance are currently working with the rooftop agriculture industry training their nodes to recognize the presence of invasive species. When I spoke to Charlie Catlett, [the senior computer scientist behind the AoT at Argonne's Mathematics and Computer Science (MCS) Division and director of the Computation Institute's Urban Center for Computation and Data] my intent was to find out what could be measured, he in turn asked me "what would you like to measure?". This means in terms of understanding nuanced human factors regarding public space as a field of study, image rec outstrips wifi considerably, yet in many cases because we have limited our imagination to "people counting" rather than other diverse characteristics most projects opt for one or the other, not both.

Each of the above methods are technically anonymous. In terms of the Wifi option, the information is encrypted then processed. Image recognition methods can be run over existing video footage (that contain-

ing PII) or can use its own hardware to process the data on the spot and delete the PI information on site. So in privacy terms, while the Wifi option, could theoretically be decrypted (particularly with the rise of quantum computing) whereas onsite image recognition processing loses its PI instantaneously leaving only the desired data. This is the route the AoT have taken with the exception of a 1% of sample images retained for research, training and development purposes.

Ultimately the decision of what method is used falls to the multiplicity in question, what they are trying to achieve with the data and their approach to citizen empowerment. Unfortunately, in many circumstances project ambitions and outcomes do not necessarily line up, as was the case with Link NYC.

05 Learning from Link NYC



Time-square was one of the original DOT pedestrianized spaces, proven to reduce traffic incidents

In 2014 the office of the New York City comptroller bureau of policy and research released a policy brief on Internet inequality regarding broadband access in NYC based on the results of the 2013 American Community Survey (ACS). The findings indicated 27% of NYC households were without broadband access, 17% lived without a home computer. 40% of New Yorkers without high-school level education and 34% outside the workforce lacked a broadband connection. The same year Mayor de Blasio announced LinkNYC a social initiative in partnership With CityBridge that would replace 7500 payphones with high-speed Wi-Fi kiosks across 5

boroughs by 2025. Given the gigabit internet speeds pitched, the project would be the most extensive and ambitious in the world and it would be entirely funded by advertising. Its now been two years since these kiosks have hit the streets, and the journey hasn't been smooth kicking up a slew of social and privacy issues along the way. Link NYC now proliferates the city scape and provides a perfect example of the cautions raised by the large-scale deployment of IoT technology in our public domain. And this is just the beginning, the same system has just landed in London under the name InLinkUK. Link NYC primarily aimed to aid un-



User brings their own furniture to use Link NYC totem

derprivileged communities in a move by the city to provide high speed Internet access and access to a range of social services. These included 911 and 311 (government benefits portal) as well as Auant Berth's database, a portal for locating "food pantries, emergency housing, childcare, health-care, transportation assistance, and financial aid programs located within that zip code." (Bliss, 2017) From their first installation in early 2016 until September for the same year the kiosk tablets offered free internet browsing. The service was pulled amid a barrage of complaints and reports of overuse (for extended periods of time) and individuals

accessing inappropriate viewing, including pornography. "Users were expected to make short stops at the kiosks. But they quickly attracted the homeless and other idle people who took full advantage of the unlimited access to the internet to watch movies and play music for hours." (McGeehan, 2016) People were treating the tablets like their own personal computers. The New York times dubbed this as "a case study in unintended consequences, commendable goals gone somewhat awry." But to placemakers it demonstrated a lack of understanding of the city's most complex parameter; people. An original oversight of where the kiosks were installed which originally demonstrated a neglect of key questions such as "how do you co-locate amenity around those things? Or bring it to amenities that exist." (Lydon, 2017)

They took notion of replacing the cities phone booth literally. On the back of the loitering issue this oversight has now become intentional, the kiosks installed in awkward and inhospitable locations, between a series of garbage bins or jammed between car parking and a narrow sidewalk. For any prolonged use its BYO chair or concrete, decreasing the habitability of the surrounding spaces while reducing their usability by less mobile citizens. There are no longer group gatherings around the kiosks, but there are still a lot of people sitting on concrete. "we were originally approached to look into how to encourage habitability at link sites, that has since fallen though." Camilla from Ghel Architects reflects.



Totems installed in deliberately inhabitable locations

In a distain for unforeseen, prolonged loitering and pornography issue has likely thrown overboard any plans on the potential for the kiosks to facilitate positive prolonged social use. While in many places we try to desperately to activate space, in this case the parameters were too successful at least for the “wrong” kind of people and social groupings. An oversight from a lack of product testing in its intended landscape has resulted in a sore loss of potential for the kiosk to properly explore how it could further benefit the social framework of the city. The scale, design and placement of the link NYC kiosks responds to advertising with little regard to people

or public spaces. The EFF (Electronic Frontier Foundation) is a digital right’s not for profit that works out of California and operates internationally. Since link NYCs initial installation the EFF have raised considerable concerns over the initiatives privacy and citizen engagement measures. The first link NYC totems found their homes in Gramercy/East Village in early June 2016, for the first 9 months of the projects deployment the EFF described the City Bridges privacy policy as “particularly invasive” at this stage the kiosks enabled their private storage of personal browser history and time spent on websites with little clarity on how it would handle gov-



Time-square was one of the original DOT pedestrianized spaces, proven to reduced traffic incidents

ernment demands for user data (Buttar and Karlia, 2017). After a letter to the Mayors office by the NYCLU (New York Civil Liberties Union) the privacy policy was revised in March 2017 removing the tracking of browser histories (for private devises) and placing time limits on data retention this includes a 60 day cap on IP addresses, anonymous MAC addresses, device type and other device identifiers as well as a 7 day cut off for video camera footage (Buttar and Karlia, 2017). When working in the public realm we need to be aware of the implication of what and who working with. Reflecting on Link NYC the EFF puts this plainly; “The emergence of constant

surveillance through a program ostensibly extending public services, without any apparent public oversight, suggests the need to be vigilant when programs that claim to make cities “smart” fail to respect privacy... There appears neither any process allowing public participation in the governance of the kiosk system, nor a redress mechanism for potential violations”. (Buttar and Karlia, 2017) This has considerable relevance when you look at the real motivation behind the funding agreement of this public service. The business model is not solely based on advertising but the collection of both PII and anonymous information on individuals and their environment to

build up location profiles for targeted advertising. The algorithms used to silo our social media spaces are finding their way onto our streets. Digital separation and spatial segregation are becoming even more closely intertwined. In April 2016 Sidewalk Labs CEO Dan Doctoroff described their business plan “By having access to the browsing activity of people using the Wi-Fi—all anonymized and aggregated—we can actually then target ads to people in proximity and then obviously over time track them through lots of different things, like beacons and location services, as well as their browsing activity.” (Rethink LinkNYC, 2018)

According to Rethink Link NYC, in October of the same year a sidewalk lab representative was quoted that he misspoke on the tracking of browser histories and the use of this information to target ads. Yet on the projects inception, their privacy policy allowed this type of targeting. While these ambitions were shifted due to outcry in the name of digital data privacy it provides a key window into company thinking on the potential use of data from public spaces.

Links Privacy policy is an interesting read, prior to undertaking my Byera Hadley it would have seemed relatively straightforward, now all I can read are loop holes. One thing is clear, it is not simply a city Wi-Fi solution helping those of lower socio economic backgrounds gain internet access.

The kiosks are so packed full of different types of IoT sensor tech which take a backseat in any marketing. For example cameras, microphones and a host of environmental sensors. These provide “Other services” like measurement of localized temperatures, humidity, ambient noise, light and air pollutants. Yet nowhere is the system advertised or recognized by the city as a means for utilizing these services and a mechanism to better understand and provide localized environmental remediation for the city, nor any capability for the public to access this information. The privacy policy states they do not sell or share information with third parties in but they use third party information to supplement the anonymized information that is collected from the kiosks. Its hard to imagine the extent of data sets that can be gained with this geographical information given that sidewalk labs is owned by Google and has all their corresponding data at their fingertips. The privacy policy states that it does not use camera footage to track you though the city. Yet we know the footage can be used for policing purposes, and a better way to track the movement of users is via wifi signals. Link NYC has both image recognition capabilities and wifi sensor capabilities, even if these are not used for those purposes now (and this is not apparently clear in their policy either) it is at the very least a power dormant system waiting to be switched on.

Will we start to see further spatial

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ramifications of digital segregation driven by algorithms further influence of urban space. The key point with Data is that it can be used in a myriad of ways, it could be used to test and try out policies that aim to increase diversity in places, to detect neighborhoods prone to poor air quality then test and install solutions to improve it. It is the city's role to make sure that this information is used for more good than the supply of free Wi-Fi. This is not to say that the feat of achieving internet and free phone access is not a great, city service, it merely call for a need to provide a great focus on community privacy and engagement when dealing with public space based data. If data is the new currency, google is looking to the future and playing an intelligent long game, the question is, is the city doing the same, will it look further to the future, past simply financing a single service?

While AoT and Link NYC have been fit for different purposes and are not directly comparable in terms of the service they provide, they are perfect case studies to pin point two completely different approaches to privacy and the distribution of IoT in public space. One being led by governance in parallel with research initiatives, the other a delivery partnership between private enterprise in conjunction with the city, financed by adverting. It flags a need to understand digital privacy in public space on the inception of any IoT based project and highlight unforeseen consequences.

06 AoT, Citizen Engagement with Big Data in Chicago



Argonne National Laboratory outside Chicago, source: <http://uk.businessinsider.com/argonne-national-laboratory-illinois-2017-11?r=US&IR=T>

Led by the Urban Centre for Computation and Data & the data computation Institute, The “Array Of Things” (AOT) is an urban sensing initiative between the Argonne National Laboratory, the University of Chicago in partnership with the City of Chicago and funded by the National Science Foundation. The project consists of a series of fit for purpose pole and building mounted sensor technology that can measure a vast range of parameters. These include pedestrian, cycle and vehicular traffic, localised temperatures, barometric pressure, light, vibration, carbon monoxide levels, nitrogen dioxide, sulphur dioxide, zone, ambient sound intensity and surface temperature with future

investigation and potential monitor track flooding, standing water precipitation, wind and pollutants. The aim of the AOT is to use the data captured by the sensors to make smarter localised decisions about how to improve urban condition of the city and gain a holistic understanding of urban health.

We have spoken some length about the difference in privacy approaches between AoT and Link NYC as well as the difference in their funding sources. Link NYC, is a social service offered by the city of New York, paid for by Google in exchange for advertising and data capture. It is a



Node sensor testing at Argonne Laboratory

commercial venture where the data is a form of currency that pays for the services (in this case high speed wifi). AoT's model is fundamentally different. AoT is funded and run primarily as a research program not via a commercial venture. It is small wonder then, that each of these urban sensing projects has a wholly different objective and outlook on data privacy, accessibility and community engagement. Each project has entirely different ambitions. This difference makes it easy to forget that Link NYC it is IoT urban sensing initiative in the first place (as it is not advertised as one). This however would be a mistake as each project deals with very similar issues on the current and future role of IoT and ICT technology in Public space. The Array of things provides perfect counterpoint to Link NYC for two key reasons. The first is

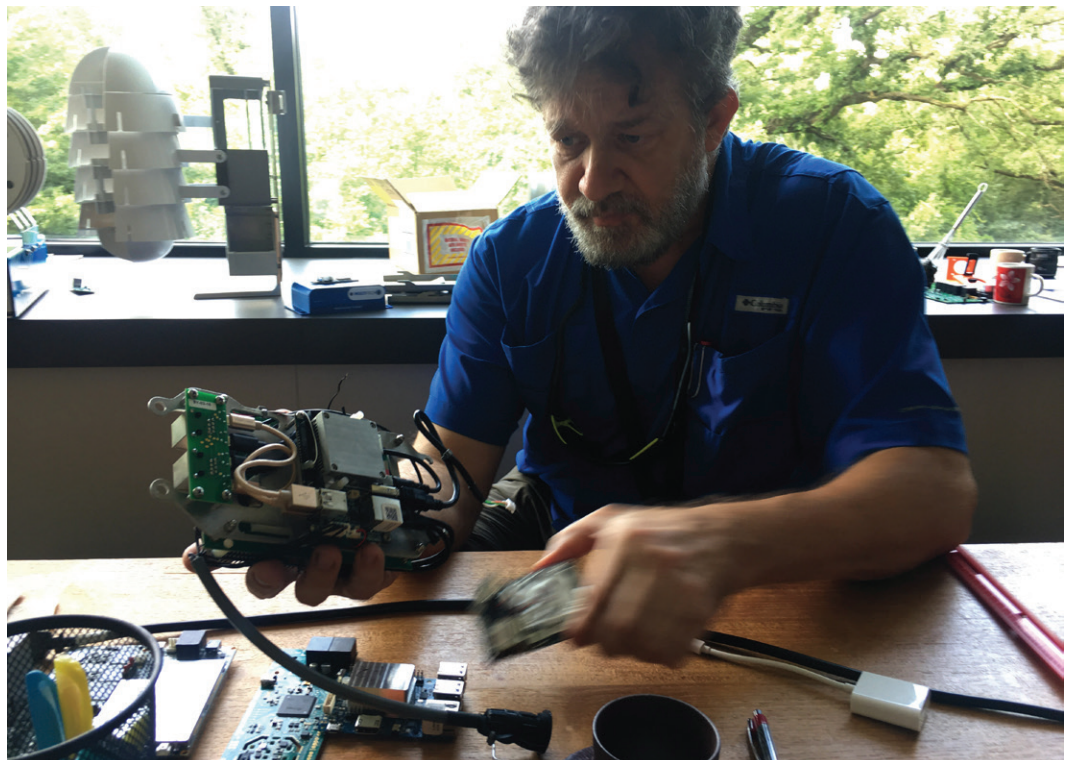
that the project addresses how we can begin to think about the role of the urban community in an increasingly data driven environment in a way that considers a scope beyond data privacy measures to discussions of education, collaboration and advocacy. The second is that starts to provide an indepth breakdown on what can be and is being measured in our public spaces and the potential understanding and implications that may arise from these measurements.

For this component of my research I spoke to three key individuals driving the AoT in order to get a comprehensive understanding of the project drivers, data received and challenges the project has faced. Danielle Dumermer - the CIO and Commissioner for the City of Chicago, to provide insight on why the city decided to undertake



AoT install monitors air quality, pedestrian, cycle and vehicle traffic in the CBD

an IoT project, how it has responded to issues of privacy and what are the key drivers behind it more grassroots community approach to data measurement and node deployment. I spent a day at the Argonne Laboratory with Charlie Catlett and his team to understand the technology, hardware, measurement possibilities and day to day running of an IoT project of this scale. I sat with Douglas Pancoast of the School of Art and Architecture Chicago, the lead urban and architectural thinker on the project to understand the conceptual driver behind the project within the academic sphere of Architecture. The Array of things project gives us a framework to begin to understand what holistic community engagement with data might look like and even how it can have an impact on what is measured in our cities and where. Following an inclusive and open philosophical approach to city data has not been without its setbacks. The AOT deployed their first sensors in summer 2016, allowing for an ideal 1 year data collection window before the Byera Visit. The ambition of the AOT was to install 500 nodes by the end on 2018 however delays in the project largely to the development of comprehensive responses to PI (Personal Information) by my visit in October 2017 less than two dozen sensors were on the ground. Chicago CIO, Danielle Dumerer reflected that one of the greatest set backs was underestimating how complex the development of an inclusive and engaged privacy would be. In their official response to public

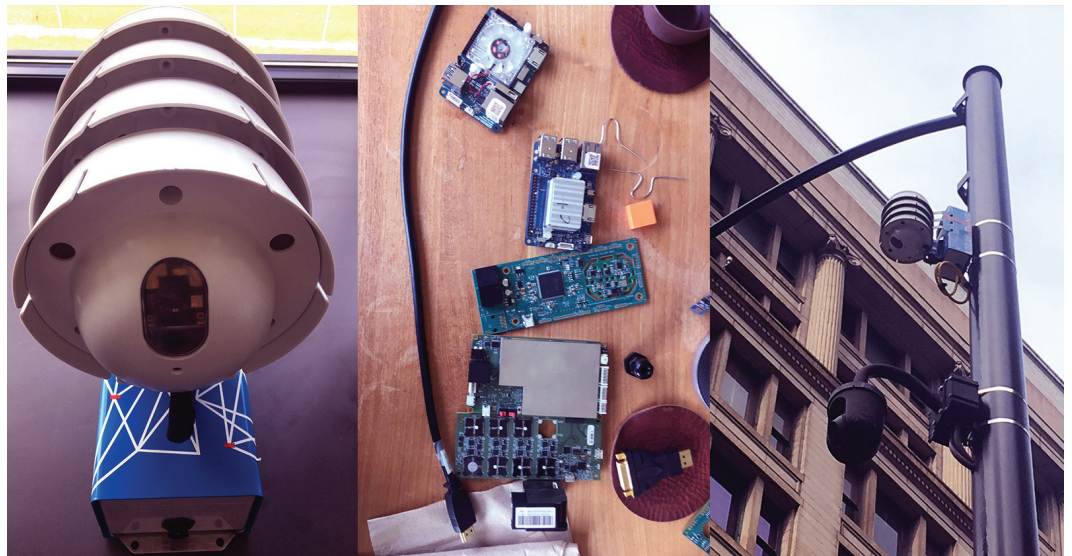


Charlie Catlett, Array of Things project lead talks through the internal hardware of an AoT node

feedback they reflect “The more policies AoT revises policy, and the more of itself it gives, the more daunting the public review task becomes. We all know there’s a bright future for AoT, but more imagination towards shaping policy that empowers people to interact with our shared picture of the urban system must occur. (Array-ofthings.github.io, 2018)

The project identified potentially one of the biggest tasks for IoT operating in public space, juggling inclusive communication, education and engagement when you’re dealing with a complex topic and interested parties ranging from complete nov-

ice to expert. Their key lesson being learning how to navigate “trade off between technical transparency and accessibility”. At one point reflecting on their public community consultation session they state “The concepts behind AoT, it is safe to say, rest on rather advanced, cutting edge technical knowledge. It took a full 70 minutes of the 90 minute session for the presenters to simply explain AoT. And of the remaining 20 minutes, all but five were devoted to basic questions.” This finding is not just reflective of Chicago, but of one of the key issues we deal with every day in inclusive



AoT module, Casing, camera, internal and street installation

design processes. When we start to integrate IoT tech into these processes this challenge is only going to increase. Their lesson to “to undergo a wider awareness campaign before asking for feedback” applies globally.

The AoT in all has around 4 categories for how they engage with the wider community.

01 Project awareness, input into and education around privacy PII (Personally Identifiable Information) and policy:

During my time in Chicago, most people who I spoke to had at least a vague understanding of the project I was investigating. This was due to a citywide public awareness campaign that was undertaken prior to

and during the development of AoT’s privacy policy. On top of consulting with many data advocacy organizations AoT ran public meetings, online forums and the use of the MyMadison tool, an online platform that opened up a complete draft of the AoT Privacy and Governance policies to be opened up to annotations, comments and edits. The outcomes of this process found that the most re-occurring questions revolved around the sensors image capture and storage conditions, PII, cell phones companies, sound recordings indicated that clear campaigns indicating what can’t be measured buy an IoT platform were as important as those indicating what could (Arrayofthings.github.io, 2018). Key suggestions included, a clear process for those concerned the PII has been shared and would like it re-



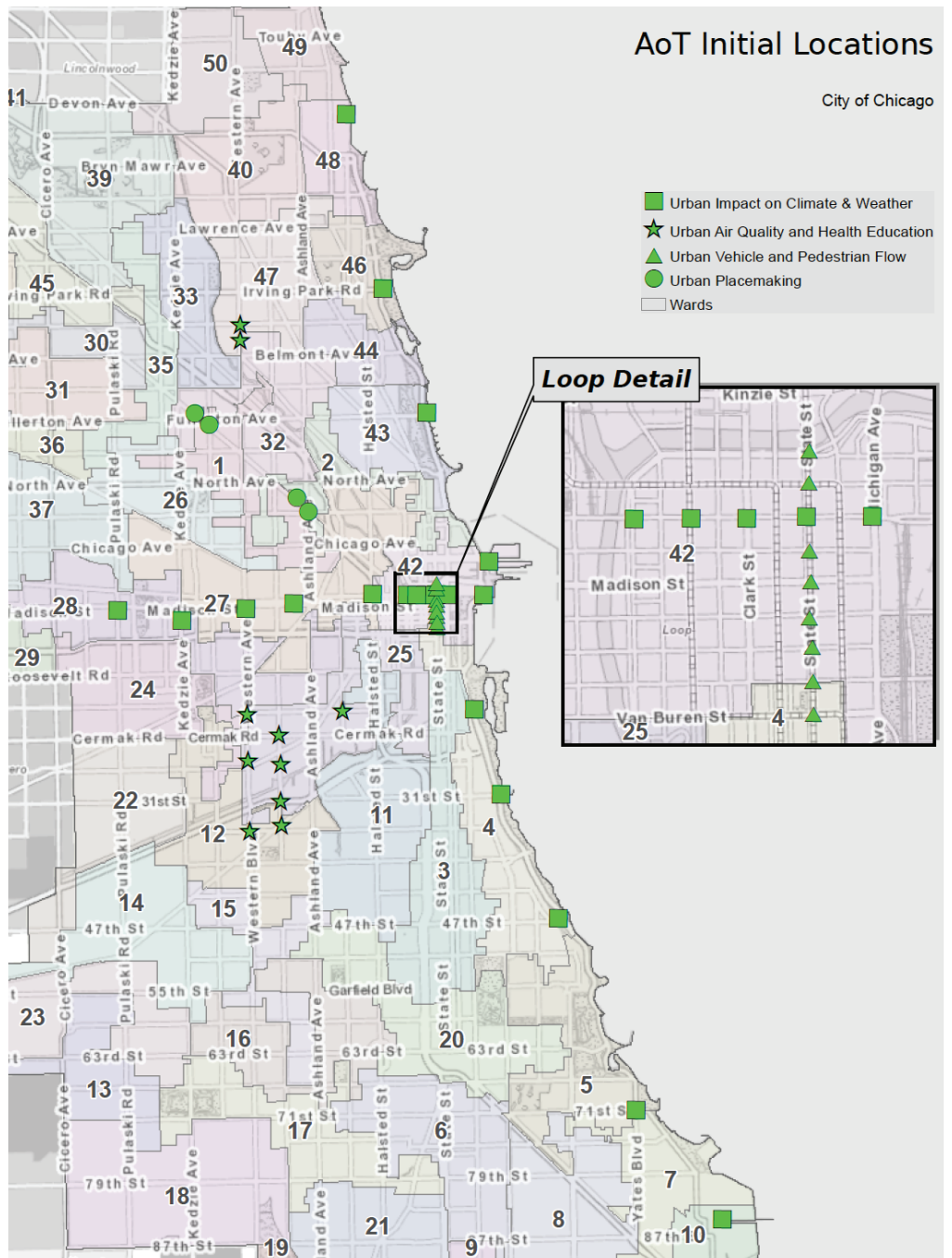
Node sensor testing at Argonne Laboratory

moved (despite, all PII being removed from the process) as well as physical solutions such as giving notice when users are in the proximity of a node with clear access to information on what is being measured in that particular location.

02 Up skilling the community, supporting community education and learning platforms.

AoT identified early on that the project was an opportunity to engage with universities and high schools and create corresponding curriculums.

The School of Art Institute of Chicago (SAIC)s architecture department was engaged early on, Lead by Douglas Pancoast the school oversaw the physical design of the nodes and were engaged in conceptual discussions of the possibility and potential impact the sensor could have on our cities. They also partnered up with AoT to oversee the lane tech curriculum for high schools. Dubbed “Lane of Things” the program was an opportunity to “use the technology and principles of the urban sensing platform to help students learn about



programming, data science, digital fabrication, and additional CS concepts.” (Ci.uchicago.edu, 2016) Charlie Carlett, AoTs project lead and Senior Computer Scientist at Argonne National Laboratory described the need for these programs. “Chicago and cities around the world want to make sure that their students receive education and experience in the technical skills that will be in demand in tomorrow’s economy.” Students developed their own sensors to measure urban factors impacting their school schooling environment such as dust, methane, humidity, traffic and then worked to developed new ideas about how they could improve their surroundings.

03 Deployment of nodes based on a response to and engagement with communities, organizations and research propositions.

When we think of the Internet of Things, we often think of intelligent, networked systems that can make quantitative decisions. But who is setting up the frameworks of what is being measured and for what reason? What is the end goal? For the AoT these questions are offered to community groups, organisations and researchers for their input. This can take place in two different ways, where the community submissions can request potential node locations, problems they could address, and data they would like to see, these are reviewed but the research team

and the city based on feasibility. The other way is when the AoT has a particular goal it would like to measure and then seeks a partnership with the appropriate neighbourhood, community group or research organisation with to support/champion and engage. As a result the project is partnered with a wide range of groups across the city. The location of the first community meetings and installs was driven by this process responding to air quality issues specifically in relation to health issues like asthma. The pilson neighborhood was selected due to both community response to air quality issues in the area and the regions focus of healthcare careers offering a dual community benefit. “After learning that the Instituto del Progreso Latino, located near factories and the Stevenson Expressway, focuses on healthcare careers we met with their leadership to explore their interest in air quality data and engaging students. The Pilsen neighborhood also has a history of community organization around improving air quality, and nodes in this part of city [Pilsen] will help to better understand air quality impacted by factories and expressways.” (Arrayofthings.github.io, 2018)

The outcome therefore helps engage with education programs, local organizations and the local community. These groups not only have a say on where things could be deployed but also what is being measured.

The Loop neighborhood, is another

targeted location for the nodes, partnerships with Chicago Loop Alliance and Vision O means that these sensors will be specifically targeted on pedestrian safety, a key issue for the community in the area. This approach is unique because it means that the nodes are responding directly to local issues whilst working to create a broader picture and understanding of the city in the long term.

So far the project has worked with scientists from over 30 universities and national laboratories that are continuing to advise the project and leverage the data. Any outside party involved must agree that all data derived from AoT will be published openly. This approach presents something unique to AoT as it aims to be a data driven piece of supportive infrastructure for the city. But it has also presented a new challenge for Charlie and his team who are receiving a high level of demand for the nodes globally with over 90 serious enquires and 30 international developments. The nodes themselves are not expensive but require partnering with the right municipal and research organizations for deployment beyond Chicago.

04 Access to open data and open software for community interaction and feedback.

All data and most software generated by the AoT project is open source. The intention of open software is to enable continued learning, community based testing input and review

([Arrayofthings.github.io](https://arrayofthings.github.io), 2018)

The data will join other existing sets within the City of Chicagos open data portal. The portal is continually updated both in terms of content and usability and will act as the public ICT platform for the project allowing users to review exiting data & create their own maps and graphs. Data can be viewed using the portals own mapping tool and visualization options but also can additionally be downloaded for any external analysis & interaction. The portal intends to become an access point for city services linking the data to appropriate city services and a community resource where residents can review neighborhood health based on a range of conditions and factors.

What outcomes can we see of this type of data measurement?

The ways the types of data for AoT can be used changes depending on the application and research body involved. The nodes have been specifically designed to ensure flexibility acting as a protective shell where different types of sensors can be installed and updated. This means that not every AoT node will necessarily be measuring the same things and are customized depending on the location. The benefit of the sensors on a high level is fairly clear. With a proper distribution we can map the air quality of a city, and break it down to the type of pollutants present and their potential sources, and correlate those with data on public health.

Noise sensors can pick up the effect of noise pollution, as well as identify gun shots and sounds of distress, these sensors could have the capability to call the authorities. Pedestrian and traffic sensors can help understand how to make complex traffic conditions safer for users, observe which areas of the city are heavily populated by pedestrians at different times of day to suggest safe and efficient routes for walking late at night or for timing traffic lights during peak traffic hours to improve pedestrian safety and reduce congestion-related pollution.

Measuring standing water and flooding along side other environmental factors like precipitation, wind speed and temperature can help understand the causes of urban flooding leading to the prevention of such conditions in the future.

07 Can IoT tech have a role in Urban Testing

Mike Lydon Interview



Flexible plaza space outside Streetplans office in Dumbo

Mike Lydon is the principle of Street Plans and Author of “A Planners Guide to Tactical Urbanism”, Lydon Coined the now ubiquitous term “Tactical Urbanism”. We sat down to talk about the role of testing urban outcomes before their implementation and the development of this approach in a climate where we can gather more and more analytic data though IoT(internet of Things) technology.

Nicola Balch [NB]: The idea of tactical urbanism is to test solutions in a low cost way “faster, cheaper lighter” means, often prior to permanent deployment. Do you see the development of sensor technology helping this process of testing and how?

Mike Lydon [ML]: In a way the work that we do [at street plans] lends itself to how data scientists might work, we come up with a hypothesis and test it to actually see if it has validity. It’s a similar approach to the start up world by thinking about the environment as a user driven experience. So rather than just sitting in a room or an office like this and coming up with something on the screen, we design a hypothesis and test it to see if it works or not, and as part of that process we undertake an evaluation. Yet we don’t have a really clear set of digital tools for that analysis, we have gone down that path a few times but not in a comprehensive way. We are interested in how we can utilise and deploy that technology for human environments. Yet there is a huge



Public Space and the City: The Role of Technology

Public Space and the City: The Role of Technology

ML: Right, it's not necessarily technology, but how it's deployed, to make sure the human and community narrative is not left out of this picture of development. It's interesting considering how much information we have, whether or not it is useful for that purpose is a whole different question. For example when it comes to public space the type of information that is widely capable of collection such as pedestrian counts are being used to measure the success for a place yet leave out so much information that is valuable about how we are utilizing space. That's a level of analysis that is still highly specialized and we're reliant on manual observation.

NB: So it's not necessarily technology, but how it's deployed, to make sure the human and community narrative is not left out of this picture of development. It's interesting considering how much information we have, whether or not it is useful for that purpose is a whole different question. For example when it comes to public space the type of information that is widely capable of collection such as pedestrian counts are being used to measure the success for a place yet leave out so much information that is valuable about how we are utilizing space. That's a level of analysis that is still highly specialized and we're reliant on manual observation.

NB: You're talking about the bottom line here coming down to engineered "efficient" approach to data, for example we are spending so much time figuring out how to get from A to B in the easiest most timely and cost efficient way but we have forgotten the impact of that along the way, or what the long term outcomes of that will be?

ML: Right, we have access to larger reams of data. But science has been used in cities for a long time and engineering the rationality behind automotive engineering of our street designs have been disastrous for the world in terms of autodependancy, congestion and pollution in cities. It's hard for me to fully trust the overarching narrative that we are going to solve the problem with technology. But what I'm interested in is using technology in a very targeted way to make sure we are getting better-targeted outcomes, better community outcomes on the ground.



NB: So at this stage you see deployment as disconnected to what's actually happening on the ground? Do you have other projects that you have tried these things on that have been more or less successful?

ML: Back in 2014 we used a traffic counter called "waypoint". They use numeric tubes that respond to air pressure when someone drives or rides over it. As a citizen to buy or use one of those is cost-prohibitive (more than \$1000). Tomorrow lab is trying to create a much lower cost system so that you actually have more citizens evaluating streets, sensitive enough to pick up both bikes and cars. We used one of their beta models on a earlier project for evaluation, we lined the bike lane with planters to see if we could get a spike in ridership. We did. It was nice to see that one to one response but it was for one day and it was part of a much bigger event and project that we were doing inviting people in. But because that drew people in more as a neighborhood, we don't know what impact that had on the ridership.

NB: You cant say for sure. To do that you would need a much longer deployment period and ideally a Wi-Fi overlay to capture repeat and new visitation.

ML: Time is the key factor there, we got positive feedback from people that they liked being protected, but is that the driver for net increase? We don't know. If we had weeks, or

months to collect that data, then it would be far more valuable, its a great tool that reads back into a website. Cities should be using technology like that, that is wired and censored but also smart.

We did another project with the consulting wing of Happy City. They do a lot of biometric sensing of people, along with straight up surveying, so how you feel before and after. This was a competition that our team won, that set up on the waterfront in West Palm Beach in Florida. They have a long promenade but there is not very much to do, little to no activity. So we used our tactical skills to create a series of interventions in one place, we had a control group to see how people were feeling prior to the intervention Measuring heart rate, happiness all sorts of things. We set up interventions called "fascination frames" about key fact and the history of the area, their response was extremely positive in mood, in people felt more trust with their fellow citizens. Pros and cons, with this tech we were able to find out that it was a very positive intervention and there should be more available. But again, would it be the same thing every day for three months or a year. I don't know?

NB: Do you think that we are just finding way to quantify what we already know? Ideally to provide some sort of measurable proof?

ML: Technology at this stage is supportive but not defining. As designers



IoT (Internet of Things) in Public Space

with the idea of using sensors to measure things like air quality, noise, and even mood. It's about using technology to make public spaces more responsive and better for everyone.

But there are challenges. One is privacy. We don't want to be constantly monitored. Another is cost. These sensors can be expensive, especially if you want to cover a large area.

So, how do we do it? We need to be smart about where we put sensors and what they measure. We also need to make sure the data is used in a way that benefits the community.

It's a big challenge, but it's also a great opportunity. If we can do it right, we can make our public spaces more vibrant and more useful for everyone.

So, what's the future? Well, I think we're going to see a lot more of these sensors in public spaces. We're going to see them used in new and creative ways.

And we're going to see them used to make our public spaces more inclusive and more accessible for everyone. That's the goal.

So, let's get started. Let's use technology to make our public spaces better for everyone. That's the challenge, and that's the opportunity.

Let's make our public spaces more responsive and more useful for everyone. That's the goal.

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Let's use technology to make our public spaces better for everyone. That's the challenge, and that's the opportunity.

Let's make our public spaces more responsive and more useful for everyone. That's the goal.



es digital technology is largely too expensive for these types of smaller projects. So how do you get that technology into the hands of the people who need it? The reality is the sensors are relatively low tech, low cost, yet the processing of that information is not. The cost is in the accuracy and the data aggregation, monitoring and findings. The people you want to give this power to don't have the money so it becomes this top down and/or product based process. The solution to this will be increased competition within this market, and it is happening but its still top down. I'm really interested in how Chicagos AoT (Array of Things) is responding to these questions. It's not just the sensors, it's the supporting groups and communities that are engaging with technology. On one side they run a program called "Lane of things" where they teach younger generations how to build their own sensor tech on the other they've had consolation and engagement with a group called the Smart Chicago Collaborative that teach people how to use and monitor different types of technology, like a tech support and learning center for the community.

It's another reason as to the dubious success rate of fixed digital infrastructure, particularly those that are deployed without a proper overlay of testing. You have huge investment in these pieces of digital urban infrastructure that arguably decrease street flexibility particularly when they are ingeniously linked to and

financed by advertising, as the scale of the advertising dictates a certain physical spatial outcome. Without the capability to test we are seeing great ideas go through so many levels of compromise that their original intention is lost. They learn their lessons after full scale "solution" deployment. This may be a regular occurrence when it come to design, but its a new type of hypocrisy if its linked to project founded on ideas of data access and measurement. It could be said that products sold to people are marketed to people based to user research, whereas products sold to city's are marketed to councils based on city ambitions. Don't get me wrong I am generally supportive of all of these projects because I think they are a step in the right direction of learning about how we utilize and deploy IoT technology, but I'm not convinced that they are the way forward. We need to start looking at them as tests and prototypes from which we learn, particularly in regards to their engagement with people, during not after their development and deployment.

ML: The way we talk about our tactical work is that we are not creating solutions, we are not solutionary. We are not going to solve all your problems, as soon as you do another problem is going to come up. This is the challenge of living in a dynamic place. There is always challenges and issues, you don't just solve it and walk away and thats fixed forever. We talk about challenges and not solutions, if



	<p>its too fixed its not going to respond well.</p> <p>NB; Which is interesting from a design perspective, because you are designing permanent solutions, and the parameters that you are responsive to correspond in some ways to a fixed moment in time. The can be arbitrary and shifting.</p> <p>ML: Right and if you had a temporary response, you could navigate some of those issues to see if they become a problem and find ways to potentially responding to that better. Let's take what you think, and lets try it out.</p> <p>NB: And this weird conception that a data response will suddenly allow us to solve all our problems. Like we will have spatial KPIs, that could also be dangerous, does that make it more difficult to sometimes make bold trade-offs which can lead to some incredible spaces or are we just then responding to another set on engineered parameters?</p> <p>ML: Exactly, do we even want to be there? I think its healthy to maintain that skepticism within the optimism. It's a really interesting topic. And a lot of people are starting to think about this. Yet I think a lot of it's not coming as fast as people say it is.</p> <p>NB: Hopefully we will see outcomes where the public have a stronger capability of understanding and working with data, so it can become an accessible community lobbying asset.</p>	<p>Yet currently these types of data are still in siloes, even on open platforms. We're not seeing the cross reference of information that can actually give us really valuable insights.</p> <p>ML: There's no real merging of it yet. I feel that this might occur when we get further down the line with the autonomous vehicles. When this has developed to some level of scale. I think that there might be some sort of oh shit moment and it at that point we are really going to have to start responding and quickly.</p>
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08 What is Being Measured and Why?

This section gives a brief overview of some of the IoT currently being deployed in public spaces, indicates some potential design applications then assesses their potential from a placemaking perspective. It is important to note that this is an overarching summary rather than a comprehensive breakdown of a very broad reaching and growing field of technology. To simplify the scope the focus is on the IoT not their corresponding ICT given that each data type could be communicated and engaged with in a myriad of different ways.

Transport & Movement oriented IoT:

- Data measured includes but is not limited to: speed, flow, number of cars, taxis, busses, cyclists and pedestrians, mobility patterns, share bikes use, movement and location (inc e-bikes) and smart parking systems. These rely on wifi tracking, image rec, mobile data Bluetooth, satellite information, proximity sensors and thermal imaging
- Traditional applications: Pedestrian safety measurements & statistics, traffic efficiency, movement and congestion (including apps such as wave and google maps), parking capacity and infrastructure planning, footfall levels for store locations, location of wayfinding solutions.
- Some other applications include: Phasing traffic lights based on real-time traffic flow to reduce stop

start traffic pollutants and real-time green wave light systems to prioritise cyclists and bus transport (this includes LED paving indicators to keep up cycle flow). Automatic rising bollards for increased adaptable/timeshare spaces between pedestrians, vehicles and servicing. LED paving modules allowing for the flexible transport options in the streets testing.

- City walkability parameters including measuring time as well distance as a major factor (influenced by how easy it is for individuals to cross the street), walkability routes based on shade from the sun or rainfall and lighting or activity for evening safety. Informed street pedestrianisation and curb sidewalk expansion strategies. Informed cycle strategies and influence of different cycle infrastructure on ridership. Alternative transport options and their impact/infrastructure requirements such as e-scooter, e-bikes, skateboarding (e.g. measuring skateboarders could indicate where skate and cycle infrastructure is lacking).

Microclimate IoT:

- Data measured includes but is not limited to: Block by block temperature, surface temperature, wind, humidity and air quality (broken down at the pollutant level most popular being carbon, nitrogen & Sulphur dioxides, ozone and pollens)
- Measurements can quantify the us-

ers climatic experience of city spaces and develop “comfort ratings”. When co-related to regional weather information, shadows studies and time we can begin to pin point quantitatively the impact of different street conditions of desirable micro climates. The number and location of street trees, vegetation, height, spacing and design of buildings, paving permeability, vegetation types (for example species & deciduous vs evergreen) can impact urban heat and roadside air quality. The outcome for this is to be able to create a target microclimate and test if this is achieved by different design outcomes. Decisions become linked the livability of a specific community as well as to larger defined outputs, for example their impact on a cities urban heat island mitigation, carbon offsets, solar energy potential, roadside pollution levels and applicable locations for rooftop and façade wind farming. Air quality data assessed against asthma related hospital visits as well as pollen counts, road locations and traffic conditions, location of nearby industry, time day/year vs wind direction & intensity could lead to proper urban buffering systems that can help mitigate the direct roadside human impact and identify at risk communities and neighbourhoods leading to targeted policy and initiative such as congestion tolling.

Water Oriented IoT

- Data measurements include water quality, urban flooding, standing water, precipitation and soil moisture

as well as wastewater, greywater and stormwater treatment facility monitoring. This includes sensors in bioswales, wetlands, rivers, large water bodies, gardens and agriculture as well as water flow in pipes and image recognition technology in urban spaces for water pooling.

- Live indicators show where in water is clean enough for primary and secondary contact in forming water activation and health strategies and though awareness help to relive instances of sickness after rainfall. Water quality sensors can determine the effectiveness and impact of wsud strategies and identify stagnant water. Soil moisture sensors coupled with weather information and species can lead to Smart irrigation proving huge savings on irrigation costs and water use. Standing water can help predict urban flooding and in disadvantaged areas detect areas with heightened health risk. Measurements can help identify a hierarchy of water quality initiatives such as wsud strategies, indicate the impact of species and planting location water use, demonstrate quantitatively the impact of sponge strategies such as permeability and planting on maintenance and irrigation as well as level and speed of run off.

Waste, Light, Noise Oriented IoT

- Data measurement include movement sensors, lux levels, environmental noise measures.



Smart City

Smart City: Smart City

- Smart waste indicates fill levels and forecasting waste, recycling and maintenance schedules.
- Noise sensors can measure noise impacts of major roads, airports and construction sites as well as detect gunshots and sounds of distress triggering emergency services, they can also measure levels of ambient noise.
- Smart lighting systems can respond to time of day, movement, time of month/year and surrounding light levels to adjust accordingly improving energy use, costs and safety. Many smart lighting systems include wifi and can also include art installation's and evening wayfinding strategies.

“People Focused” IoT:

- Data includes user mood sensors and demographic measures including age, and gender. These can include more experimental brain wave monitoring exercise whilst walking users though urban space mapping associated “feelings” with different environments. While facial recognition also falls under this area and uses more nuanced image recognition software often adopted for a lot of people focused solutions.
- This category also includes more nuanced “placemetrics” being developed to try and count behavioral characteristics of people in spaces that are often observed in place audits. Examples include dwell time and differentiation between sitting, standing, leaning level of mobile phone use vs book reading, quantity of prams, dog walkers, wheelchairs, walking frames and other mobility factors, public activity rhythms (identifies repetitive use of space over time) and specific uses (football, yoga, chess, boot camps/outdoor training etc).
- The idea is to be able to measure how a space is used by the public on a activity and behavioral level accurately over time to ensure spaces are providing properly for the demographics and types of activities undertaken by a particular community. Cross referenced with other data sets the intention is to see if there are new index's to understand or “read” public space for example the number of women in public spaces as an index for safety.
- Place audit findings undertaken (whether it be by the community, consultant, government or IoT) can be input into newly developed websites and platforms that cross reference findings with other quantifiable and qualitative factors in an attempt to holistically to determine place value. These include sites such as neighbourhoods and place score.

Placemaking and IoT

Most place audits are undertaken manually and are a mechanism of engagement to help governance and communities see their spaces in a different way. “We do place audits but the biggest value the biggest outcome isn't the analysis and the data it's the listening,



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it defining the problem more broadly and allowing communities to take responsibility more broadly.” Notes Ethan Kent from Project for Public Spaces. This indicates that although IoT based place auditing sounds interesting, it in no way replaces this function. Furthermore it is far from being properly developed for public space analysis purposes. Unlike traffic and utility focused IoT there is not direct link to savings that have a clear corresponding economic index. I spoke with Camilla Siggard Anderson of Gehl Architects one of the leaders in this area about these road blocks. “We need more nuanced information via IoT than we can get currently but they are not going to put time in writing a code if there is no monetary value attached to it, but if we can get technology to do binary counting activities then it frees out our team to focus on the more qualitative aspects of space”. In each case the measurement systems were in no way indicated to replace qualitative analysis but to complement it. Ethan re-iterates this;

“The first 20 years of PPS we were doing a lot of user analysis, in the last 20 years however its been about helping communities do that analysis themselves, facilitating the capacity building of communities to create change, humanizing the process of changing and creating cities....The biggest benefit that is built though placemaking is the community capacity...if we are getting measurements that are holistic and inclusive

and challenge people to observe and appreciate things that aren't being appreciated then that's good, but it has to be ground in a larger place first focus, in the community. If it is just data being extracted and a designers coming up with a solution to that extraction, you're still designing in a vacuum, its not capacity building, allowing the community to take ownership of their public spaces which is the real success factor.”

This observation further reflects the value add identified in the AoT case study, where the success is not only in the high level data and the possibilities it unlocks but how designing meaningful human interactions with space within a smart city framework is linked to ensuring meaningful community interactions with data. Means of engaging community with IoT discussed during this study include but are not limited to:

- Portable sensors engagement exercises and workshops (such as air quality and pedestrian counting)
- DIY sensor building workshops, sensor application direction and lobbying (deciding what is being measured where and why)
- Local research group partnerships, engagement and study support, co-design & urban testing for programs and suggested uses (such as community based tactical urbanism exercises), augmented and Virtual Reality.

09 Conclusion

We have indicated how IoT in public space is stuck in a product oriented procurement framework in an industry dominated by large tech companies within a funding structure that relies on large capital matched PPP (public private partnerships). We have also highlighted how the industry is still greatly focused on data capture and where solutions are sought they are often for the purpose of maintenance and engineering savings or on the back of a misguided idea that smart “communities” can be built from scratch. The result of this is a lack of an overarching intent driving smart city strategies and a need to clearly understand what larger problems cities and their communities are facing and then identifying how IoT may help them achieve long term change. This approach would result in a targeted rather than a scatter-gun approach to the procurement of smart city solutions.

By shifting to a problem based, outcome oriented approach we can become far more creative in how we engage with and deploy IoT in urban space and how we harness and work with communities to achieve meaningful, lasting outcomes.

This apparent lack of outcome orientation, means testing solutions in urban spaces (whether this be via design or behavioral change) is strikingly uncommon. Testing and a product oriented approach in many ways oppose one another, as one offers a predetermined solution and the other does not. Clients will only pay for a product when they know ex-

actly what they are going to get. This is at odds with how urbanists and placemakers work, where the value in many ways is front heavy, you are paid to come up with a holistic solution to a predetermined problem or set of requirements, there is capital input into the creative process not just the outcome.

Therefore if we as professionals want to engage in this sphere in a meaningful way there needs to be an industry shift in how large tech companies engage in and think about urban space to a more place specific, community and humane approach as well as how governance frames and funds smart city projects and their expected outcomes.

10 Projects Developed - McGregor Coxall

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The following projects were developed as a series of design competitions with McGregor Coxall, each of these either won or were shortlisted in major London Smart City Initiatives. They target the product oriented framework of the smart city industry but do so in a way that aims to bring community interaction and flexibility to public space.

Project Preamble

The development of Internet of Things (IoT) and Information Communication technology (ICT) is growing at an exorbitant rate. For the “Smart City” movement this means leveraging data to achieve a constantly adapting, connected, intelligent, healthier and more efficient human habitat. But what does this mean for our public spaces and communities? As we identify stronger quantifiable links between our environment and our physical and mental health, we increasingly need to ensure the development of this technology responds to the most complex parameter – “people”.

Movements such as placemaking and tactical urbanism have identified the importance of our public spaces to maximise human encounters, prioritise community driven outcomes, and provide spatial flexibility. With a huge shift in technology we have the opportunity not just to engineer a more efficient city-scape but to provide co-working physical and digital platforms that hand our communities greater ownership over their public spaces, while improving the health and sustainability of our cities. These trends coupled with a rapidly urbanising global population call for a reinterpretation of traditional open spaces in favour of a new testing ground for smart, innovative, adaptable, and flexible solutions that can create new opportunities within the existing urban tissue.

It is here that McGregor Coxalls new “Smart Design” proposals find their home. Each project “Smart Carpet”, “Hi Croydon!” and “Living Breathing Lobbies” are a product of their new “Smart City” Think-Tank and continue their broader investigation on the role of landscape architecture to facilitate change within a wider urban context. The works hybridise existing & developing technology’s to offer feasible, innovative solutions that:

- involve and empower communities though input/ownership & engagement;
- provide opportunity for endless adaptability and testing of social & transport outcomes;
- create a transparent and efficient governance tool;
- increase the sustainability of local environments;
- offer an intelligent system that can learn from itself;

The aim of these works are to provide a taste of what a future public domain could be and how they could support a deliverable framework for incremental change.

Hi Croydon!

“Hi Croydon!” is a shortlisted design developed for the ‘i-Street Croydon competition’ and it is now in the preliminary prototype-stage with the Croydon City Council. “Hi Croydon!” plans to be a series of ‘interventions’ constructed of modular and endless adaptable furniture components –



I-Croydon looks at how augmented reality, light installations and DIY public domain intervention can catalyze nighttime activation

think 'Lego' – to build street furniture, totems, planting etc. These elements are coupled with an augmented reality app that allows the community to design their own public spaces using a system that can respond to a range of programs, spaces, lighting and way finding options. Each placement will be composed of and built around the character and topography of the specific location and each 'intervention' can be considered to be unique – composed of a different set of component parts and designed by a different community groups. "Hi Croydon!" targets both social and en-

vironmental sustainability initiatives. Where manually surveyed approach to tactical urbanism can be data driven providing live measurements on the success of any given configuration. This mobile, habitable, botanic garden provides a momentary "escape" from the polluted city air by using endemic planting and low tech fans to actively filter and breaths fresh air into its immediate surrounds.

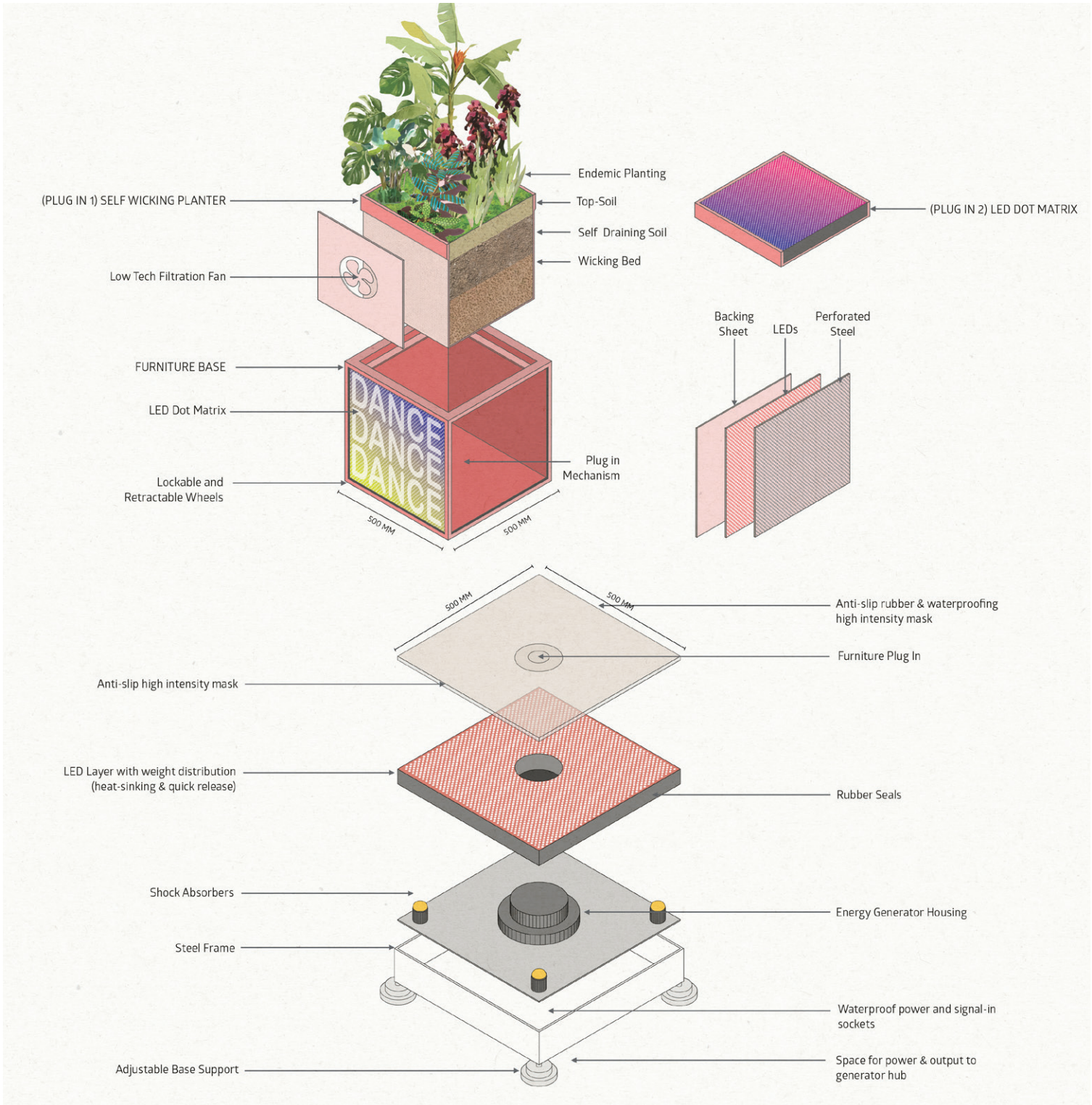
Smart Carpet

“Smart Carpet” is an innovative street design awarded by the City of London. “Smart Carpet” is designed as a living, thinking surface treatment that adaptively responds to user demand. Comprising of a series of paving modules, the street is revealed as an intelligent multi-functional system that supports energy creation, interlockable furniture, LED lighting displays, sensory recognition and live analytics. These paving modules facilitate modular street furniture for social interaction, recreational zones for active health, street markets and exhibitions for cultural expression or commuter traffic during peak periods.

The surface interacts directly with pedestrians and motorists changing the traffic conditions of any given street while delivering wayfinding, street notifications and live localised news. “Smart Carpet” innovates our street into an adaptable, data driven, multi-functional space that curates public life through an intelligent, flexible street surface. The street is no longer “for people” or “for cars” but a self powered space that can adapt to any program or traffic condition and learn from its findings”



Smart Carpet can test different traffic and public space condition in an ever-changing streetscape



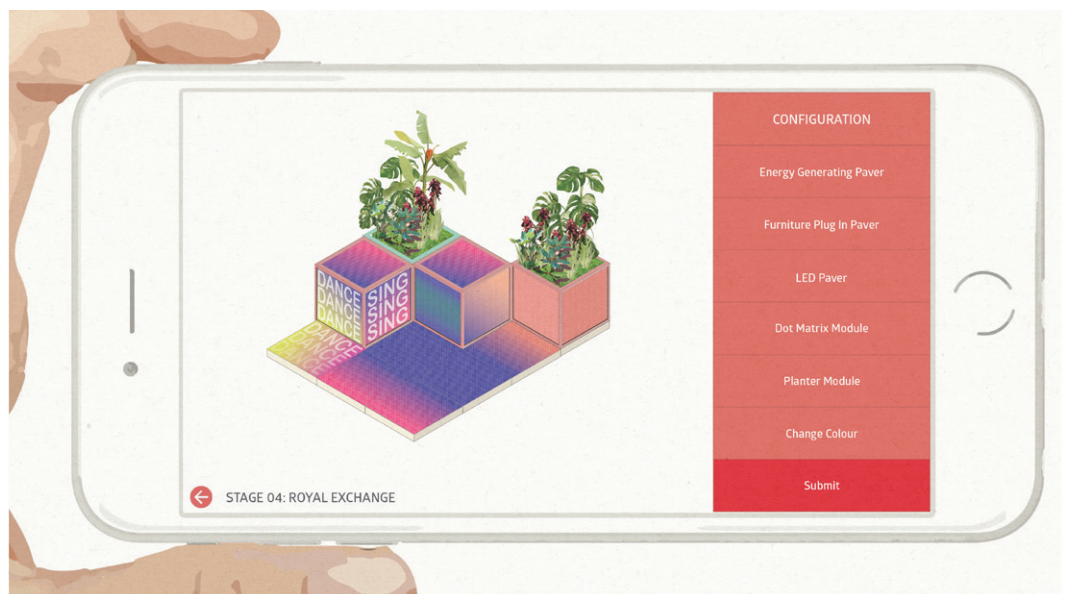
Smart Carpet integrated components



Living Breathing Lobbies

“Living Breathing Lobbies!” looks at the lobby as a unique spatial environment where we can trial strategies for future buildings. What if our lobbies could become an extension of our green-networks? What if they could engage meaningfully with the street and provide space for activity and respite? “Living Breathing Lobbies provides a flexible, adaptable solution that uses live data to test the future role of these valuable spaces. More than smart furniture, the system can take the role of green facades by actively filtering air, engage with the public and tenants through interactive furniture which can be rented and endlessly designed and re-designed for sponsorship events, dining, meeting

spaces, work stations, public & private talks. It can engage directly with users delivering, live localised news, wayfinding and building notifications. Living Breathing Lobbies is an interim solution, with an end goal of creating a more seamless, public/private interaction along our city streets where our lobbies can be the future rainy-day public spaces.



Smart Carpet looks at community engagement through mobile technology.





Umbrellium paving used for adaptable transport conditions.

11 References

Arrayofthings.github.io. (2018). Policies-Final-Draft-CeC. [online] Available at: <https://arrayofthings.github.io/final-policies.html> [Accessed 25 Oct. 2017].

Australian Government: Smart Cities and Suburbs Program. (2018). Smart Cities and Suburbs Program. [online] Available at: <https://cities.infrastructure.gov.au/smart-cities-program> [Accessed 10 Nov. 2016].

Baker, L. and Dave, P. (2018). Qualcomm, JMC seek to exit Alphabet-backed New York WiFi project: sour. [online] U.S. Available at: <https://www.reuters.com/article/us-qualcomm-jmc-new-york/qualcomm-jmc-seek-to-exit-alphabet-backed-new-york-wifi-project-sources-idUSKBN1D166C> [Accessed 12 Nov. 2017].

Bliss, L. (2017). ‘Yelp for Social Services’ Now Available on Hundreds of New York City Wi-Fi Kiosks. [online] CityLab. Available at: <https://www.citylab.com/life/2017/04/new-york-citys-wifi-kiosks-now-include-a-yelp-for-social-services/522801/> [Accessed 13 Apr. 2017].

Buttar, S. and Karlia, A. (2017). LinkNYC Improves Privacy Policy, Yet Problems Remain. [online] Electronic Frontier Foundation. Available at: <https://www.eff.org/deeplinks/2017/09/linknyc-improves-privacy-policy-yet-problems-remain> [Accessed 7 Jan. 2018].

Catlett, C. (2017). Array of things Argonne Laboratory Visit.

CCLM Smart Cities Plan Submission. (2016). Canberra, ACT: Council of Capital City Lord Mayors.

Certomà, C., Dyer, M., Pocatilu, L. and Rizzi, F. (2017). Citizen Empowerment and Innovation in the Data-Rich City. 1st ed. Cham: Springer International Publishing.

.....

Chase, J., Crawford, M. and Kaliski, J. (2008). New York: Monacelli Press.

Chicago. (2012). City of Chicago | Data Portal | City of Chicago | Data Portal. [online] Available at: <https://data.cityofchicago.org> [Accessed 4 Apr. 2018].

Ci.uchicago.edu. (2016). “Lane of Things” Brings Sensor Science to Schools | Computation Institute. [online] Available at: <https://ci.uchicago.edu/blog/“lane-things”-brings-sensor-science-schools> [Accessed 4 Apr. 2018].

Citiscopes.org. (2017). Criticism of India’s Smart Cities Mission is mounting. [online] Available at: <http://citiscopes.org/story/2017/criticism-indias-smart-cities-mission-mounting> [Accessed 14 Jan. 2018].

CityBridge Privacy Policy Effective March 17. (2017). Exhibit 2. [online] New York: CityBridge. Available at: <https://www.link.nyc/privacy-policy.html> [Accessed 11 Nov. 2017].

DuMerer, D. (2017). Interview - AOT Privacy policy and Implementation - City of Chicago.

Ethan Kent. (2017) . (2017). Interview.

Harari, Y. (2015). Sapiens. New York: Harper, p.140.

Housing and Land Rights Network (2017). India’s Smart Cities Mission: Smart for Whom? Cities for Whom?. A Human Rights and Social Justice Analysis of Smart City Proposals. New Delhi: Housing and Land Rights Network.

Hutson, M. (2017). New software can track many individuals in a crowd. [online] Science | AAAS. Available at: <http://www.sciencemag.org/news/2017/04/new-software-can-track-many-individuals-crowd> [Accessed 11

.....

Sep. 2017].

Siggaard Andersen, C. (2017). Interview.

Jcdecaux.com. (2018). Home. [online] Available at: <http://www.jcdecaux.com/for-you#more-responsible> [Accessed 21 Jan. 2018].

Jeff Muthondu, S. (2018). INTERNET OF THINGS | BRCK. [online] BRCK. Available at: <https://www.brck.com/iot/> [Accessed 10 Mar. 2018].

Kaklauskas, A. and Gudauskas, R. ed., (2016). Intelligent decision-support systems and the Internet of Things for the smart built environment. In: Start-Up Creation: The Smart Eco-Efficient Built Environment. [online] Vilnius, Lithuania: Woodhead Publishing, pp.413–449. Available at: <https://www.sciencedirect.com/science/article/pii/B9780081005460000170> [Accessed 10 Sep. 2017].

Lydon, M. (2017). Interview - IoT and Testing Tactical Urbanism.

McGeehan, P. (2016). Free Wi-Fi Kiosks Were to Aid New Yorkers. An Unsavory Side Has Spurred a Retreat.. [online] Nytimes.com. Available at: <https://www.nytimes.com/2016/09/15/nyregion/internet-browsers-to-be-disabled-on-new-yorks-free-wi-fi-kiosks.html> [Accessed 7 Jan. 2018].

McLean, A. (2018). City of Fremantle readies AU\$8m energy and water blockchain project | ZDNet. [online] ZDNet. Available at: <http://www.zdnet.com/article/city-of-fremantle-readies-au8m-energy-and-water-blockchain-project/> [Accessed 13 Jan. 2018].

Melia, J. (2016). Quantum technologies offer promise for data protection. [online] Infosecurity Magazine. Available at: <https://www.infosecurity-magazine.com/>

.....

opinions/exactly-quantum-cybersecurity/ [Accessed 10 Dec. 2017].

Nance, B. and Krafcik, E. (2017). Making Smart Parks | None | National Recreation and Park Association. [online] Nrpa.org. Available at: <http://www.nrpa.org/parks-recreation-magazine/2016/may/making-smart-parks/> [Accessed 15 Sep. 2017].

Pancoast, D. (2017). Interview - AOT.

Rethink LinkNYC. (2018). Rethink LinkNYC. [online] Available at: <http://rethinklink.nyc> [Accessed 7 Jan. 2018].

Sidewalktoronto.ca. (2018). [online] Available at: <https://sidewalktoronto.ca> [Accessed 16 Jun. 2018].

Sri.com. (2018). Our Work | SRI International. [online] Available at: <https://www.sri.com/work> [Accessed 7 Jan. 2018].

The Guardian (2016). Wi-Fi Kiosks Changes New York. [online] Available at: <https://www.theguardian.com/technology/2016/sep/15/wi-fi-kiosks-changes-new-york-linknyc> [Accessed 6 Nov. 2017].

UChicago News. (2016). Chicago becomes first city to launch Array of Things. [online] Available at: <https://news.uchicago.edu/article/2016/08/29/chicago-becomes-first-city-launch-array-things> [Accessed 4 Apr. 2018].

Williams, H. and Dvorsky, G. (2018). All The Ways Your Smartphone And Its Apps Can Track You. [online] Gizmodo Australia. Available at: <https://www.gizmodo.com.au/2018/01/all-the-ways-your-smartphone-and-its-apps-can-track-you/> [Accessed 3 Jan. 2018].

.....

